Cartographic user interface design models for mobile Location-Based Services applications

A thesis submitted in fulfilment of the requirements for the degree of
Doctor of Philosophy

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Declaration

This is to certify that:

(a) except where due acknowledgement has been made, the work is that of the candidate alone;

(b) the work has not been submitted previously, in whole or in part, to qualify for any other academic award;

(c) the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program;

(d) any editorial work, paid or unpaid, carried out by a third party is acknowledged; and

(e) ethics procedures and guidelines have been followed.

Karen Wealands (née Urquhart)

2 March 2008

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List of Acronyms

2G	Second generation (mobile radio networks)
3G	Third generation (mobile radio networks)
A-GPS	Assisted GPS
ARC	Australian Research Council
CDMA	Code Division Multiple Access
CDP	Cartographic Design Principle
CGI	Global cell identity
cHTML	compact HTML
DHR	Domestic holiday-related (travel)
DP	Design Principle
EDGE	Enhanced Data Rates for Global Evolution
E-OTD	Enhanced observed time difference
GIS	Geographic Information Systems
GML	Geography Markup Language
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global Systems for Mobile Communications
HDML	Handheld Device Markup Language
HTML	Hypertext Markup Language
mLBS	Mobile Location-Based Services
MLP	Mobile Location Protocol
MMS	Multimedia Messaging Service
OGC	Open Geospatial Consortium (formerly OpenGIS Consortium)
OMA	Open Mobile Alliance
OpenLS	Open Location Service
PDA	Personal Digital Assistant
PDE	Preliminary design evaluation
PIM	Personal Information Management
PLS	Plain Language Statement
POI	Place of Interest
RE	Requirements Engineering
SMS	Short Message Service
TA	Timing advance
TDMA	Time Division Multiple Access
UCD	User-Centred Design
UE	Usability Engineering
ug	Usability goal
UI	User Interface
UL-TOA	Uplink time of arrival
UMTS	Universal Mobile Telecommunications System
WAP	Wireless Application Protocol
W-CDMA	Wideband CDMA
Web	World Wide Web
WML	Wireless Markup Language
XHTML-MP	Extensible HTML Mobile Profile
XML	Extensible Markup Language

Thesis Terminology

Cartographic UI — The components of a user interface (see definition below) that are specifically concerned with the access and representation of, and interaction with, geospatial information.

(Cartographic UI) Design models — Visual depictions (and accompanying descriptions) of the general functionality required for an application to support its users' geospatial goals, with specific detail incorporated regarding support for individual users and tasks, including alternative inputs, outputs and interaction flows and the cartographic representation, presentation and interaction techniques involved.

Domestic holiday-related (DHR) travel — Travel within one's own country for tourism and/or leisure purposes. See Section 5.2.1.

Geospatial information — Characterised by spatial, temporal and thematic referencing, refers to information pertaining to the large-scale space (and time) of the Earth, which is beyond immediate experience but can be perceived through the combination of multiple views. See Section 2.2.1.

Goal — The overall purpose or objective of an endeavour. See Section 6.2.

Handheld device — A highly portable, digital device that generally fits into the user's hand or pocket (as opposed to desktop or laptop/notebook computers) with the ability to deliver mLBS applications. Includes tablet computers, palmtop (clamshell) computers, PDAs, mobile phones, SmartPhones and custom-built hardware. See Section 2.3.1.3.

Mobile Location-Based Services (mLBS) — Wireless services which utilise the mobile Internet, along with the location of highly portable, handheld devices, to deliver personalised applications that exploit pertinent geospatial information about a user's surrounding environment, their proximity to other entities in space (e.g. people, places), and/or distant entities (e.g. future destinations), in real-time. See Section 2.3.

Non-expert users — Compared with expert users (or 'professionals'), refers to 'novices' who lack specific knowledge and experience in interpreting and analysing representations of geospatial information, while requiring mLBS applications that satisfy their everyday geospatial information needs. See Sections 2.5.2 and 5.2.5.

Personas — Fictional or pretend people, developed from user data, who are representative of user types within the target user population, but who should not be confused with real people. See Section 6.4.2.2.

Qualitative (social) research — Involves exploratory data collection methods and interpretive analytical techniques to produce outcomes grounded firmly in the experiences and perspectives of the people under study, as opposed to employing statistical procedures or other means of quantification. See Section 4.3.1.

(Cartographic) Representation	"The transformation that takes place when information is depicted in a way that can be perceived, encouraging the senses to exploit the geospatial structure of the portrayal as it is interpreted" (Fairbairn *et al.* 2001, p.14).
Scenario	A description of a usage episode, having a setting, actors with goals or objectives, and sequence of actions and events. See Section 6.4.2.2.
Task	A unit of actual work, or course of action, taken towards achieving a goal. See Section 6.2.
Usefulness	Concerns whether a system can be used to achieve the desired goal and is made up of the concepts of utility – whether the system can perform the function(s) required by users to achieve their goals – and usability – the extent to which users can employ the system to achieve their goals with effectiveness, efficiency and satisfaction. See Section 2.5.1.
User interface (UI)	Includes the aspects of a computer system/program which can be seen, heard or otherwise perceived by the human user (i.e. outputs) as well as the commands and mechanisms used to control its operation and input data.
User-Centred Design (UCD)	A methodological approach to the development of useful computer systems which positions the end user as the focus of all design and evaluation activities so that the final product is easy to use and ultimately meets their needs. See Section 4.2.
XHTML Mobile Profile (XHTML-MP)	A hypertext document type definition, or authoring language, defined specifically for resource-constrained Web clients that do not support the full set of XHTML features (e.g. mobile phones, PDAs, pagers); derived from XHTML Basic, which is a specialised 'light' version XHTML – the successor to HTML. See Section 2.3.1.4.

Thesis Summary

Throughout modern history, geospatial information has been almost exclusively delivered to members of the general population in the form of highly portable and convenient printed maps. With the advent of digital technologies, in particular multimedia and the Internet, it became possible to communicate interactive geospatial information in a variety of other representation forms. Despite the benefits and success of various digital cartographic products (e.g. online navigation tools), however, these applications generally lacked the portability to be useful for most everyday activities. Changing this situation, mobile Location-Based Services (mLBS) – based on wireless telecommunications, the positioning of (ubiquitous) Internet-enabled handheld devices and the delivery of rich content and applications – are today expanding the users and uses of digital cartographic products, through an ability to deliver geospatial information within varying mobile contexts. Indeed, through their unique combination of digital content, portability, interactivity, location-awareness and real-time information delivery, mLBS have the potential to offer increased convenience and support for the everyday geospatial decision-making tasks (e.g. "Where is the closest service station?") of a widespread population of non-expert, general public users.

In spite of their benefits, inherent limitations within mLBS technology (e.g. small screens), along with the dynamic and changeable contexts in which they are used, impact on the effectiveness with which mLBS applications can communicate geospatial information to end users and, as a result, their overall acceptance. The users themselves present perhaps the greatest challenge in this respect: applications for everyday use must cater to the sometimes limited cartographic abilities of non-expert users as well as vast differences in their preferences, goals, tasks and needs for geospatial information access. For this reason, it is necessary to design end products that offer *usefulness* (i.e. utility and usability) to end users. This research focuses on the usefulness of the entire cartographic UI for mLBS applications – those components that are specifically concerned with the access and representation of, and interaction with, geospatial information – differentiating it from related mLBS research and application design. Particular emphasis is placed on the usefulness of the interplay between various geospatial components of the cartographic UI, in support of a broad range of everyday geospatial tasks for non-expert users. Contributing to this, the research explored a wide array of alternative techniques for representing, presenting and interacting with geospatial information, from the outset determining those that offered the most utility within different contexts (i.e. users and tasks) and thus allowing greater

focus on improving the usability of the selected techniques for the tasks to which they were applied.

A User-Centred Design (UCD) methodology was adopted for the study. Involving an early focus on users and their tasks, empirical measurement of usage, and iterative design and evaluation, UCD was implemented to ensure that all design efforts would be firmly grounded in the needs and characteristics of the end users. A specific application area and associated user group were selected to drive the research, comprising domestic holiday related (DHR) travel/travellers. The UCD process itself was implemented as a qualitative study, involving four phases directed towards the design of a useful cartographic UI. The first of these – *user profiling* – culminated in a comprehensive understanding and definition of the selected user group, in terms of their characteristics, use contexts and preferences. Closely linked to this, the second phase – *user task analysis* – served to identify the users' DHR travel goals, tasks and geospatial information requirements, as well as the interrelationships between each. Drawing on the outcomes of these activities, two phases of *design and evaluation* were undertaken. Both involved the development and evaluation of a set of cartographic UI design models, embodied within an evolutionary prototype 'Holiday Helper' service, which was implemented on an i-mate™ SP5 SmartPhone. Each phase involved evaluation by representative users, who compared the relative usefulness of a range of alternative cartographic representation, presentation and interaction techniques, as well as the utility and usability of the overall cartographic UI. The ultimate outcome of each evaluation was a set of recommendations for the models' improvement. Iterative redesign undertaken as part of these two phases enabled refinement of, and extensions to, the cartographic UI design models.

The primary result of the UCD methodology is a set of cartographic UI design models for communicating geospatial information in a useful manner to the non-expert users of a DHR travel mLBS application. Of these, a single high-level model presents the content of, and structural relationships between, seven major Modules designed to support users' DHR travel goals. Of these Modules, three (addressing the goals *View my current location*, *Get info about a location* and *Find things to do*) form the basis of seven detailed models, which offer users options in terms of inputs, outputs and interaction flows for several common DHR travel tasks. Moreover, each detailed model incorporates a range of alternative cartographic representation, presentation and interaction techniques considered useful by representative users, with egocentric maps arguably being the most important for accessing geospatial information while travelling.

The design models offer a structural foundation to researchers and developers seeking to produce useful cartographic UIs for tourism/travel-related mLBS applications with non-expert user bases, as well as guidance regarding cartographic representation, presentation and interaction techniques that offer utility and usability in particular contexts. Additional outputs from the research include the UCD research methodology employed (along with certain suggestions for improvement) – which offers a guide for ensuring usefulness during the design of mLBS applications in general – and a set of general recommendations for designing useful mLBS applications – which are likely to provide benefits to industry and academia alike, both in terms of assisting specific design activities and also by contributing empirical results to the future development of mLBS application design guidelines.

1 Introduction

1.1 Context of the Research

Cartography continues to evolve, adopting and adapting technological innovations and new communication mediums to deliver geospatial information to end users. The first major revolution in the delivery and use of geospatial information stemmed from the development of the printing press and movable type in the 15th century (along with lithography and photography not long after this), which led to the automation of the processes by which maps and map-related products were published and reproduced (Robinson *et al.* 1995). Enabling mass production for the first time, this resulted in an expansion in the types of users and uses of cartographic products, with printed maps to this day continuing to offer high accessibility for members of the general population who seek geospatial information to support their everyday tasks. A second revolution during the last century added a new dimension to geospatial information access and use, prompted by the advent of digital computing technologies. Further increasing the speed, efficiency, quality and quantity of map production, developments such as digital databases, optical storage media, and multimedia techniques also contributed to the evolution of more functional cartographic representations integrating multiple data types, providing alternative views of the data and enabling interaction with the underlying geospatial information (Cartwright *et al.* 2007; Keates 1989; MacEachren 1994). While the additional introduction of distributed networks – in particular the Internet – ensured a widespread audience for these new cartographic products, their use on a day-to-day basis remained limited by a lack of portability, with stationary devices and wired networks required for their access. In this respect the printed map remained the most accessible option when it came to supporting everyday geospatial tasks such as comprehending orientation, perceiving distances and negotiating road networks.

What appears to be a third revolution in the communication of geospatial information is currently underway. This involves the delivery of highly functional and interactive digital cartographic products (and associated content) to mobile users in an easily portable format – the result of advances in, and the convergence of, wireless telecommunication networks, multimedia-capable Internet-enabled handheld devices (e.g. mobile phones, Personal Digital Assistants), handset positioning technologies and Geographic Information Systems (GIS) capabilities (Koeppel 2000). Known as mobile Location-Based Services (mLBS), this new technology is defined for the research as *wireless (cartographic) services which utilise the mobile Internet, along with the* *location of handheld devices, to deliver personalised applications that exploit pertinent geospatial information about a user's surrounding environment, their proximity to other entities in space (e.g. people, places), and/or distant entities (e.g. future destinations), in real-time.*

While still relatively new, mLBS offer value-added benefits over the more traditional cartographic communication mediums – in terms of their physical freedom, interactivity, location sensitivity, timely information delivery and convenience – and as such are creating opportunities for novel applications that support users in their everyday geospatial decision-making tasks. Some current examples include: travel directions (i.e. routing), directory/information services (e.g. "Where is my nearest …?", "What is that landmark?"), traffic alerts, weather alerts, friend finder, emergency dispatch (e.g. roadside assistance) and targeted advertising. Associated with this, due to the ever-growing ubiquity of handheld devices worldwide, the potential user base for mLBS applications is extremely vast, essentially comprising the general public, most of whom can be considered 'non-experts' *in terms of their knowledge and skills in interpreting traditional cartographic representations* ("about 64% of the general population has difficulty reading maps" (Streeter & Vitello 1986)). Indeed, mLBS have the potential to expand the user base and variety of uses for interactive cartographic products further than ever before, and may some day even match the popularity of the printed map – accessible anywhere, anytime from a device that most people already carry on a daily basis.

In spite of their promise, a number of technological limitations and contextual considerations influence the effectiveness with which mLBS can communicate geospatial information to end users. Considering first the technology, despite continuing improvements to the handheld devices and wireless networks used to deliver mLBS applications, their capabilities will never truly compare to those of desktop computers and wired networks in terms of display (e.g. smaller screens), interaction (e.g. slower input controls) and performance (e.g. lower transmission rates). Combining this with limitations on the accuracy and availability of device positioning, and general issues with interoperability, mLBS are restricted in the amount of geospatial information that they can deliver, as well as the cartographic forms that can be employed for its representation. With respect to contextual parameters, here further constraints apply, with dynamically changing physical conditions (e.g. light levels, noise), the attentional demands of the surrounding environment and the social and cultural setting all impacting on the effectiveness of the cartographic representations conveyed by mLBS applications. Arguably having the greatest impact, however, are the characteristics of the end users, involving widely varying differences in preferences, abilities, goals, tasks and needs with respect to geospatial information access.

Being a largely commercial concept, early mLBS application development was predominantly supply-driven, with vendors focused on the underlying technology and its possibilities while rushing to deliver innovative products to new, mainly consumer markets. During this time, little attention was paid to the effectiveness of their cartographic communication, resulting in applications characterised by simplistic text and/or low-level map-like graphic representations which proved difficult to use and understand for their non-expert user base (potentially contributing to the initially slow uptake of mLBS products). Following increasing recognition of the aforementioned technological and contextual impacts, however, more recent focus has turned to the end users and, in particular, ensuring usefulness during the design of mLBS applications, including that of the techniques employed for representing, presenting and interacting with geospatial information within different contexts.

A major factor affecting system acceptance, usefulness is *made up of the concepts of utility – whether the system can perform the function(s) required by users to achieve their goals – and usability – the extent to which users can employ the system to achieve their goals with effectiveness, efficiency and satisfaction*. In more specific terms, the usefulness with which a user can access the geospatial information they require through a given mLBS application will impact on their ability to make geospatial decisions while mobile and, as a natural progression, their uptake of the product. The (non-expert) user population's lack of experience in dealing with cartographic representations, however, along with their diverse and ever-changing goals, tasks, needs and preferences for geospatial information, present particular challenges to ensuring the usefulness of mLBS applications. As a result, a need has been recognised for understanding the characteristics of, and differences between, users and their geospatial information needs, in order to address these during the design of mLBS applications and their component cartographic representations.

1.2 Problem Statement

The usefulness of applications for different users and varying use contexts is already a focus of mLBS research and development, attracting interest from cartographers and Human-Computer Interaction (HCI) designers alike. Thus far, however, efforts to specifically improve the usefulness with which geospatial information is communicated through mLBS applications have been limited. At one end of the scale, a number of HCI studies have concentrated on the design of the overall system structure for their focal mLBS applications, approaching issues of usefulness from a generic user interface (UI) point of view. Despite determining and catering to a range of user characteristics, information needs and usage contexts within the UI, though, very little emphasis has been placed on the delivery of the underlying geospatial information, leaving unanswered questions about the usefulness of the cartographic representation, presentation and interaction techniques employed. At the other end of the scale, much cartographic work has focused on the design and development of individual, isolated representation forms in support of a limited range of tasks – the vast majority involving maps to assist users' orientation and navigation. While the usability (and utility) of these representations has invariably been improved for their target users and tasks, and insights gained into their design for the mLBS medium, little knowledge has been sought/obtained here regarding the usefulness of the representations within the broader application context. In particular, the interplay between the cartographic representation, presentation and interaction techniques supporting different everyday geospatial tasks within the same 'cartographic UI' (i.e. *all components of a user interface specifically concerned with accessing and representing geospatial information*) has not yet been comprehensively investigated.

Related to this, a need is seen for determining the suitability of particular representation techniques for the contexts (i.e. users and tasks) they are intended to support, prior to their implementation. As opposed to current practice, whereby cartographic representations are chosen based on assumptions, convenience, technical feasibility and/or novelty, with efforts then made to improve their individual usability for the task at hand, this implies making informed selections of those techniques expected to offer particular utility for each context, **before** comprehensively evaluating and assessing their usefulness. Inherent in this is a so far unaddressed need to compare alternative techniques for representing, presenting and interacting with geospatial information through mLBS, in order to determine which provide the most usefulness in different contexts. In particular, there are a wide variety of representation techniques available within Cartography which may offer greater utility and usability to non-expert users beyond the maps commonly employed for this medium (e.g. diagrams, photographs, video, natural language, sound and touch). In order to establish this, however, it is necessary to have a comprehensive understanding of the end user, which is best achieved through taking a user-centred approach to mLBS application design.

User-Centred Design (UCD) is *a methodological approach to the development of useful computer systems which positions the end user as the focus of all design activities so that the final product is easy to use and ultimately meets their needs* and encompasses three basic principles: (1) an early focus on understanding users and their tasks; (2) empirical measurement of product usage by representative users; and (3) an iterative cycle of design and evaluation (Gould & Lewis 1985). This has already been successfully applied (to differing degrees) within mLBS applications research, including the aforementioned studies concerned with designing and evaluating the overall system structure and individual representation forms. Extending this, UCD offers additional promise for informing and evaluating the design of the complete cartographic UI for any given mLBS application, including comparisons of the relative usefulness of alternative cartographic representation, presentation and interaction techniques for multiple tasks. Furthermore, in contrast to alternative approaches (e.g. Activity Theory), particular value is seen in the involvement of real users throughout the UCD process, with the usefulness of the cartographic UI dependent upon its satisfaction of comprehensively established user needs, goals and tasks. Indeed, only by involving representative users during the design and evaluation of the UI can its usefulness truly be assured for those who will ultimately use it. This is especially important considering the predominantly non-expert user base anticipated for most mLBS applications.

Overall, a need is seen for taking a UCD approach to the design of the cartographic UI for mLBS applications, in order to produce models which can be applied during development to ensure a useful end product for non-expert users within different contexts. For the purposes of this research, such 'cartographic UI design models' are defined as *visual depictions (and accompanying descriptions) of the general functionality required for an application to support its users' geospatial goals, with specific detail incorporated regarding support for individual users and tasks, including alternative inputs, outputs and interaction flows and the cartographic representation, presentation and interaction techniques involved.*

1.3 Research Objectives

The overall aim of this research is to develop cartographic UI design models for the useful communication of geospatial information to non-expert users through mLBS applications.

Alongside this, a number of specific research objectives exist:

- To compare and evaluate alternative cartographic representation, presentation and interaction techniques for the mLBS medium.
- To trial and assess the effectiveness of a UCD methodology for improving the usefulness of mLBS applications.
- To make general recommendations for ensuring useful mLBS applications.

In satisfying these aims and objectives, the following key research questions are addressed, taking into account the nature of UCD, which requires concentration on a particular population of users, and therefore a specific mLBS application area, for which usefulness is assessed:

1. What geospatial information do users require from a specific mLBS application?
2. What geospatially-related user goals and tasks require support within a specific mLBS application?

3. What techniques for cartographic representation, presentation and interaction are/are not considered useful in the context of a specific mLBS application?
4. Can a UCD approach ensure the usefulness of geospatial information communication via a specific mLBS application?

1.4 Scope and Nature

1.4.1 Research Scope

Introduced above with respect to the research questions, this study documented within this thesis focused on the development of useful cartographic UI design models for a specific mLBS application area. For this purpose the area of domestic holiday-related (DHR) travel – defined as *travel within one's own country for tourism and/or leisure purposes* – was selected, with tourism being identified as a typical, everyday application of commercial interest to the research's industry partner (refer to Section 1.4.2). As such, it was not the aim of the research to produce a set of techniques for representing, presenting and interacting with geospatial information that can be applied to **any** given mLBS application. Indeed, such an undertaking would be impossible (at least for a project of this scale), considering the widely varying contexts within which mLBS technology has potential application – not least of which are the vast differences between user characteristics, interests, preferences, abilities, goals, tasks and geospatial information requirements present within individual target user populations. Further to this, it was also not the intention of the research to produce a fully functional DHR travel mLBS application. Instead it sought to provide more general guidance, at a conceptual level of design, for researchers and designers who are committed to developing useful cartographic UIs for mLBS applications, and at the same time offer specific value as a foundation for the design and development of tourism-based mLBS applications.

The research also did not attempt to address issues of usefulness for **all** possible user types and goals/tasks within the DHR travel application area, both of which were considered too vast to be encompassed by the available resources. Introduced in Section 1.1, the research aimed to develop cartographic UI design models for *non-expert* users of mLBS applications. As such, the final models are not intended to apply to geospatial information domain experts. Related to this, the involvement of a relatively small user population in the UCD process, coupled with the need to obtain an in-depth understanding of the individual user characteristics and usage contexts present, called for a qualitative approach to the research – involving *exploratory data collection methods and interpretive analytical techniques to produce outcomes grounded firmly in the experiences and perspectives of the user population* – as opposed to statistical procedures or other means of quantification. The implication here is that the design models cannot be readily generalised beyond the target user population, requiring at least some project-specific validation in order to do so. Looking then to the study's coverage of the target users' DHR travel goals/tasks, in keeping with the qualitative UCD approach, depth was favoured over breadth. In this respect, while a full set of goals and tasks was identified and incorporated within the overall structure of the final cartographic UI design models (comprising four goals and 11 tasks in total), only a sub-set of these (two goals and five tasks) were comprehensively elaborated within the detailed design models.

Finally, while seeking to compare alternative representation forms in order to determine those that offered the most usefulness for particular users and tasks, it was not the intention of this research to produce novel techniques not previously applied to the representation of geospatial information. Instead the study endeavoured to take a more practical approach, by focusing on currently available cartographic representation, presentation and interaction techniques that could feasibly be delivered using existing mLBS technology. In this respect, a number of specific boundaries were set by the prototyping technology selected to evaluate the design models and thus demonstrate the research – namely the XHTML-MP browser of an i-mate™ SP5 SmartPhone – which was chosen from the technology available to the research at the time of its conduct, as detailed in Section 7.3.4.

1.4.2 Nature of the Programme

From its outset, this research incorporated the efforts of team members from both Geospatial Science at RMIT University and Webraska Mobile Technologies, SA (hereon referred to as Webraska) – the collaboration being in accordance with the Australian Research Council (ARC) Linkage Grant supporting the programme. The main objectives of ARC grants are to:

- encourage excellent collaborative research within universities and across the innovation system;
- contribute to a strong knowledge economy;
- create opportunities for cooperation with related programmes across Commonwealth portfolios;
- facilitate international linkages both within universities and industry; and
- encourage industry oriented research training.

More specifically, ARC's Linkage-Projects are designed to support collaborative research projects between higher education researchers and industry with the additional aims:

- To encourage and develop long-term strategic research alliances between higher education institutions and industry in order to apply advanced knowledge to problems, or to provide opportunities to obtain national economic or social benefits.
- To support collaborative research on issues of benefit to regional and rural communities.
- To foster opportunities for postdoctoral researchers to pursue internationally competitive research in collaboration with industry, targeting those who have demonstrated a clear commitment to high quality research.
- To provide industry-oriented research training to prepare high-calibre postgraduate research students.
- To produce a national pool of world-class researchers to meet the needs of Australian industry.

Addressing these aims and objectives this research was conducted for the purpose of acquiring new knowledge towards the usefulness of cartographic UI design models for mLBS applications for both academia and industry.

1.5 Thesis Outline

Following this introductory chapter, the thesis begins by setting the scene for the research (Chapter 2). Here, the concept of mLBS is introduced along with the benefits offered for the communication of geospatial information over other, more traditional cartographic mediums. The range of technological limitations and contextual issues affecting the use of mLBS applications are also identified, leading to recognition of the need to move beyond technology-driven development and towards design processes focused on ensuring usefulness in the end product. As part of this, the importance of understanding the characteristics and geospatial information needs of a largely non-expert mLBS user base is also discussed.

In Chapter 3, the range of representation, presentation and interaction techniques available for communicating geospatial information are identified, with informed recommendations made regarding the relevance of each for the mLBS medium. Following this, an extensive literature review is undertaken, examining how recent user-focused mLBS research has approached issues of usefulness in the communication of geospatial information, including the cartographic representations employed and the methodologies followed for their design and evaluation. The benefits and limitations identified within this existing body of work serve to highlight a number of major themes requiring further investigation, each of which is addressed by the current study: the design of the entire cartographic UI for a given mLBS application; the comparison of alternative cartographic representation techniques for specific users and tasks; and the value of taking a user-centred approach to the design of useful mLBS applications.

Chapter 4 describes the qualitative UCD methodology chosen to guide the research activities. As part of this, the links between qualitative social research and methods for conducting UCD are identified. The general plan for the research is then set out comprising two major pre-design activities – user profiling and user task analysis – aimed at defining the potential usage contexts and user requirements for a mLBS application, followed by two phases of iterative design and evaluation intended to assess and improve usefulness in the end product. The chapter concludes with a discussion of the importance of optimising the credibility (i.e. accuracy and rigour) of the qualitative research results, while identifying methods to be applied in order to achieve this.

The first major phase of the research methodology – user profiling – is documented in Chapter 5, beginning with the selection of an application area and associated user group through which to focus the research (i.e. DHR travellers). Aimed at defining the characteristics of the target user population, the method chosen to collect the user profiling data was an online social survey/questionnaire, created specifically for the research and distributed to members of the user group. Qualitative analysis of the questionnaire results served to provide an emergent picture of the target user population, in the process generating a User Profile 'range' that comprehensively described the characteristics, use contexts and preferences to be addressed by the cartographic UI design models.

Augmenting the results of the user profiling, Chapter 6 describes the second phase of the research methodology: user task analysis. To gather data about users' travel-related goals, tasks, geospatial information requirements and usage environments, the method of Critical Incident interviews was selected and conducted with a small sample of users (focusing on their recent DHR travel events). In response to the ill-defined and open-ended nature of users' goals in tourism environments, a goal-driven approach was chosen to interpret and model the interview data. Several valuable results were generated throughout this process and directly input into the design model development, the most important being six goal-task models (describing the interrelationships between the users' goals, tasks and requirements), four user personas (representing the user types within the population) and five scenarios of use (describing typical usage episodes for the application).

Chapter 7 details the development of preliminary cartographic UI design models, developed directly from the user profiling and user task analysis results. Beginning with the definition of a set of qualitative usability goals and the compilation of relevant UI and cartographic design guidelines, all of which provided guidance for the design activities, a process of scenario-based design was undertaken. This involved the development of a basic structure for the design models, followed by the detailed design of functionality and components required for a sub-set of user goals/tasks – each ultimately incorporating alternative techniques for representing, presenting and interacting with the underlying geospatial information. The design itself was specified through a limited functionality prototype, which enabled the exploration of design ideas while embodying the design in a form that could be readily evaluated.

Completing the initial phase of iterative design and evaluation, Chapter 8 describes the process by which the preliminary design models were evaluated. To this end an informal method of empirical usability testing was planned and conducted, allowing a small sample of representative users to evaluate and compare the relative utility and usability of the various representation, presentation and interaction techniques on trial for each task. An interpretive analysis of the observational and verbal data collected during the evaluation sessions produced a comprehensive set of design recommendations for improving the usefulness of the design models, including specific suggestions for the removal of representation techniques seen to offer little utility and usability.

The second and final phase of the iterative design and evaluation is documented within Chapters 9 and 10, respectively. Again taking a scenario-driven approach, the design models and associated prototype were revised to: (a) address the recommendations generated by the preliminary design evaluation; (b) extend their detailed functionality to support a number of additional user tasks; and (c) incorporate further representation, presentation and interaction techniques for evaluation. More formal empirical usability testing was employed to evaluate the updated design models, again involving the collection of observational and verbal data from a small sample of representative users. Qualitative interpretation of the results served to highlight those representation techniques that were/were not considered useful in particular contexts, while a new set of recommendations for further improving the usefulness of the design models was generated.

The final results of the research are presented and analysed in Chapter 11. Addressing many of the design recommendations produced by the second evaluation, the primary result set comprises seven detailed cartographic UI design models for communicating useful geospatial information to the users of a DHR travel mLBS application, which are organised by an additional (high-level) model describing their interrelationships along with the overall UI structure. The second major result involves an assessment of the effectiveness of the UCD methodology employed to inform the design models' development, with respect to each phase of the research. As part of this, potential improvements to the methodology are proposed. Finally, a number of general recommendations are drawn from the research findings, intended to assist future researchers and developers seeking to design useful cartographic UIs for mLBS applications.

Chapter 12 presents the research conclusions along with recommendations for further investigation concerning the usefulness with which geospatial information is communicated to non-expert users through mLBS applications.

1.6 Chapter Summary

This chapter has provided context for the research, highlighting the need to improve the usefulness with which mLBS applications communicate geospatial information to non-expert users, incorporating a user-centred approach to the design of the entire cartographic UI. Additionally, the aim and objectives driving the research have been presented, along with its scope, nature and the overall thesis structure.

The following chapter sets the scene for the research by introducing and describing the major themes of geospatial information communication, mLBS and the need for designing applications with usefulness in mind.

2 Mobile LBS: Technology, Use and User Issues

2.1 Introduction

The identification and utilisation of a mobile user's location is of current interest to both wireless developers and cartographic researchers. Based on the communication of geospatially referenced information, rapid deployment of so-called 'Location-Based Services' has led to a range of applications containing cartographic representations that are widely available to general, non-expert user populations. It can be argued, however, that the utility and usability of Location-Based Services applications and, more importantly, their component cartographic representations has not been made a priority during development and thus their usefulness for communicating geospatial information cannot be assured. In this chapter the concept of mobile Location-Based Services is defined, including their evolution from, and amalgamation of, the various preceding cartographic communication mediums (Sections 2.2 and 2.3). The benefits and limitations of Location-Based Services for the communication of geospatial information are also discussed (Section 2.4), leading to the identification of a growing need to move away from technology-driven design towards a focus on users and issues of usefulness (Section 2.5).

2.2 Geospatial Information

2.2.1 Definition

Geospatial relationships are intrinsic qualities of everyday existence: they are the natural methods by which people understand and relate to their environment. The information involved can be described as 'pervasive' (Niedzwiadek 2002) with many common daily activities involving geospatial thinking: comprehending orientation and direction; perceiving distances and proximities; understanding reference frames (e.g. latitude/longitude); negotiating road networks; recognising landmark arrangements; and so on (Golledge 2003). But what exactly is geospatial information?

According to Peuquet (2002), *spatial data* refers to "any data concerning phenomena composed of elements that are distributed in two, three, or more dimensions" (p.229). But this is too broad a definition for the research since physical space can encompass anything, ranging from manipulable, small scales – such as objects on a table-top – through to very large scales – such as the world and the universe (Freundschuh & Egenhofer 1997). Egenhofer & Mark (1995) help to narrow the definition by identifying geographic space (i.e. *geospatial*) as large-scale space, which is beyond immediate human experience but can be directly experienced and perceived through combining multiple views of it (e.g. via navigation within the space). Essentially, it is "the space of the environment around us, the greater world in which we live" (Peuquet 2002, p.1). Inseparable from geographic space is a temporal aspect, whereby geographical entities are considered to be distributed over space *and* time (Egenhofer & Mark 1995). Raper *et al.* (2002) acknowledge this in their definition of geospatial information[1] as being characterised by spatial and temporal referencing. The following provides an illustration of what 'geospatial information' is, comprising a number of commonly used terms:

Space	location, position, place, where, here, there, how far, area, region, distance, orientation, direction, vicinity, landmark
Time	period, duration, events, past, present, future, when, then, now, minute, hour, day, week, month, year, itinerary

2.2.2 Communication mediums

It has been claimed that the representation and use of geospatial information influences most aspects of human life (Peuquet 2002). This prompts the question of how people access the geospatial information they require on a day-to-day basis. Here is where Cartography comes in, being the collection, analysis and communication of geospatial knowledge to users though a variety of representational techniques – most notably maps (Raisz 1948; Robinson *et al.* 1995). Since its recognition as a discipline, Cartography has continued to evolve, adopting and adapting theoretical, technological and artistic innovations and new mediums in order to improve the quality and distribution of its representations (Keates 1989; Robinson *et al.* 1995; Wood 2003). The brief overview that follows concentrates on the historical progression between the major mechanisms used by cartographers to communicate geospatial information (predominantly via maps) to users. A detailed treatment of the range of cartographic representation techniques available is provided in Chapter 3.

2.2.2.1 Paper and print

One of the earliest known physical maps, etched on a clay tablet, is of Mesopotamian origin and is dated around 2800 B.C. It is believed to depict the location of a landowner's estate (Raisz 1962). While the medium may have changed, this idea of simultaneously storing and presenting geospatial information using a single instrument, has endured. Indeed for centuries, paper-based maps have been *the* dominant symbol of Cartography (Wood 2003). Originally created and reproduced through painstaking manual techniques, paper-based maps grew so much in their importance to society that it was only a matter of time before methods were developed for

[1] Peuquet (2002) distinguishes between the terms information and data, recognising that data "are characteristically raw observations that have been remembered or recorded in some way", whilst information is "data that are ordered and contextualized in ways that give them meaning", with information generally separating "important" data from that considered "unimportant" to the problem at hand (p.52).

automating their production, thereby increasing the speed, efficiency, quality and quantity of map output while reducing the costs (Robinson *et al.* 1995; Keates 1989; Peterson 2007). The first such advances were mechanical, resulting from the development of the printing press and movable type in the mid 15th century. Following this, progress in optical and then photo-chemical technologies (from the 16th century) enabled developments such as lithography and photography, which were quickly adopted for the compilation, printing and reproduction of paper-based maps (Robinson *et al.* 1995). The most recent (and ongoing) technological advance to affect Cartography, however, was electronics – specifically digital computing – which began to take hold in the early 1950s. In terms of the paper-based medium, this enabled the conversion of two dimensional analogue maps into digital form, further increasing the speed at which maps could be created and printed (Wood 2003; Keates 1989). Even with all of these advances, however, the printed map remained limited as a form of cartographic communication. Not only were these abstractions of reality passive (i.e. there was "nothing beyond the printed image"), they also became outdated as soon as they were printed (Fuhrmann & Kuhn 1999; Wood 2003, p.113; Brown *et al.* 2001).

2.2.2.2 Digital databases

A further advance attributed to digital computing vastly improved the situation. In the 1960s, much effort was put into investigating computer-aided techniques for exploring and analysing geospatial data and information – eventually resulting in the development of Geographic Information Systems (GIS) (Wood 2003). The databases underlying early GIS became an important medium for storing geospatial information, while printed maps (themselves ultimately based on database management systems) continued to provide the representation component (MacEachren & Kraak 2001; Wood 2003). As the technology progressed, GIS became known for their sophisticated integration of geospatial data acquisition (input and storage), manipulation (statistical and analytical processing) and presentation (retrieval and output) (Barkowski & Freksa 1997; Peuquet 2002). Today, many GIS-supported systems employ the map as their user interface (UI) which "(if well designed) can support productive information access and knowledge construction activities", while retaining "its traditional role as a presentation device" (MacEachren & Kraak 2001, p.4). Overall, GIS demonstrated major advantages over the printed medium, most notably: (1) the "preservation of correct knowledge" (Barkowski & Freksa 1997, p.348-9) – all maps are, by definition, distortions of reality (Monmonier 1991), however GIS databases store and provide access to all of the underlying geospatial information, regardless of their use/non-use within a given representation; and (2) the ability to readily produce alternative views of the stored information (Keates 1989).

2.2.2.3 Multimedia

One limitation of GIS as a mechanism for geospatial information communication was that the computer screen lacked the graphical spatial resolutions (dots per unit area) supported by the paper medium (Peterson 2007). Additional advances in computing technology during the 1980s enabled the development of alternative methods of geospatial information presentation which reduced the affect of this and related problems. 'Multimedia' became a household word, applied to both computing interfaces and discrete storage media. Multimedia Cartography soon followed, referring to the combination of maps with different visual and audio media (text, speech, images, animation, video, etc.) to represent geospatial information in digital environments. This allowed for double encoding of information, interactivity and the use of complementary information to produce more realistic and intuitive representations of geographic space, support knowledge construction and ultimately ensure efficient communication and dissemination of the underlying data (Buziek 1999; Cartwright & Peterson 2007). Moreover, the introduction of dynamism and the ability to interact with the representations meant that the 'map' was no longer a static instrument, being able to better convey the dynamic nature of the world, and that the geospatial communication process was no longer unidirectional between the cartographer and the user, through increased user control over the information display (Fuhrmann & Kuhn 1998; Peterson 2007). Geographical Visualization, an important application and extension of Multimedia Cartography, further advanced the representation of geospatial information through the application of Scientific Visualization theory, which promoted geospatial communication and *thinking* for both individual (private) and collaborative (public) use (Cartwright *et al.* 2004; MacEachren 1994).

2.2.2.4 Distributed computer networks

Alongside these more recent advances, equivalent developments were being made into distribution techniques. The aforementioned introduction of optical media with increasing storage capacities (videodiscs, CD-ROM, DVD-ROM), introduced a beneficial alternative to paper for the publication of geospatial information (Cartwright 2007). A revolution occurred, however, with the introduction of distributed networks, in particular the Internet and the World Wide Web (Web) – the Web being an interactive, multimedia-based interface for the Internet. Through the Internet and the Web, geospatial products based on maps, GIS, Multimedia Cartography and geographical visualization could be distributed and used in near real-time, which was a vast improvement over the days, weeks, months and even years it once took to create and deliver paper-based map products (Peterson 2007; Cartwright *et al.* 2004). Perhaps the greatest impact of this technology, however, has been the associated increase in the audience for geospatial information – consider that the growth rate of Internet map use, which has been strongly exponential since 1997, now exceeds the growth rate of even the Internet itself (Peterson

2003b). Where previously computer-based cartographic representations were the domain of the geospatial scientist and professional, the combination of the Web and Multimedia Cartography (in particular) has created "a more conducive map use environment" which provides access for, and has consequently attracted, a wide variety of new users (Peterson 2003a, p.443). This includes so called 'non-expert' users, or those people who are untrained in the use of geospatial information and representation tools (including maps) and who are discovering new needs for access to such on a day-to-day basis. It is such users who form the focus of the major research activities detailed in this thesis (see Section 2.5.3).

2.2.3 Mobility

When viewed in terms of usage environments, the progression of the cartographic communication mediums signalled further change. While paper- and print-based maps were always (and continue to be) relatively lightweight and easily transportable to wherever they are needed (e.g. on a ship, in a car, out walking), GIS and multimedia-based representations introduced the need for access to sophisticated computing hardware to ensure an optimal user experience. Similarly, Internet-based Cartography concentrated on theory and applications relating to geospatial information services delivered via stationary, desktop computers and wired Internet connections, neither of which are readily portable. Although the advent of portable laptop computers and wireless networks increased the mobility of these representations (Goodchild 2005), they were still not as convenient as the paper map, thus limiting their use – particularly for non-expert users with day-to-day needs. Things began to change in the early 1990s, however, with the development of increasingly sophisticated handheld computing devices that are today far superior to their desktop counterparts in terms of mobility (refer to Table 2.1).

Table 2.1 Comparison of mobility-related factors for handheld devices and desktop computers (Weiss 2002).

Characteristic	Handheld device	Desktop computer
Form factor	Can be used standing up; usually held in one hand	Must be seated; requires a table for operation
Size	Typically fits into a shirt pocket	Takes up over half a typical desk space
Weight	Measured in grams (typically less than 250g)	Measured in kilograms
Components	Generally all-in-one (may require a stylus for input)	Usually requires a monitor and input devices (e.g. keyboard, mouse)
Cables	Power cable for recharging only	Cables for component connection (newer systems may be wireless)

One of the first examples of a handheld digital cartographic product, *iGo*, was accessed on a modified Apple Newton (circa 1994) and employed interactivity and multimedia to guide visitors through a museum exhibit space, in a non-linear fashion (Amirian 2001). This and similar applications produced around that time were constrained, however, by a lack of location awareness (limiting the delivery of contextual information) and network connectivity (impacting on the currency of information, which had to be stored on the device), as well as a reliance on customised devices (reducing the accessibility of the services). Further technological advances led Broadbent & Marti (1997, p.88) to discuss the potential of integrating "hand-held computing with wireless communication and positioning technologies", with the aim being to produce a truly mobile, multimedia experience for the communication of real-time, dynamic geospatial information anywhere, at any time, to anyone. Today this is a reality.

2.3 Mobile Location-Based Services

The term 'Location-Based Services' first appeared in the literature around 1999, differentiating information systems that use contextual geospatial information – in particular location and time – as filters for data querying and presentation. This new medium of geospatial information delivery and communication emerged as a result of advances in, and the convergence of, wireless telecommunications, Internet-enabled mobile devices, positioning technologies and GIS capabilities (Koeppel 2000). Since their beginnings, Location-Based Services, also variably known as 'location services', 'wireless location services' and 'context-aware systems', have amassed a number of definitions, ranging from very simple to relatively complex:

> *"a set of new applications that utilise the geographic position of a mobile device."* (McCabe 1999);
>
> *"services accessible with mobile devices through the mobile network and utilizing the ability to make use of the location of the terminals."* (Virrantaus et al. 2001, p.66);
>
> *"Location Services = f (GIS + Internet + Wireless)"* (Niedzwiadek 2002);
>
> *"any service or application that extends spatial information processing, or GIS capabilities, to end users via the Internet and/or wireless network"* (Koeppel 2000);
>
> *"concerned with supporting dynamic spatial decision making through the provision of real-time, geographically based information."* (Smith et al. 2004, p.25).

As illustrated by the first three quotes, most of the available literature uses the expression 'Location-Based Services' to describe geographically related services/applications accessed over *wireless* telecommunication networks on highly *mobile* devices. While this is an acceptable use of the term, it is important to emphasise that the concept of Location-Based Services is not limited to being 'wireless' and 'mobile'. A wide variety of Location-Based Services applications can in fact be accessed using *stationary* (eg. desktop, laptop) computing devices, across *wired* distribution networks – as highlighted by Koeppel (2000). Keeping this in mind, the scope of the current research has itself been limited to wireless, mobile Location-Based Services, which from hereon will be referred to as 'mLBS'. The following is a more refined working definition of mLBS for the research, which draws on their intended functionality (based in part on Golledge 2001):

> mLBS are wireless services which use the mobile Internet, along with the location of a portable, handheld device, to deliver personalised applications that exploit pertinent geospatial information about a user's surrounding environment, their proximity to other entities in space (e.g. people, places), and/or distant entities (e.g. future destinations), in real-time.

2.3.1 Enabling technologies

In general, mLBS rely on: knowledge about a user's location; access to relevant infrastructure, data and applications for turning the location into useful geospatial information; devices for making requests and conveying location-based information to the user; and timely transmission of data between the user and service provider(s). There are numerous technological components involved in satisfying these requirements, with the key technologies illustrated in Figure 2.1 and elaborated below.

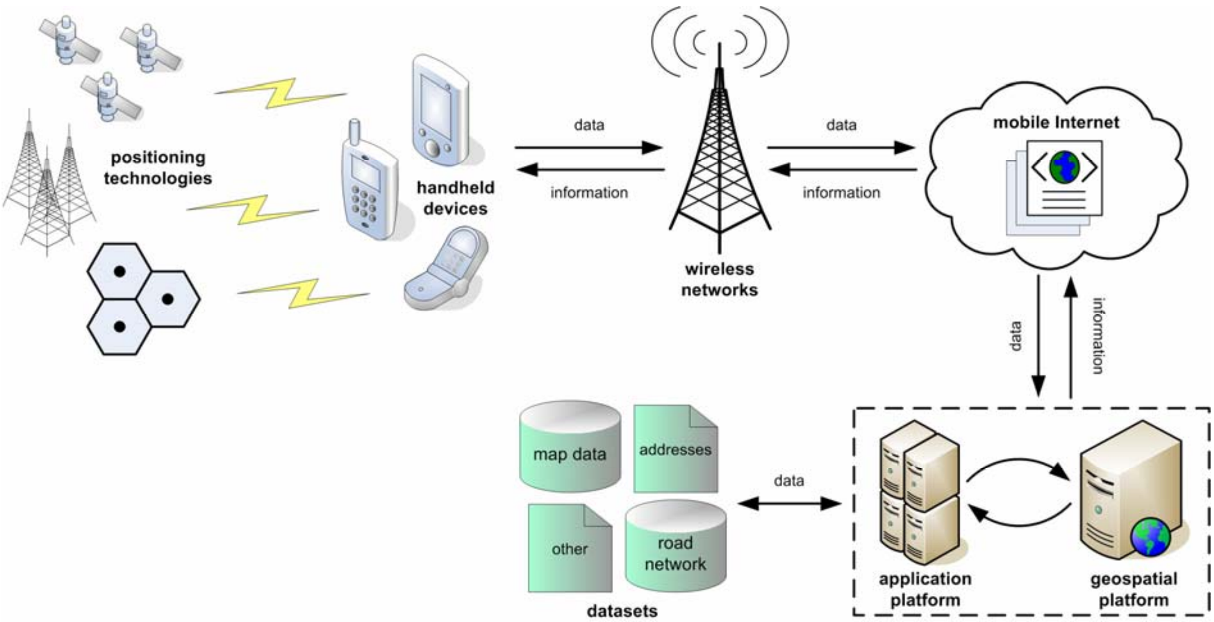

Figure 2.1 A simplified overview of the technological architecture underlying mLBS. The position of the user's handheld device is obtained via one of several positioning technologies. This data is then transmitted through the mobile Internet, across a wireless network, to a geospatial platform where it is processed into a location, along with other geospatial content. An application platform then integrates the data (i.e. producing information), before serving it back to the user's handheld device via the mobile Internet and wireless network.

2.3.1.1 Locating the user

Determining the location[2] of a user, or perhaps more correctly the position[3] of the device a user is carrying, is fundamental to the operation of mLBS (Gartner & Uhlirz 2005). It provides the contextual information required to answer queries such as 'where am I?' and 'how do I get to

[2] Location – "an identifiable place in the real world"; e.g. an address, description, postcode, phone number, landmark, etc. (Davies 2004).

[3] Position – "the coordinates … that represent a place on the earth"; e.g. latitude, longitude (Davies 2004).

…?'. A number of techniques currently exist for positioning handheld devices, which are classified as either network-based, handset-centric or hybrid. A fourth category, less common in today's mLBS, is user-defined positioning. Before the advent of automatically locatable handsets, early mLBS required manual entry by the user of their location in the form of a street name, city or postcode (Mitchell & Whitmore 2002), which could be extremely accurate, depending on the user's knowledge about their current location, but was clumsy and time consuming. The focus here is on those techniques which developed from a desire to dynamically and rapidly position the user. Table 2.2 lists the most common positioning methods, along with their accuracies and examples of mLBS applications for which each is appropriate. This information and the following discussion were compiled from a number of sources (Mitchell & Whitmore 2002; Zeimpekis *et al.* 2002; Mountain & Raper 2000; Andersson 2000; ETSI 2001; Zlatanova & Verbree 2003).

Table 2.2 Relative accuracies and potential applications for common mLBS positioning techniques.

Technique	Positioning accuracy	Example applications
Network-based		
CGI / CGI-TA	100m – 2km (up to 10m for micro-cells)	Proximity services (e.g. what's nearby?)
UL-TOA	50–150m	Roadside assistance
Handset-centric		
GPS	Around 10m	Driving/walking directions
E-OTD	125–200m	Proximity services
Hybrid		
A-GPS	1–10m	Tracking (people, vehicles)

Network-based positioning solutions are those which utilise the terrestrial wireless network infrastructure supporting mobile phone communications to return a handset position. Any given wireless radio network (Section 2.3.1.4) comprises a number of base stations, each of which covers an area known as a 'cell'. The simplest network-based technique is 'cell global identity' (CGI) which determines an approximate position for the handset based on proximity to the base station of the cell within which it is located. Accuracy is determined by cell size, and is therefore poorer in rural areas (compared with urban areas) where base station density is low. CGI is often accompanied by timing advance (TA) information – the time between the transmission and arrival of data – which can improve positional accuracy. The benefit of these techniques is that no additional network infrastructure is required. In contrast, the uplink time of arrival (UL-TOA) method requires the installation of location measurement units (LMUs) at almost all base stations in the network. This technique measures the difference in the time of arrival of a known signal (sent from the handset) at three or more base stations/LMUs. Hyperbolic calculations are performed on the data by a dedicated server within the network to determine the handset's position.

While no handset modifications are required for network-based positioning, handset-centric techniques require additional hardware and/or software to be installed on the device. Used by vehicle navigation systems and dedicated handheld devices for some time, the Global Positioning System (GPS) is one of the best known and most accurate positioning technologies available for mLBS. Position determination operates via a GPS receiver either embedded as a chip within the handset or else linked to the handset via a Bluetooth®[4] or other connection (i.e. as a separate device), which receives navigation messages transmitted from three or more GPS satellites and processes them to compute the position of the handset. Although this technique is widely available, it suffers from the need for direct line-of-sight between the handset and satellites, making it unsuitable for positioning in urban environments (where signals are blocked by buildings, tunnels, etc.) and indoors – although indoor GPS is maturing (Zeimpekis *et al.* 2002; van Diggelen 2002). A second handset-centric technique, similar to the network-based UL-TOA, is known as enhanced observed time difference (E-OTD). Here, the handset calculates its position based on measurements of the time difference between synchronised signals sent from three or more network base stations (of known location). This technique requires additional software installed on the handset to 'listen' for the signals and to perform the positioning calculations (it may also need additional infrastructure within the network, such as fixed GPS receivers, to determine base station positions); however a clear view of the sky is not necessary.

Hybrid techniques combine network and handset positioning to overcome their respective limitations and thus improve the accuracy of derived positions. The best known of these is Network-Assisted GPS (A-GPS). Here, LMUs incorporating fixed GPS receivers are installed within the network every 200-400km. The information gathered is used to augment timing measurements (from GPS satellites) collected by the handset, with position calculations then performed by a server within the network. In this way the handset is not required to decode the GPS information, thus reducing calculation time while increasing GPS coverage.

Overall, the choice of technique for positioning mLBS handsets comes down to a trade-off between cost (to users and/or network carriers), availability (different networks/devices/ locations support different techniques) and accuracy (the importance of which is dependent on the application). The improvement of each of these factors has been a driving force for the

[4] Bluetooth is a specification for short-range wireless (radio) personal area networks, providing a means for connecting and exchanging information between devices such as PDAs, mobile phones, laptops and printers.

development of the above techniques, with many of the resulting advances linked to one or both of the following:

- In the U.S. a 1996 regulatory push by the Federal Communications Commission mandated that at least 67% of wireless callers to emergency services must be locatable to within 125m by October 2001 (Koeppel 2000; Finney & Williams 2001). As a result of delays, the deadlines for the rules, known collectively as E-911 (Enhanced 911), were pushed back, with total carrier compliance still outstanding (FCC 2006).
- In the European Union the motivation has been commercial, based on a desire to capitalise on the potential of providing location-sensitive services to enterprise and consumers (Andersson 2000; Mountain & Raper 2000). In addition, a European equivalent to E-911 has been introduced, known as E-112, however this contains no mandate on accuracy or technology requirements (Warrior et al. 2003).

In Australia the driving forces for mobile positioning are, as in Europe, largely commercial, however the Australian Communications and Media Authority has highlighted a future need for "highly accurate location information to enhance the emergency call service" (Australian Communications Authority 2004, p.3). They recommend that Australia should delay taking a regulatory approach and allow time for the supporting technologies to mature, whilst encouraging industry to drive the development and deployment of suitable location techniques.

2.3.1.2 Geospatial information processing

The approximation of a mobile user's location does not on its own amount to a service. It is the processing of position information, along with other geospatial content, that adds value to mLBS applications. The geospatial functions utilised by mLBS are essentially the same as many of those underlying traditional GIS, however where GIS applications bundle them into an integrated, closed framework, mLBS employ them as separate, often interlinked components (Niedzwiadek 2002; Mapflow 2002). The reason for the difference lies in the purpose of each system type: GIS are designed for detailed geospatial data analysis, with only secondary concern for performance issues; conversely, mLBS – as real-time offerings – are required to execute geospatial calculations in minimal time and deliver compact, meaningful information while maximising performance (Quirion 2001). Some of the more common functions provided by the geospatial platforms underlying mLBS are described in Table 2.3.

Vital to the operation of these and other mLBS functions is access to geospatial and geospatially-enabled content, generally contained within compact file formats (as opposed to bulky relational databases). This includes both static and dynamic (real-time) information such as: *(static)* base map data, road networks, landmarks, addresses, route models, Points of Interest (POIs), yellow pages (e.g. businesses); and *(dynamic)* traffic, weather and road works (Niedzwiadek 2002; Mapflow 2002; Quirion 2001). An application platform controls the business logic of a mLBS, obtaining the user's position from the device/network and integrating this with the geospatial content, delivering and presenting the end result to the user (Mitchell & Whitmore 2002). For examples of potential mLBS applications, refer to Section 2.3.2.

Table 2.3 Functions of a geospatial platform (Mapflow 2002; Quirion 2001; Peng & Tsou 2003).

Function	Description
Geocoding	Conversion of text-based address information (i.e. street, suburb and/or state) into position coordinates (latitude and longitude).
Reverse geocoding	Conversion of position coordinates (e.g. of a handset) into a text-based description/address for that location; may return a list of possible descriptors from which the user can select the most precise (i.e. location refinement).
Geospatial search	Use of a geospatial engine to support the querying of entities based on their proximity to a given location (along with their name, type, etc.); e.g. finding nearby businesses or POIs.
Routing	Provision of detailed, turn-by-turn, guidance instructions (e.g. in text or map format) between two points; may take into account road networks, mode of transport and traffic.
Map rendering	Generation and display of a map of a given location, including pertinent geospatial features.

2.3.1.3 Interaction / presentation devices

A user's request for geospatial information and its subsequent communication by an mLBS application is enabled by a third key category of enabling technologies. Discussed above with respect to user positioning, the devices used to access mLBS applications perform an additional, yet equally important role as mechanisms for information input and output. Today, a multitude of handheld devices[5] are available, which can be generally divided into the following categories (distinguished largely by their form factor):

- **Tablet computers**[6] – consist of a large touch screen; operate similarly to desktop/laptop computers (i.e. preferred use is on a desk or table), but are generally lighter; e.g. Fujitsu Stylistic®, Motion Computing LE-Series.
- **Palmtop (clamshell) computers**[6] – similar in design to laptop computers (but with specialised functionality); much smaller and more lightweight than a tablet, often fitting into a large pocket or purse; can be operated in one hand, but for prolonged use, resting on a flat surface is preferable e.g. Psion Revo, HP Jornada.

[5] An additional class of mLBS 'device', which is outside the scope of the research, concerns wearable computers whereby "the computer is contained in the user's clothing, and the input and output devices interact with the normal motions and senses of the human body, including normal vision" (Clarke 2001, p.1482).

[6] These devices are less commonly employed for commercial mLBS, compared with PDAs, mobile phones and SmartPhones.

- **Personal Digital Assistants (PDAs)** – handheld personal information management (PIM) tools incorporating address books, calendars, email, Web browsing, desktop synchronisation, native applications, etc.; smaller than a palmtop, but generally larger and heavier than a mobile phone; whilst traditionally data-centric, today's PDAs often have voice capabilities, thus enabling mobile phone-type communication; e.g. Palm series, i-mate K-JAM, Mio A701.
- **(Basic) mobile phones** – used primarily for voice communication, contact management and short message services (SMS); highly compact and lightweight; those suitable for mLBS must be enabled for the mobile Internet (see Section 2.3.1.4); e.g. Nokia, LG, Samsung, Motorola models.
- **SmartPhones** – advanced mobile phones incorporating PDA-type computing functions (e.g. PIM); early models were larger and heavier than mobile phones, but today are more comparable; smaller and lighter than PDAs; e.g. BlackBerry 8700g, i-mate SP5, Nokia 6110 Navigator.
- **Custom-built hardware**[6] – of varying form and functionality; designed and built for specific purposes; may be largely fixed in place (e.g. vehicle navigation systems).

(Source: canalys.com 2004; Gorlenko & Merrick 2003; Peng & Tsou 2003; Weiss 2002)

Between and within the above categories of handheld devices, there are widely varying techniques for user interaction and information presentation. Beginning with the former, the possibilities for data input are especially vast, including: **keypads** – mobile phones, SmartPhones; **touch sensitive screens** with **virtual keyboards/handwriting recognition** – tablets, PDAs, some SmartPhones; **physical keyboards** – palmtops, some PDAs, some SmartPhones; and **voice recognition** – mobile phones, SmartPhones, some PDAs. Furthermore, specific navigational controls may also be present (i.e. for scrolling, selection and action), including: **labelled buttons** (e.g. physical buttons above the keypad on a mobile phone); **soft keys** (physical buttons which relate to changeable labels immediately above them on the screen); **directional keypads**; **rocker controls**; **roller wheels;** and, again, **touch screens** (Weiss 2002).

In terms of information output, this is where the multimedia capabilities of handheld devices (or lack thereof) are revealed. Each type of device invariably has some form of visual display – i.e. screen – with a range of dimensions, resolutions and capabilities available. In general, mobile phones have the smallest, most limited visual displays, followed by SmartPhones, then PDAs. Palmtop and tablet computer screens are generally larger again, and more sophisticated – with the latter akin to a desktop computer. Whilst older mobile phone screens are commonly monochrome, with text-based displays of four to six lines (12-20 characters per line), newer models have higher resolutions (e.g. 100×80 pixels, or eight lines) – often with 256-colour displays – and support images, video and animation. As the next generation in mobile phones, SmartPhones have display resolutions typically in the realm of 160×160 to 240×320 pixels, with up to 16-bit colour. They generally have the same image, video and animation capabilities as newer mobile phones, with the addition of touch screens in some cases. PDAs are similar to SmartPhones, however these have long offered display resolutions of 240×320 (with newer models up to 480×640), 16-bit colour, and support for graphics, video and animation (Quirion 2001; Weiss 2002).

Audio output is also a feature of many devices, particularly mobile phones, SmartPhones and voice-centric PDAs which each offer voice communication. In addition, audio players (hardware and software) embedded within/attached to these and other devices enable the output of a variety of speech and non-speech sounds (Brewster & Murray 2000; Weiss 2002). Further adding to their multimedia capabilities, some devices even enable the user's sense of touch to be utilised as a form of information output. The most obvious example of this is the use of vibration by mobile phones to alert the user to an incoming call or message. Perhaps the most powerful feature of some of the handheld devices available for mLBS, however, is the presence of an operating system (OS) on the device, providing a development environment within which native mLBS applications can be created, making optimal use of the available multimedia and interactivity features. This applies primarily to tablets, palmtops, PDAs and SmartPhones with examples being: Palm OS, Microsoft Windows CE, Symbian OS and Java Platform (see Section 7.3.4.1 for further discussion of these).

2.3.1.4 Information transmission

The determination of a user's position, its processing into useful geospatial information and the interactive presentation of the results would not be possible without a means by which the various information are transferred between the different parts of the system. This brings us to a concept known as the *mobile Internet* which, as the name suggests, refers to the transmission of data via the Internet to, from and within mobile environments.

Essential to the delivery and functioning of mLBS, the mobile Internet relies on two main elements. The first was introduced briefly in Section 2.3.1.1 and comprises terrestrial wireless mobile phone radio networks which serve the often dual roles of transmitting data to/from a handset and positioning the user[7]. There are numerous standards in use today for these digital

[7] There are other wireless connection networks available, many with faster transfer rates, however these are not yet in general use by mLBS. Examples include:

mobile radio networks – a result of independent efforts around the globe – and they continue to evolve. Second generation (2G) networks[8] were the first to offer data transmission in addition to voice and are today represented by the Global System for Mobile Communications (GSM) and Time Division Multiple Access (TDMA) standards. With their 'circuit-switched' connections, however, these are characterised by extremely slow data transmission rates (Figure 2.2), and it was not long before improvements were made (Peng & Tsou 2003). Considered an interim solution, 2.5G standards such as the General Packet Radio Service (GPRS) and Enhanced Data Rates for Global Evolution (EDGE) are upgrades to 2G networks. These were the first to introduce 'packet-switching', whereby the handset is continuously connected to the network enabling immediate transfer of data packets without the need to 'dial up' to the service. This vastly improved the speed of the data transmission and reduced the cost to the user (who now pays for data, not time), resulting in an overall boost to mobile Internet usage (Mountain & Raper 2000; Ramsdale 2000). Currently emerging are 3G technologies, which can provide significantly higher data transmission rates and, as such, enable high-quality multimedia applications (including graphics, video, audio, etc.) in addition to standard voice services (Peng & Tsou 2003; Gartner & Uhlirz 2002). Examples of 3G standards are cdma2000 (an extension of the Code Division Multiple Access standard) and W-CDMA (Wideband CDMA).

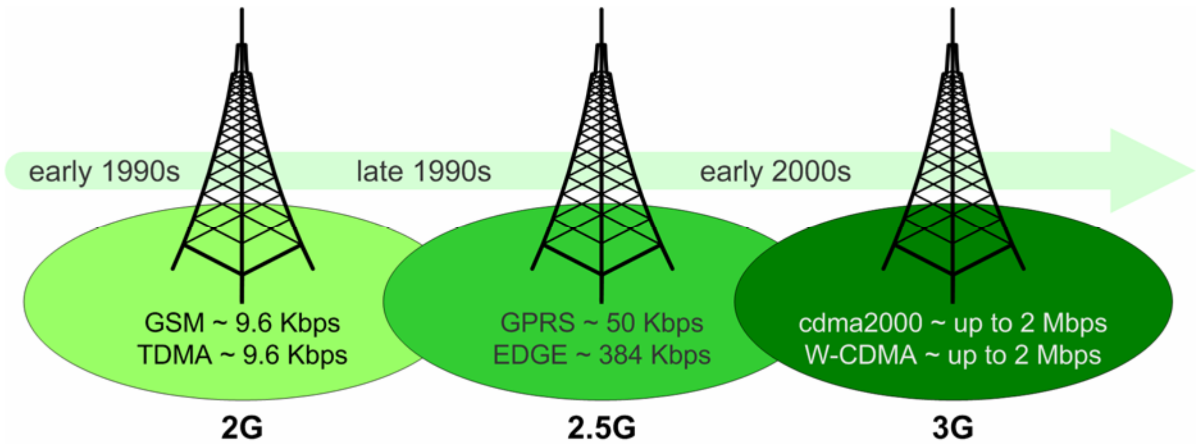

Figure 2.2 The progression and average throughput of various wireless data transfer standards, measured in bits per second (Computerworld 2005; PC Magazine 2005).

The second major component supporting the mobile Internet involves data protocols, which are responsible for the 'correct' transmission of data between the client-side (devices) and the server-side (in the case of mLBS, the geospatial and application platforms). There are a number of

- Wireless Local Area Networks (WLANs) – radio-based networks which connect users within small coverage areas (10-100m). The network backbone is generally wired, incorporating wireless access points for connecting mobile users; and
- Wi-Fi (Wireless Fidelity) – the common name for the family of IEEE 802.11 standards. Allows mobile users to connect compatible devices to WLANs (e.g. for Internet access) whilst within the coverage area of a wireless access point (hotspot).

[8] So named because they immediately followed the voice-only, first generation analogue networks.

different proprietary and open standards developed specifically for the mobile Internet, with the main differences being in the way that the data is organised and transferred (Li & Liu 2001). Whilst each is independent of the aforementioned wireless radio networks, they are not all mutually compatible (Peng & Tsou 2003). Furthermore, in order to receive information and build applications using a given data protocol – and thus access the mobile Internet – a device must be enabled for that protocol (i.e. 'Internet-enabled'), with some devices supporting more than one. The following are some of the most common data protocols in use for mLBS development and delivery today:

- **WAP** – Wireless Application Protocol; a set of open protocols introduced in the 1990s, originally maintained by the WAP Forum and now the responsibility of the Open Mobile Alliance (OMA); designed by the wireless industry to optimise mobile Internet access for small displays and slow network transmission rates; uses WML (Wireless Markup Language) for content development – a subset of XML (eXtensible Markup Language) based on HDML (Handheld Device Markup Language), which requires much less bandwidth and processing power than HTML and offers more flexibility within the mobile technology environment; whilst early versions were text-based, today's WAP supports multimedia content (Peng & Tsou 2003; Weiss 2002; Li & Liu 2001).
- **i-mode** – a highly successful mobile data communication service created by Japan's NTT DoCoMo in 1999; data connections are packet-switched; content is built using cHTML (compact HyperText Markup Language) – a subset of HTML, making the transfer of content between the wired Web and the mobile Internet a relatively simple matter; offers Internet-based services such as email, online shopping and restaurant guides; supports text, images and graphics (Peng & Tsou 2003; Weiss 2002; Li & Liu 2001).
- **XHTML Mobile Profile (XHTML-MP)** – a hypertext document type definition, or authoring language, defined by the OMA specifically for resource-constrained Web clients that do not support the full set of XHTML features (e.g. mobile phones, PDAs, pagers); derived from XHTML Basic, which is a specialised 'light' version XHTML – the successor to HTML (OMA 2006).
- **SMS** – Short Message Service; a technical standard originally designed for the transfer of short, text-based messages between handsets on the GSM network (available today on most networks); a low cost option for delivering data to mobile devices; does not support graphics or images (Li & Liu 2001; Weiss 2002).
- **MMS** – Multimedia Messaging Service; an 'evolution' of SMS which provides for the transfer of longer text-based messages and multimedia content; delivery of messages is via WAP; supports text, graphics, audio and video (Weiss 2002; Mapflow 2002).

- **GML** – Geography Markup Language; specified by the Open Geospatial Consortium (OGC – formerly the OpenGIS Consortium) in 2000; "an XML encoding for the modeling, transport and storage of geographic information including the spatial and non-spatial properties of geographic features" (OGC 2007a); claimed as critical to the evolution of mLBS (Lake 2001).

2.3.2 Applications

In closing, it is useful to provide a categorisation of the various mLBS applications that are enabled by the above technologies. There are numerous methods for doing so, and indeed limitless application possibilities, with two quite different groupings included here. Perhaps the most common classification divides mLBS applications into the categories 'Pull' and 'Push' (Jiang 2006): while *pull* refers to those applications that provide information when/if requested (i.e. pulled) by the user; based on the location of the mobile device, *push* encompasses applications that automatically trigger (or push) events/information based on the position of the device (i.e. without the user making an explicit request). Examples of each type are (adapted from Koeppel 2000):

Pull services

- Travel Directions (routing) – "I am here, how do I get there?"
- Taxi Hailing – "I need a taxi here now."
- Mobile Yellow Pages (directories) – "Where is my nearest ...?"
- Instant Information (context) – "Provide information on this landmark."

Push services[9]

- Mobile Advertisements (target marketing) & Buying Services (m-commerce) – "Notify me when I am near a supplier carrying the item I need"; may include incentives such as discount coupons.
- Friend/Buddy Finders – notification when friends are nearby.
- Traffic Alerts – notification of the current status of a pre-determined route.
- Zone Alerts – includes tracking of people and vehicles.

Evident from even these few examples, mLBS applications incorporate diverse sets of geospatial (and other) data and appeal to a wide variety of users, ranging from consumers to private industry, governments and the military (Niedzwiadek 2002; Cosgrove 2002). As a result, numerous end products are possible, which comprise the second categorisation of mLBS applications (shown in Table 2.4), classified according to the types of geospatial information utilised/presented and the class of user.

[9] Generally provided on an 'opt-in' basis.

Table 2.4 Examples of applications driven by mLBS (adapted from Niedzwiadek 2002).

Types of Geospatial Information	Applications		
	Consumer	Business	Government
Positions	Where am I?	Contact nearest field service personnel	Location-sensitive reporting
Events	Nearest theatre playing the movie I want to see?	Local training announcements	Local public announcements
Distributions	House hunting in low density area	Sales patterns	Per capita open space
Assets	Where is my mobile phone?	Status of utility field devices	Where are the street sweepers?
Service Points	Where are the sales?	Targeted advertising	New zoning
Routes	How do I get to …?	Taxi dispatch	Emergency dispatch
Context	Show me the nearest…	Nearby competitors	Local commerce
Directories	Where can I buy …?	Best supplier within 50km	Public services
Transactions	Must purchase in a specific location	Location-sensitive billing	Location-sensitive tolls
Sites	Tourist attractions to visit	Candidate store sites	Environmental monitoring stations

2.4 Success Factors for mLBS

As early as 1996, Webraska pioneered the vision that mLBS "would open new markets and revenue streams for large wireless service providers" (Webraska 2002). Indeed, when mLBS applications first appeared in the commercial market, their growing popularity led to mLBS being deemed the long-awaited 'killer application' of wireless data services (Hamai 2001). By this measure, it was expected that users would willingly pay a premium for use of the services, thus providing a strong return on investment to the telecommunications operators who had already outlaid vast amounts of money on infrastructure for the imminent 3G mobile networks. This in turn led observers like McCabe (1999) to declare that mLBS would succeed due to their capacity for simultaneously serving both consumers and network operators. In 2002, however, Sweeney identified that mLBS had not lived up to expectations, citing that operators were hesitant to support location services due to a perceived lack of demand and profit. Furthermore, he claimed that the provision of location capabilities was seen as an additional and unjustifiable expense (Sweeney 2002).

Despite this, the future appears bright for mLBS, with market predictions (Jiang 2006) and independent studies revealing a growing demand worldwide. Specific research includes a June 2002 IDC survey that showed that emergency assistance, navigation and concierge services were considered the most important mobile phone uses amongst US consumers, taking precedence over wireless e-mail, news alerts and interactive games (Wrolstad 2002). A similar study by

Ericsson Australia aimed to identify what Australian consumers sought from the mobile services of the future, and uncovered an extremely high level of interest in mLBS, specifically emergency location and mapping services (Australian Communications Authority 2002). Ultimately, however, the success of any mLBS lies in the value it offers to users – particularly with respect to providing safety, convenience and/or saving time and money (Quirion 2001; McCabe 1999) – and a large part of this rests on the effectiveness of the representations used to communicate the relevant geospatial information. This section introduces those factors which impact on the value of mLBS as a medium for delivering and communicating geospatial information.

2.4.1 Benefits over traditional mechanisms

As we have seen, mLBS embody a merging of the preceding cartographic mediums – paper/printed maps, handheld computing, desktop computing and the desktop Web – combining advantages from each in order to support users' day-to-day geospatial decision-making (Figure 2.3). Looking at the benefits they offer in turn, first and foremost is the true mobility of the devices and networks underlying mLBS, which provide users with a greater degree of physical freedom over desktop/wired systems and thus make them equally as convenient to use as paper maps; i.e. "easily portable and can be consulted anywhere" (Brown *et al.* 2001, p.61). Second, whilst mLBS will never match the ability of paper maps to support high visual resolutions, they do have the potential to offer alternative and user-specific views of the data, and thus (potentially) better communicate the geospatial information, through the incorporation of Multimedia Cartography and, in particular, interactivity (Peterson 2007). Third, the GIS data processing capabilities of mLBS provide tools for manipulating the underlying geospatial content and combining it with relevant non-geospatial information, to answer users' questions and thus provide them with a 'service' (Koeppel 2000; Niedzwiadek 2002).

Fourth, where real-time positioning of the user is available, location can be added to other contextual parameters (see Section 2.4.3) and incorporated into the mLBS query, tailoring the resulting representations to the user's current situation and thus improving communication of the geospatial information. Fifth, connection to the mobile Internet ensures that not only are the geospatial and other information disseminated by mLBS as current and as accurate as the original sources (avoiding the out-datedness inherent in static data storage), it also facilitates their rapid delivery and wide-ranging distribution. Following on from this is the final benefit whereby, like distributed desktop computing services before them, mLBS have the potential to bring geospatial information to even more people – many of whom will be non-expert, everyday consumers (Peterson 2007). Of course mLBS are only suitable for those users and uses that are likely to benefit from any/all of the above factors; e.g. a highly mobile user with an immediate need for geospatial information relating to their environment, who has limited time to spend searching for that information and does not require a detailed map presentation. In other situations (e.g. modelling geospatial distributions; geographical visualization), mLBS will likely not be appropriate at all.

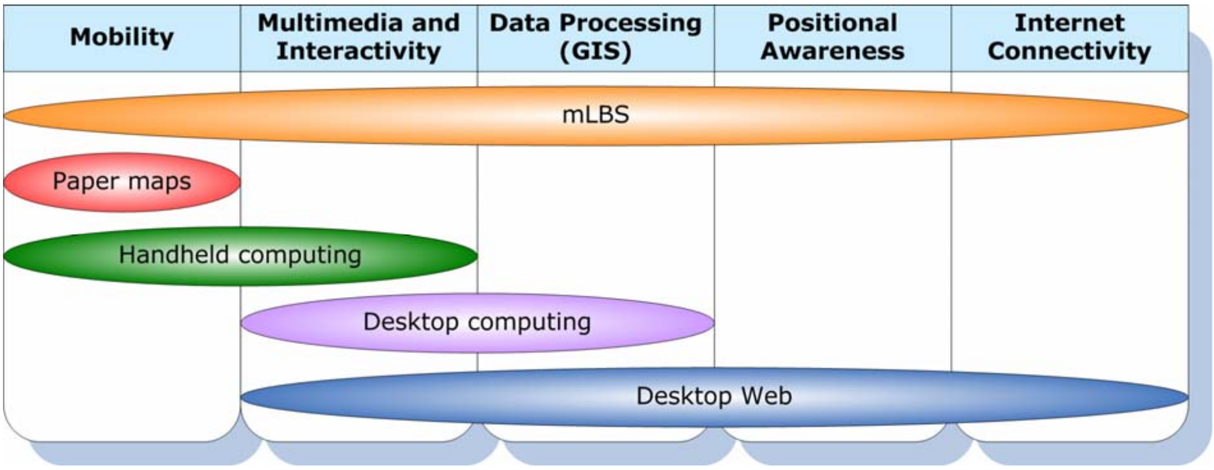

Figure 2.3 The benefits of other geospatial information communication mediums, which are shared by mLBS.

2.4.2 Limitations of the technology

Despite such promise, a number of technological factors currently restrict the effectiveness of geospatial information delivery and communication through mLBS applications. This refers to inherent limitations within the devices, networks and positioning techniques underlying mLBS operation, as well as issues of interoperability. Perhaps the most obvious limitation involves the small screen sizes of handheld devices which, although improving all the time (Hassin 2003; Gartner & Uhlirz 2005), are characterised by limited display areas, resolutions and colour ranges in comparison with desktop computers. As identified in Section 2.3.1.3, the screen of a typical PDA (and newer SmartPhones) measures 240×320 pixels and supports 16-bit colour. This is much lower than a desktop computer with average screens supporting resolutions larger than 800×600 pixels and 32-bit colour. Faring even worse are mobile phones, whose screens have resolutions around 100×80 pixels with only 256 colours (Weiss 2002). The resulting 'screen real estate' restrictions pose implications concerning how much geospatial information can be visually communicated to a mobile user (exacerbated by their device type) at any one time (Yue *et al.* 2005), and the need to ensure that the limited amount of information presented is pertinent and useful to the user (Holtzblatt 2005; Helyar 2002b; Jiang 2006). Furthermore, the type of media used within the visual display is impacted, with the effectiveness of (static and dynamic) graphical representations, such as maps, diminished through poor resolutions and insufficient colours (Quirion 2001).

A second device-related limitation centres on user interaction with the mLBS application and the information communicated. This concerns both input and output capabilities. Dealing first with the former, the small size of handheld devices means that desktop-type input methods such as keyboards and mice are generally absent, being replaced with various slower and less accurate controls – e.g. small keypads, touch screens/styli and/or voice recognition (Weiss 2002; Sandnes 2005). This impacts on the overall effectiveness of the user input, potentially leading to high error rates – particularly during character entry and/or for inexperienced users. Output capabilities are also restricted (mentioned above in relation to screen displays), with early mLBS applications comprising simplistic text and/or low-level, often black and white, graphics which were difficult to use and understand (e.g. Figure 2.4a). Fortunately, improvements in screen and device technology have meant that current devices are more sophisticated, often providing true multimodal output, incorporating audio (voice, sound), visual (text, graphics, animation, video) and/or haptic (vibration) techniques (e.g. Figure 2.4b). Additionally, the mobile development environments featured in many new devices provide for the creation of custom applications. Through these, mLBS can take advantage of the device's individual multimedia and interactivity features to deliver mature applications. Unfortunately, however, screen size remains a limiting factor (Goodchild 2005; Gartner & Uhlirz 2005).

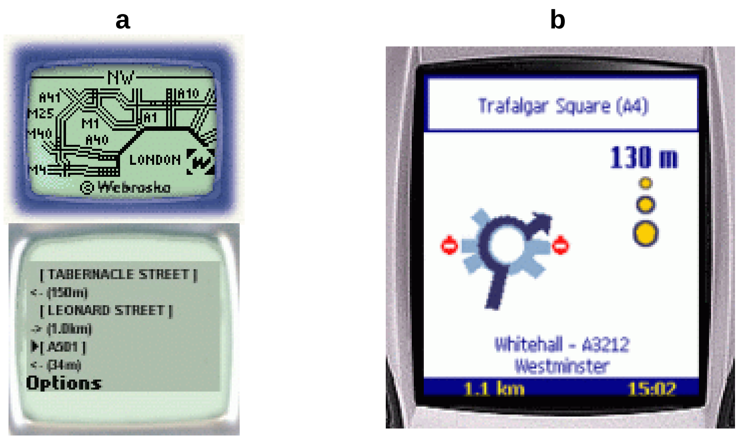

Figure 2.4 Examples of representations in (a) an early mLBS and (b) a more recent offering (images reproduced with permission of Webraska).

The next set of constraints concerns both the devices and the underlying wireless radio networks. Of the wide range of devices used to access mLBS applications, many (particularly mobile phones) are characterised by slow CPUs, minimal processing power, limited memory and relatively short battery lives (Lee & Benbasat 2003; Billsus *et al.* 2002; Passani 2002; Helyar 2002b). Considering that performance is critical for mLBS (Quirion 2001) and that the processing of geospatial content can be intensive, it is therefore not practical to put mLBS applications (processing and content) wholly onto the device – i.e. in a stand-alone client architecture. Indeed, even if the device is able to accommodate the storage and processing requirements, its subsequently high rate of power consumption would likely diminish the service's operation (Hassin 2003) and require frequent recharging, which is unsuitable for (and difficult during) prolonged mobile use[10]. This situation has led to much of the geospatial content and processing for mLBS being shifted to servers within the network (Weiss 2002), under a client-server, distributed client-server or service architecture (Hassin 2003).

Placing the functionality within the network is not without its problems, however, since the networks in common use today (2G and 2.5G) suffer from restricted transmission rates – i.e. low bandwidths and high latencies – which can make supposedly 'time-critical' mLBS applications unresponsive and cumbersome and limits the amount and form of geospatial information that can be delivered to a device within a reasonable period of time (Meng 2001a). A related issue concerns network coverage often being intermittent, unreliable and sparse, particularly outside metropolitan regions in countries like Australia. The implications of this are twofold: first is the impact on user access to the functions (including positioning) and data stored on the server when a network connection becomes unavailable, and second is the inequity in land and population coverage with users in 'uncovered' regions unable to access the services altogether (Hassin 2003; Quirion 2001). Essentially, until the faster, more reliable, multimedia-capable 3G wireless radio networks are able to provide widespread, equitable coverage, mLBS applications will not realise their full potential as a rich means of geospatial information communication.

The availability and accuracy of suitable positioning techniques is a further limitation to mLBS, being impacted by the network infrastructure and/or the device features at hand. Not all networks and devices have the necessary location capabilities built in, leading to either additional expenditure by the user and/or carrier, where existing techniques are insufficient for a specific application, or else misleading representations of the user's location within the service. It is important to reiterate, however, that the positional accuracies required will vary according to an application's purpose (Table 2.2) and so the related technology limitations only apply where a higher level of accuracy is required than that which is currently attainable. A final set of limitations relates to issues of interoperability – i.e. how all of the mLBS components work together. This is largely constrained by the range of proprietary mLBS platforms and protocols currently in use to communicate geospatial information, with the OGC maintaining that the success of mLBS will ultimately depend on "consistent [integration] … across different providers, technology platforms, application domains, classes of products, and national regions"

[10] Additionally, data currency is an issue where it is stored solely on the device, requiring users to be educated on managing data updates or else risk making decisions based on outdated information.

(OGC 2007c). A number of efforts have been made toward ensuring interoperability in mLBS, including:

- **OpenGIS® Location Service (OpenLS) Implementation Specification** – as a functional area of the OGC, the OpenLS Testbed was devoted to specifying standard interfaces and protocols for easy integration of geospatial data and processing into mLBS, telecommunications and Internet infrastructure (OGC 2007c). The resulting platform (GeoMobility Server) supports five core services: Directory (Search), Gateway, Location Utility (Geocoder/Reverse Geocoder), (Map) Presentation and Route (OGC 2007b). The Gateway Service is based on the Mobile Location Protocol (see next point) and provides an interface between the mLBS and handset positioning infrastructure (Wilbrink 2004).
- **Mobile Location Protocol (MLP)** – now under the umbrella of the OMA, the Location Inter-operability Forum specified the MLP as an application-level protocol for querying the position of a mobile handset, independent of the underlying network infrastructure (Wilbrink 2004). The MLP enables five different types of 'location services': Standard Location Immediate Service, Emergency Location Immediate Service, Standard Location Reporting Service, Emergency Location Reporting Service, Triggered Location Reporting Service (OMA 2005).

While these specifications are intended to become standard, until they (and others) have been widely adopted by service providers, wireless carriers, developers and data providers, mLBS applications will continue to suffer from problems of interoperability, impacting on their delivery and communication of geospatial information and ultimately their acceptance by users.

2.4.3 Contextual considerations

Aside from technological restrictions – many of which will undoubtedly improve over time – there are a number of issues related to the always changing mobile context of use which additionally affect the communication of geospatial information through mLBS applications. As a general rule, mobile users have limited time, are hurried and often need to make 'on-the-spot' decisions (Reichenbacher 2003), making it important to present only information of genuine interest to their current context, in an effective way (Coschurba *et al.* 2001; Helyar 2002b; Meng & Reichenbacher 2005). This is in direct contrast to users of stationary desktop (and similar) systems, who generally have more time to spend 'browsing' through extensive information (Weiss 2002). It is such contextual differences that require alternative approaches to the design of applications for the two mediums, with the inappropriateness of applying traditional cartographic principles and employing representations designed specifically for the desktop medium within mobile applications recognised (Jiang 2006; Sarjakoski & Nivala 2005).

Before continuing, it is important to establish that the inter-dependent dimensions of *context* shown in Figure 2.5 (and discussed below) represent just one interpretation of the term, which is in this case specific to the research. There are in fact many other, quite valid understandings of context, put forward by researchers in a wide range of fields, not least in the realm of context-aware computing (Schmidt *et al.* 1999; Abowd & Mynatt 2000; Dix *et al.* 2000; Dey 2001; Graham & Kjeldskov 2003; Nivala & Sarjakoski 2003; Reichenbacher 2004).

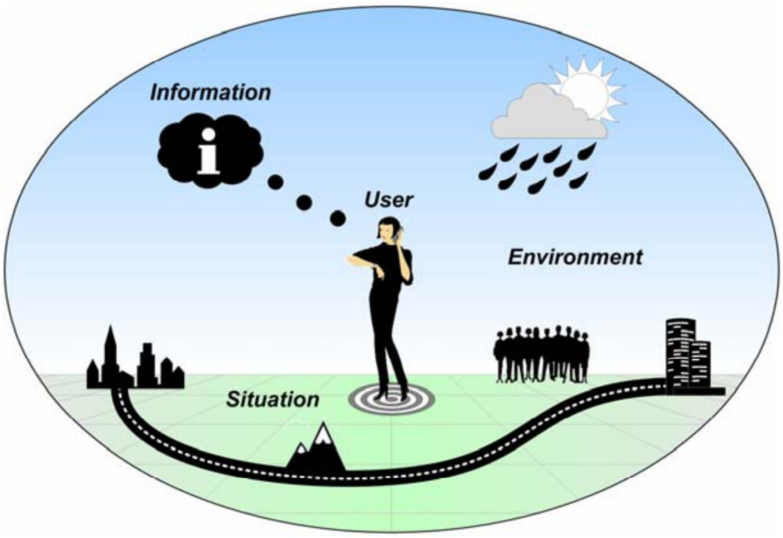

Figure 2.5 The contextual dimensions of mLBS for the research.

Arguably the most fundamental aspect of context for mLBS applications, **situation** incorporates both the user's location (current, historical and future) and time. Knowledge about location, in particular, was the impetus behind the first context-aware computing systems[11] – i.e. "to adapt applications to people's whereabouts" (Schmidt *et al.* 1999, p.894). Closely related to situation is the user's **environment**, which is made up of physical factors, such as conditions (e.g. weather) and nearby objects, as well as the social and cultural setting. A third dimension concerns the individual characteristics of the **user** including their goals, tasks, preferences and abilities, while a final, cross-cutting consideration is the availability, accuracy, quality and currency of the **information** required by the user, as well as how it is represented.

Incorporating the user's dynamically changing situation is the purpose of mLBS and is a major factor differentiating this from other geospatial information communication mediums (Nivala & Sarjakoski 2003). By using location and time as input/search parameters mLBS applications can provide, in real-time, value-added functionality and information that is tailored (and thus relevant) to the user's past, present and/or future situation (Kjeldskov 2002). Examples of this include: showing a lost user their location on a map; providing the addresses of nearby banks that

[11] Context-aware computing refers to the investigation of mobile services which "utilise contextual information, such as location, display medium and user profile, in order to provide tailored functionality" (Cheverst *et al.* 2000, p.17).

are open; finding a restaurant near the user's destination and booking this to coincide with their arrival; guiding the user along a pre-defined route, updating the estimated time of arrival along the way and re-routing them when they deviate from the path; and using historical locations to determine when a user is stationary, providing more detailed information about the surrounding area accordingly. While such situational representations have the potential to enable more informed decisions and actions on the part of the user (Mapflow 2002), in reality there are constraints on their effectiveness which relate not only to technological factors (e.g. data transmission rates, network coverage, positioning accuracy), but importantly to the geospatial and other information available. As with most geospatial systems, the use of mLBS applications suffers where the underlying content is of poor quality, inaccurate, outdated and/or simply unavailable, leading to diminished user faith in the service. Moreover, as Jiang (2006) identifies, "the existing geospatial data infrastructure is not particularly suitable for [m]LBS applications" having been designed for access using large-screen, stationary devices with greater storage capacities. Unfortunately, this state of affairs is an ongoing problem in mLBS with non-standardised data collection and maintenance being the responsibility of numerous, disparate organisations, even within the same application domain (Davies 2004).

The need to provide information about what is 'around' a user's location (e.g. landmarks, other people) is only one part of the environmental context dimension affecting mLBS. In addition to their changeable surroundings, a mobile user's situation is also subject to constantly changing conditions within the physical environment, such as variable weather, temperature, light levels and background noise (Kaasinen 2003). Such factors need to be catered for by a system to ensure effective information communication – e.g. the device should be weather-proof and able to be operated in a range of temperatures, pressures, etc.; adaptive screen brightness, text size and colours can be used to contend with different levels of lighting (e.g. day-time vs. night-time); alternatives to audio input/output techniques may be offered for use in noisy environments; etc. (Nivala & Sarjakoski 2003). A third environmental component concerns user safety while using mLBS applications. Naturally, the mobile user's primary task is not the operation of the service and, as Lumsden & Brewster (2003) identify, when mLBS applications are used the user's primary visual attention must remain with their surrounds, rather than the device, so that they can move safely through their environment. Both Kjeldskov (2002) and Yue *et al.* (2005) see this as a significant consideration affecting the amount of information that should be presented to the user and the level of explicit interaction required of them, since small, cluttered displays and high interaction frequencies place considerable demands on a user's attention. Looking finally to the social and cultural setting of the user's environment, issues arise in two respects. First is whether an mLBS application caters to appropriate cultural conventions (e.g. symbols, colours, language, address formats (Nivala & Sarjakoski 2003)), which can vary even between users in similar locations. The second concerns the presence of other people in the user's immediate environment, which impacts on the appropriateness of certain interaction techniques – such as voice or gestural input/output (Lumsden & Brewster 2003) – as well as protection of the user's privacy.

Integral to the effective communication of geospatial information via mLBS applications are the users themselves. Each individual user has his/her own identity, including personal preferences for the presentation of geospatial information and physical and cognitive/perceptual abilities with its access and interpretation (Nivala & Sarjakoski 2003; Meng 2001b). These factors may be harnessed by mLBS through profiles (either user-defined or modelled on behaviour) which, when combined with a user's situation, can enable personalised applications through their employment as filters for information search and presentation (Mountain & Raper 2000). An additional factor is the importance and difficulty of understanding the user's purpose for accessing a given mLBS application (Nivala & Sarjakoski 2003), since goals will vary between users and use contexts, requiring different sets of geospatial (and other) information as well as alternative representations. Caution must be exercised, however, in constraining the information presentation by pre-empting user goals in specific contexts, particularly when incorrect determinations of context (e.g. poor positioning accuracy) are a genuine possibility (Cheverst *et al.* 2001). Closely connected to the user's goals are their tasks and actions, which also vary with context. By identifying their tasks, users' related geospatial information needs may be better understood (Meng 2001b) and thereby addressed by the system. Furthermore, appropriate representations may be matched to each task in order to improve the effectiveness of the information communication process – although research in this area remains immature (as discussed in Chapter 3).

2.5 Use and User Issues

> *"In order to develop suitable concepts for visualising geographical spatial information, new and developing media need to be critically assessed, not only in terms of their technological potential, but also with respect to their ability to represent spatial information in a readily accessible format."* (Dickmann 2005, p.44)

A recurring theme throughout the previous section, the *user* plays a pivotal role in the success of any mLBS application, since it is they who originally create demand for a service and also they who ultimately choose to adopt or reject it, based on their usage experience. Despite this, the majority of mLBS applications currently available, and more importantly the cartographic representations employed, have been largely supply- and/or technology-driven (Reichenbacher 2004), with developers capitalising on improvements in the underlying technology without equal consideration for the users and their use contexts (particularly their individual goals, expectations and requirements for geospatial information communication). This situation mimics the shift from map use research to investigating the technical aspects of map production observed in the broader field of Cartography during the 1980s and 1990s (van Elzakker 2005; Meng 2003). It may be argued, however, that while such 'technology-driven design' is important in a research and development sense (Goodchild 2005) – without it cartographers may not have produced many of the innovations and concepts in common use today – it should not be employed in isolation[12]. Indeed, the need for supplemental attention to use and user issues for the design of information systems has been long recognised by many industries, most notably in the field of Human-Computer Interaction (HCI) (Gould & Lewis 1985; Nielsen 1993; Mayhew 1999).

Cartographers, too, are becoming aware of this growing research need (MacEachren & Kraak 2001; Slocum *et al.* 2001; Meng 2003), although efforts thus far have been limited to pure map use research and the evaluation of supply-driven geovisualization and multimedia map displays, in both cases rarely involving 'real' users (see van Elzakker 2005 for examples). The next step, therefore, is to broaden the cartographic research scope to include, among other things, comprehensive investigations of "the characteristics and information needs of the user and the usability of the hardware and software involved", including the *cartographic communication interfaces* (van Elzakker & Wealands 2007, p.488). Such an outlook is particularly important for mLBS considering their unique technological and contextual constraints. Joining the ranks of others in the field who have begun to recognise a similar need (Reichenbacher 2004; Meng 2005b; Jiang 2006), the research thus advocates and pursues a complementary approach to the technology-driven design activities which have characterised (and were arguably appropriate for) the early development of mLBS applications. This involves a focus on users and, more specifically, ensuring *usefulness* in the communication of geospatial information by mLBS applications, through user-centred application design – a methodology that is increasingly supported by mobile Internet developers and researchers as a way of designing products that meet users' needs and expectations (Ramsay & Nielsen 2000; Helyar 2002a). The following sections conclude the chapter by explaining the concept of usefulness in the context of mLBS, geospatial information experience and human geospatial cognition.

2.5.1 MLBS usefulness

Usefulness is a major dimension of system acceptability and for the purposes of this study was taken to be "the issue of whether the system can be used to achieve some desired goal" (Nielsen 1993, p.24). It is made up of two complementary concepts: utility and usability (Grudin 1992).

[12] The limitations of technology-driven design and development are illustrated by the overwhelming failure of the first-generation WAP services, with studies uncovering numerous usability problems leading to their ultimate rejection by users (Ramsay & Nielsen 2000; Helyar 2002b).

Utility concerns whether a system can perform the function(s) required by a user to achieve their goals (Nielsen 1993). Thus, by understanding what it is that the user needs or wants to do, and designing a product to address this, utility may (at least theoretically) be readily accomplished. Usability is perhaps more difficult to achieve, relating to:

"… the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use, where:

- *Effectiveness is the accuracy and completeness with which users achieve specified goals;*
- *Efficiency concerns the resources expended in relation to the accuracy and completeness with which users achieve goals; and*
- *Satisfaction relates to freedom from discomfort, and positive attitudes toward the use of the product."*

(ISO 9241-11: Guidance on usability)

Nielsen (1993) augments this with his definition of usability, incorporating: *learnability* – how quickly the user can begin to achieve 'work' with the system; *efficiency* – relating to productivity during system use; *memorability* – to cater for causal / infrequent use; *errors* – regarding rates, significance and recoverability; and *satisfaction* – how pleasing users find the system to use (Figure 2.6). The major usability problems facing mobile systems like mLBS applications include: diverse use activities; diverse usage contexts; changing users; distracted users; heterogeneity of devices; and interaction restrictions (Reichenbacher 2004).

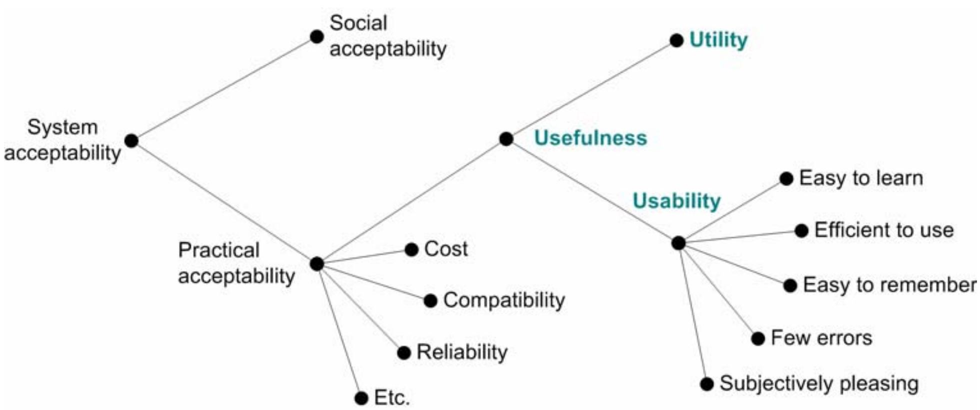

Figure 2.6 Attributes of system acceptability (redrawn from Nielsen 1993).

On the whole, it is evident that utility and usability in the eyes of the user are of paramount importance to the acceptance of mLBS applications: if the user cannot use a system to (a) achieve their goals, and (b) do so with efficiency, effectiveness and satisfaction, they will be unlikely to adopt it.

2.5.2 Geospatial experience and information usefulness

Alluded to in Section 2.2.2.4, there are essentially two types of end user for geospatial information systems: experts and non-experts. Whilst an additional definition (specific to the research products) is given in Section 5.2.5, here the differentiation of the user categories relates to opposing levels of experience and knowledge with respect to geospatial information and/or the systems themselves (McGuinness 1994). Expert users are therefore 'professionals' who quickly develop advanced skills through the use of specialised systems and/or those who possess *a priori* capabilities in the interpretation and analysis of the component geospatial information; for example a climatologist studying global climate change models (Cartwright *et al.* 2001). Non-expert users on the other hand, are 'novices' who commonly lack specific knowledge and training for dealing with geospatial information (Wachowicz *et al.* 2002; McGuinness 1994) and require systems for more 'everyday' purposes – e.g. route planning, weather checking, historical/ geographical education, etc. (Peuquet 2002).

The cartographic field has observed that geospatial information is becoming increasingly available to the general public in more diverse and tangible forms (Fuhrmann & Kuhn 1998; Peterson 2007; Cartwright *et al.* 2001; Quirion 2001; Wachowicz *et al.* 2002), which includes its delivery and communication through mLBS (Reichenbacher 2005a; Meng 2005b). Indeed, it is widely acknowledged that mLBS applications will be of most benefit as decision-support tools for "the public at large", constituting a market of non-expert consumers (Virrantaus *et al.* 2001, p.69; Rainio 2001; Jiang 2006). It is for these reasons that the current research is focused on ensuring useful cartographic communication via mLBS for *non-expert users*. This 'narrowed' scope is not without its challenges, however, with vast differences in geospatial information knowledge and use within the general population presenting difficulties for communicating the same information to every user (Buziek 1999; Montello & Freundschuh 2005).

2.5.3 Geospatial knowledge and cognition

> *"Cognition of geographic information deals with human perception, memory, reasoning, problem-solving, and communication involving earth phenomena and their representation as geospatial information."* (Montello & Freundschuh 2005)

Human beings naturally form cognitive maps – mental representations, or sets of such – of the geospatial arrangement of phenomena in their surrounding environment (Montello & Freundschuh 2005). An individual's unique cognitive map is contingent on their *geospatial knowledge* of the environment, with varying categorisations for this provided in the literature (Stern & Leiser 1988; Mark 1993; Peuquet 2002; Montello & Freundschuh 2005). Arguably the most common classification describes the progression of geospatial knowledge through three main stages: landmark, route and survey (Figure 2.7). *Landmark knowledge* exists when discrete landscape features can be recognised, but without knowledge of their relative positions in space. Over time, increased familiarity allows the individual to accumulate *route knowledge* through recognition of the connections, or travel sequences, between known landmarks; however they still possess little knowledge of the geospatial relations among different routes and landmarks. The final level is *survey* or *plan knowledge* whereby the individual has acquired an integrated and comprehensive view of how landmarks, routes and other features in the environment interrelate (i.e. preservation of geospatial relationships). Note, however, that a person's geospatial knowledge is "by definition incomplete", never corresponding "precisely with one of the three discrete levels" shown in Figure 2.7 but rather existing somewhere along the continuum (Gould 1989, p.444).

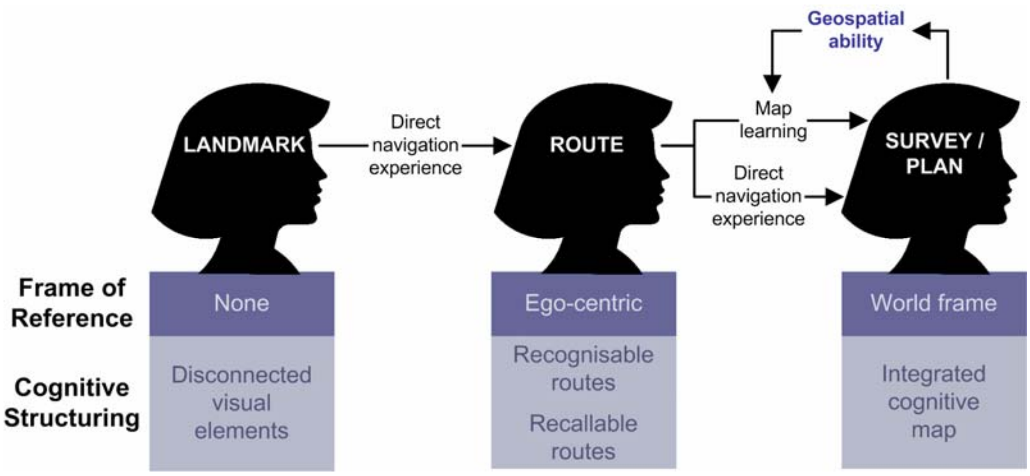

Figure 2.7 The progression and characteristics of geospatial knowledge (redrawn from Stern & Leiser 1988).

Clearly it is not innate to be a competent geospatial thinker, with humans developing strategies over time for spatial reasoning (Golledge 2003). It stands to reason then that individuals possess varying levels of geospatial knowledge, not only in comparison with one another, but also within themselves, at different times and in different environments (e.g. familiar vs. unfamiliar locations). Closely related to this, variable cognitive processes and mental representations are employed for (a) different geospatial tasks undertaken by an individual, and (b) the same geospatial task undertaken by separate individuals (Mark 1993; Peuquet 2002); where geospatial tasks may be cognitive (e.g. visualising a route) or physical (e.g. navigating a route). Understanding how humans conceptualise the physical world comprises a major field of study, receiving contributions from widely varying disciplines such as Behavioural Geography, Cartography, Urban Planning and sub-fields of Research Psychology (Montello & Freundschuh 2005). Whilst it is not the intention of this research to focus on human geospatial cognition, it recognises the importance of considering cognitive differences when designing UIs that are intended to communicate geospatial information to a broad range of non-expert users in a useful manner. Of most relevance are the users' cognition-related needs for different geospatial information and representations of such, depending on their knowledge, abilities, preferences and tasks (Meng & Reichenbacher 2005).

2.6 Chapter Summary

This chapter has set the scene for the research, introducing its major themes of geospatial information communication, mLBS and the need for designing applications with usefulness in mind. The box below summarises the main points that were discussed, altogether addressing the questions: (1) how can mLBS improve the communication of geospatial information over more traditional delivery mechanisms? and (2) what factors impact the ability to communicate geospatial information via mLBS? Overall it may be concluded that if a given mLBS application is not considered useful and is therefore not adopted by its end users, it will have failed not only as a commercial product but more importantly in its communication of geospatial information. Being focused on the latter, this research specifically aims at investigating the usefulness of cartographic communication techniques employed within mLBS applications. The following chapter provides a comprehensive overview of existing user-focused research into, and techniques for, geospatial information representation within mLBS and related mobile systems, identifying gaps where they appear and thus defining the scope for the research.

- Geospatial information is an essential and often intangible aspect of everyday life.
- Over time, the communication of geospatial information has progressed through several delivery mediums, beginning with paper and print-based maps and advancing through digital (GIS) databases, Multimedia Cartography and geographical visualization, distributed computer networks (Internet, Web) and handheld computing.
- MLBS are a relatively new delivery medium for cartographic communication, having been enabled by the combination of technological advances in dynamic user positioning, geospatial information processing, handheld presentation devices and wireless radio networks.
- MLBS applications are widespread and can be variously categorised as either 'push' or 'pull', or else according to the geospatial information they employ and the particular class of end user.
- There are numerous benefits of mLBS over other mediums for cartographic communication, particularly in their blend of high mobility, multimedia and interactivity, GIS processing, positional awareness and mobile Internet connectivity, as well as their expansion of the audience for geospatial information.
- The technological limitations impacting on the success of mLBS applications relate to: devices – small screens (size, resolution, colour), restricted interaction possibilities (input, output) and limited performance (CPU, processing power, memory, power); networks – slow transmission rates (bandwidth, latency) and poor coverage; positioning techniques – variable availability and accuracy; and issues of interoperability – proprietary platforms and protocols.

- Furthermore, the success of mLBS applications is also impacted by 'context of use' issues such as: the user (identity, goals and tasks), their situation (location and time), their surrounding environment (physical and social/cultural) and the information they require (availability, accuracy, quality and currency).
- To date, research and development in mLBS has been largely driven by the possibilities offered by the underlying technologies. In response to this state of affairs, the current research advocates a shift in focus toward design that is driven by the characteristics and needs of the end users. In particular, new designs must ensure the usefulness of the end products and their component cartographic representations.
- This research is most interested in non-expert users, who have minimal experience and knowledge with respect to geospatial information and mLBS applications.
- It is acknowledged that each individual user has a unique capacity for geospatial cognition: (a) compared to other individuals, (b) at different times and in different environments and (c) in their approach to different geospatial tasks.

3 Communicating Geospatial Information to Mobile Users

3.1 Introduction

Geospatial information can today be conveyed to non-expert users through the combination of new and advanced technologies collectively known as mLBS. In the previous chapter, the concept of *usefulness* was identified as a major factor governing the acceptance of mLBS applications, with specific emphasis on the cartographic communication process. But how is this achieved? It has been acknowledged that the application of existing cartographic principles and methods to representations within mLBS is insufficient for, and in many cases inappropriate to, ensuring their usefulness (Reichenbacher 2004; Nivala & Sarjakoski 2003). Rather, it seems more likely that careful selection and appropriate design is required, taking into account not only the unique technological and contextual constraints of the medium, but more importantly the needs and characteristics of the end users.

This chapter begins by introducing and defining the realm of cartographic and related representation, presentation and interaction techniques concerning the research (Section 3.2) – i.e. the pool from which mLBS applications may draw in order to communicate their underlying geospatial information, with some arguably more appropriate for the medium than others. Making up the remainder of the chapter is an overview of research projects which have paid at least some attention to use and user issues within mLBS (Sections 3.3.1 and 3.3.2) and related systems (Section 3.3.3), highlighting the cartographic representations employed along with the procedures followed in their selection and evaluation. Based on this, the research focus is established (Section 3.4), centred on a holistic approach to ensuring the usefulness of the cartographic UI for mLBS applications by comparing the utility and usability of alternative geospatial information representation, presentation and interaction techniques for individual users and tasks.

3.2 Representation, Presentation and Interaction

3.2.1 Definitions

"Cartography is about representation" (MacEachren 1995a, p.1).

The ultimate goal of Cartography is to create representations of geospatially distributed phenomena that aid users in accessing and processing geospatial knowledge for their own many and varied purposes. Maps are but one form of cartographic representation and have proved an extremely successful and natural medium for users to interpret and reconstruct the underlying information during decision-making, exploration and other behaviours in space and time (MacEachren 1995b; Barkowski & Freksa 1997). Although the term **representation** can be used to describe the modelling of geospatial data (i.e. producing geospatial information), this research follows the lead of Fairbairn *et al* (2001) in consigning the modelling step to the realm of "data-handling", thereby adopting a **presentation**-focused definition of cartographic representation as:

> *"the transformation that takes place when [geospatial] information is depicted in a way that can be perceived, encouraging the senses to exploit the geospatial structure of the portrayal as it is interpreted"* (p.14).

Not explicitly included in this definition, but also of major significance, is the concept of **interaction** which, it can be argued, is inherent within any representation. Discussed in more detail in Section 3.2.2.3, interactivity refers to the processes and tools by which a user can actively access and/or affect the cartographic representation at hand. The process of interaction may comprise anything from using a zoom tool to view more detail on a Web map to varying the parameters of a three-dimensional (3D) stream flow model in order to view the effects of different flood events.

Providing perhaps the most comprehensive characterisation of cartographic representation, MacEachren proposed the [Cartography][3] structure in 1994 (Figure 3.1). In doing so he formulated a diagrammatic description of Cartography that focused on *map use*, as opposed to map-making or cartographic research approaches, conceptualising a 3D space (cube) defined by three continua:

- **High human–map interaction ↔ Low human–map interaction:** High – where users can manipulate the map in substantial ways; Low – where users have limited abilities to change the map presentation.
- **Private map use ↔ Public map use:** Private – where maps are generated by individuals for their own needs; Public – where pre-prepared maps are made available to wider audiences.
- **Revealing unknowns ↔ Presenting knowns:** Unknowns – where map users search for interesting information, patterns, etc; Knowns – where map users seek access to particular geospatial information.

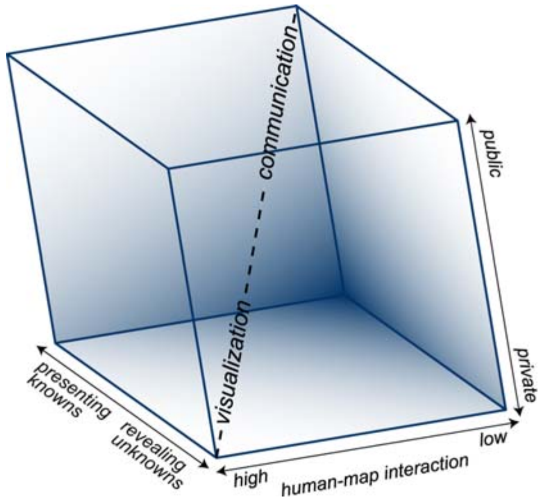

Figure 3.1 [Cartography]³ (redrawn from MacEachren 1994).

Through [Cartography]³, MacEachren emphasised a distinction between cartographic visualization[1] (towards the *private—revealing unknowns—high interaction* corner of the map use space) and cartographic communication[2] (towards the *public—presenting knowns—low interaction* corner of the map use space). In doing so he was careful to point out the absence of a sharp division between the two, describing instead a 'fuzzy' boundary. Indeed, it is generally acknowledged that all cartographic visualizations inevitably involve some degree of communication, while the use of even a simple map constructed for presentation purposes engages the user in the process of cartographic visualisation (Peterson 2003a).

Before discussing the various cartographic representations available to mLBS applications, it is useful to define the scope of representations relevant to the research by relating them to [Cartography]³. This requires a few minor variations on the model, beginning with an expansion of its focus from the space of *map use* to that of *cartographic representation use* – cartographic representations have long moved beyond maps to include any and all 'mappings' of geospatial information into perceptible forms (Fairbairn *et al.* 2001), no matter which of the users' senses are invoked: visual, auditory and/or haptic. Furthermore, the research is not concerned with advancing theories on cartographic visualization and communication (although it will draw on relevant results and guidelines from these fields to ensure the usefulness of cartographic representations employed within mLBS applications), so these components do not apply. Based on this, and the user-related discussions in Chapter 2, Figure 3.2 presents the characteristics of

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1 Equivalent to 'geographical visualization', cartographic visualization relates to the exploration, analysis, synthesis and presentation of geospatial data using visualization techniques, for the depiction of natural and cultural phenomena, hypothesis generation, problem resolution and knowledge construction (Kraak 2003; Cartwright *et al.* 2004).

2 Cartographic communication refers to the viewing of Cartography as a formal (graphical) communication system from the cartographer to the map user, with an emphasis on functional map design (MacEachren 1995a; Peterson 2003a).

cartographic representations deemed relevant to the research, positioned within an adapted version of [Cartography][3]. The justification behind this perspective is provided below with respect to each of the three continua:

- **Low interactivity:** the representations investigated for delivery via mLBS should minimise the need for user interaction (in response to the nature of the mobile use context – Section 2.4.3) and thus incorporate a low degree of interactivity, enabling users to perform basic manipulations in order to access, tailor and understand the information they require.
- **Public *and* private use of geospatial information representations:** the end users considered important to the study are non-experts and, while the largely pre-prepared representations will be accessible to a wide audience, each individual user should be able to access representations that are tailored to their own personal characteristics and private purposes.
- **Presenting known geospatial information:** the non-expert user focus implies that the cartographic representations investigated will not be used for exploring the underlying geospatial data (i.e. to uncover new information or patterns), but rather will enable users to access known geospatial information relating to their current (mobile) context.

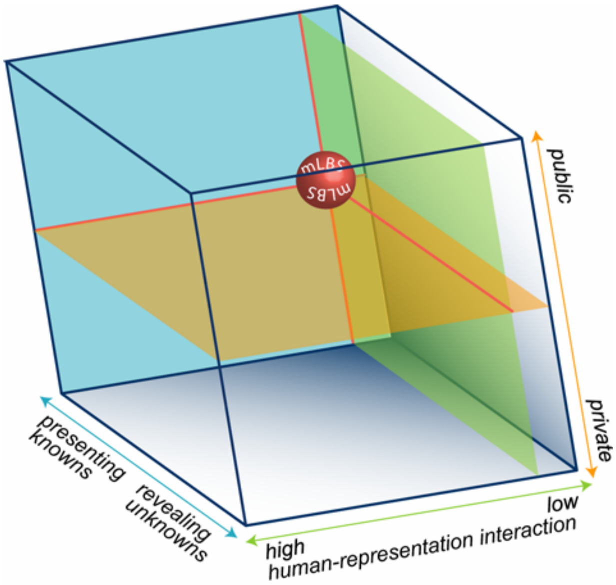

Figure 3.2 The context of the research within an adapted version of [Cartography][3].

3.2.2 Maps and map-related representations

In Section 2.2.2 the evolution of cartographic communication mediums was outlined, illustrating the wide range of representations available to cartographers in the past, present and future. While historically maps were considered *the* classic form of cartographic representation, as time passed the introduction of alternative techniques led to the recognition of additional, non-map representations (Raisz 1962). Best described as 'map-related representations' [3], these range from traditional – e.g. hand-constructed physical terrain models – to contemporary forms – e.g. digital, photographic panoramas. Table 3.1 presents a high-level categorisation of the map and map-related representation forms available for communicating geospatial information through mLBS applications, including a number of cross-cutting features. Note that, due to the contemporary nature of the technology at the centre of the study (Section 2.3.1), and the representation scope identified above (Section 3.2.1), only digitally-based cartographic representations are considered.

Table 3.1 High-level map and map-related representation forms employed by contemporary cartographers.

Map Representations	Map-Related Representations	Cross-Cutting Features
• Base maps	• Images & graphics	• Dynamism
• Thematic maps	• Descriptions & instructions	• Interactivity
• Navigational maps & charts	• Remotely sensed imagery	• Multimodality
• Image maps		• Adaptation
• 3D maps		
• Map signs & symbols		

The following sections provide a brief definition of each representation type shown in the table, followed by initial expectations regarding those considered relevant to the research, including instances of where they have been specifically investigated as part of mLBS applications.

3.2.2.1 Map representation forms

Raisz's (1962) definition of a map as "a selective, symbolized, and generalized picture of some spatial distribution of a large area, usually the earth's surface, as seen from above at a much-reduced scale" (p.32) continues to hold true in today's digital world. Further distinction of what constitutes a map is required, however, and to this end five major categories were identified:

- **Base maps** – two-dimensional (2D) general reference maps depicting the locations of various features on the Earth's surface including coastlines, roads, water bodies, vegetation and place names, at a wide range of scales. Where relief is included, such maps are considered *topographic*, while all others are *planographic*. Base maps commonly provide the 'base' information for maps in the other categories, obscuring the distinctions described here (Kraak & Ormeling 2003; Robinson et al. 1995).
- **Thematic maps** – special-purpose 2D maps representing the geospatial distribution of a single phenomenon, or the relationship between multiple phenomena (Kraak & Ormeling 2003; Robinson *et al.* 1995; Monmonier 1991; Raisz 1962). Three major sub-categories exist:

[3] A term that originated in the field of mountain cartography (Häberling & Hurni 2002).

  - *Qualitative or chorochromatic maps* – portray phenomena characterised by nominal data values (e.g. geology, vegetation, dominant religion);
  - *Quantitative or statistical maps (dot, choropleth, isoline, symbol, flow, etc.)* – render ordinal, interval and/or ratio data variations (e.g. temperature, rainfall, population); and
  - *Diagrammatic maps* – also considered 'map-related' (or 'map-like') representations due to their highly abstracted form whereby map areas, boundaries and/or locations are distorted (e.g. cartograms, transport maps).
- **Navigational maps & charts** – specialised 2D cartographic forms, combining both base and thematic mapping techniques, primarily used as aids for wayfinding, position-finding and orientation activities. The term **chart** is traditionally used to describe maps used for water- and air-based navigation. Being highly variable and often specific to the navigation task at hand, nautical charts typically depict features such as coasts, soundings, tides, currents, shoals, harbours and radio aids. Similarly, aeronautical charts portray mountain altitudes, landmarks, landing fields, runway beacons and radio facilities (Raisz 1962; Robinson *et al.* 1995). Despite being equivalent in function, the cartographic representations used for land-based navigation are termed **route maps**. These provide assistance to drivers and pedestrians alike, incorporating information such as routes, distances, road/path networks, stopping places, landmarks, hazards and place names (Robinson *et al.* 1995; Keates 1989).
- **Image maps** – planimetrically accurate, geo-referenced 2D orthophoto mosaics (refer to Section 3.2.2.2), overlaid with map elements (Robinson *et al.* 1995; Keates 1989).
- **Three-dimensional (3D) maps** – often referred to as *3D terrain models*, these are (virtual) perspective representations of relief surfaces, which possess map characteristics (i.e. a projection system, map signs & symbols, known scale, etc.), and are able to portray and explain complex geospatial relationships within a region of interest (Häberling 2002; Kraak 2001). 3D maps are the visual embodiment of digital terrain models (DTMs) and digital elevation models (DEMs) – numerical representations of terrain characteristics, the latter being concerned with altimetric aspects only (Kraak & Ormeling 2003). Digital *globes* are a special type of 3D map, providing the most correct representation of the Earth, with a distortion-free scale (Riedl 2007). In the absence of interactivity (see below), these maps are primarily used for illustrative purposes only, rather than measurement-based analysis, with perspective distortions, variable scale and obscured terrain inherent (Häberling *et al.* 2001).

Integral to each of these map categories is the following additional 'map' representation form:

- **Map signs & symbols** – the primary content of map representations, these are used to inform on real world point, line and area features, using varying degrees of generalisation to reveal geospatial relationships/patterns, provide an overview of the distribution of geospatial phenomena and convey the physical (e.g. position, direction, extent) and thematic characteristics of the features themselves (Kraak 2001; Robinson *et al.* 1995). Fundamental *visual variables* are used to differentiate various map signs & symbols and were first formalised by Bertin in his 1967 work *Sémiologie Graphique* (Bertin 1983), where he identified the variables **location** (i.e. x,y position), **size**, **colour value**, **texture**, **colour hue**, **orientation** and **shape**. Subsequent researchers have since expanded this list, adding **crispness**, **resolution**, **transparency**, **colour saturation** and **arrangement**, among other things (MacEachren 1995a).

Through their ability to represent and convey complex geospatial relationships and patterns in an efficient and familiar graphic form, it is likely that maps will remain a favoured tool for humans in support of their geospatial tasks:

> *"Maps as representational media have proven useful for dealing with geographic knowledge over centuries … they have become a natural means for accessing and processing this knowledge in our culture."* (Barkowski & Freksa 1997, p.347)

Therefore it is envisaged that a range of simplified *2D map* forms (*base* and/or *thematic maps*, *route maps* and *image maps*) will be useful, if not necessary, for communicating various geospatial information to users through mLBS applications. In fact a large number of studies have focused on designing maps for mLBS applications – mostly to support users' wayfinding, orientation and localisation tasks – and have yielded a number of specific concepts which will likely be relevant to the current research. These include:

- Overview maps – providing a view of an entire route; considered to be essential when navigating (Chincholle *et al.* 2002; Gartner & Radoczky 2007).
- Schematic maps (or topographs) – strongly simplified, schematic representations which are topologically correct but generally not scaled (Brunner-Friedrich & Nothegger 2002).
- Focus maps – directing the user's attention to a region of current interest which is "shown in full detail while the rest of the map is displayed such that it is easily recognized as negligible", thus simplifying the interpretation process (Zipf & Richter 2002, p.36) – see example in Figure 3.7.
- Simple image maps – based on aerial or satellite images, superimposed with routes, user's current location, etc. (Dillemuth 2005b; Almer *et al.* 2004); found to be (potentially) more effective than conventional maps for users with lower spatial abilities and "for time-critical military or disaster situations where a changing landscape renders existing maps obsolete" (Dillemuth 2005a, p.146).

Closely related to this, *map signs & symbols* will be essential for identifying map features and indicating thematic geospatial characteristics. Like 2D maps, much research has been focused on this representation form within mLBS, covering concepts such as: 'tool tips' and 'hot spots' for providing additional map object information on request while simplifying the map display (Heidmann *et al.* 2003; Gartner & Uhlirz 2001); display of the user's current location to support effective movement through the environment (Abowd *et al.* 1997a; Dillemuth 2005b); and adaptation of map symbols based on the current usage situation and user needs/preferences, in order to reduce interruptions during the user's map reading process (Nivala & Sarjakoski 2005).

Additional to this, it is expected that *3D maps* may also be of some relevance, with mobile technology becoming increasingly capable of supporting these representation forms (Zlatanova & Verbree 2005). Again, a great deal of research has begun to explore the potential of 3D maps/models within mLBS applications for supporting users' tasks, with an emphasis on providing geospatial information in a more intuitive and natural way than is achievable using 2D maps. Such studies include: Schilling *et al.* (2005) and Rakkolainen & Vainio (2001), who each compared the usability of 3D maps/models with 2D paper and/or digital maps; and Malaka & Zipf (2000) who developed 3D building reconstructions for visualising landmarks. The results of such work indicated (among other things) that 3D maps/models, while somewhat less efficient than 2D maps for completing orientation and navigation tasks (mainly due to their relative novelty), enable easier recognition of objects (e.g. landmarks) in the surrounding environment. There are still many issues with bringing 3D maps to mLBS, however, not least of which are the often large file sizes involved, which can lead to unacceptable download times and rendering speeds, making the representations largely unusable (Rakkolainen & Vainio 2001; Zlatanova & Verbree 2005; Gartner & Radoczky 2007).

In closing, the only map representations not expected to be relevant to the study are *nautical* and *aeronautical navigational charts*. This assumption is based on the current reliance on terrestrial radio networks for mLBS data transmission and the expected application types (Section 2.3.2), which suggest that marine and air-based applications are not likely to be marketable in the near future.

3.2.2.2 Map-related representation forms

Practically any non-map form used to depict geospatial phenomena can be considered a 'map-related representation'. As illustrated below, this incorporates everything from the simplest text entities to map components and remotely sensed imagery. The following summarises the possibilities for non-map representation under three main categories:

- **Images & graphics** – arguably the most common form of representation for communicating geospatial information, these make use of the map user's visual sense in a variety of ways and range from the highly abstract to the truly realistic. The most prominent type of images & graphics employed by cartographers are maps and map signs & symbols, however with the emphasis here on map-*related* representations, two additional forms were relevant:
  - *Diagrams* – comprise all diagrammatic representations that convey geospatial information, with the exclusion of maps (other than diagrammatic maps) and map signs & symbols. These may accompany or be superimposed on maps, or appear in the absence of maps altogether, and generally represent geospatial relationships which are either too complicated for a map to convey on its own (Raisz 1962) or else do not require such a complex representation. The main forms of diagrams are: *drawings* – such as the schematic (3D) block diagrams produced by mountain cartographers (Häberling & Hurni 2002); *graphs* – e.g. bar, line, radial and triangular graphs, climatograms and 2D and 3D graphs (Raisz 1962); and basic *signs & symbols* – e.g. turn arrows.
  - *Photographs* – also arguably a form of remotely sensed imagery (see below), here these refer to close-range portrayals of geospatial information, comprising realistic, natural scenes. Photographs may accompany maps or be presented in isolation and are generally carefully constructed, bestowing focus upon selected entities or phenomena (MacEachren 1995a; Peuquet 2002). They often provide perspective views – something that traditional map representations generally do not. Associated representations include photographic *panoramas* – i.e. a collection of photographs taken from a common viewpoint which are joined together to create a 360° view of the scene (Peuquet 2002) – and *video*.
- **Descriptions & instructions** – encompass a wide variety of visual and non-visual methods for storing and conveying geospatial information (e.g. position coordinates, place names), as well as assisting geospatial tasks (e.g. wayfinding, orientation). In the process they often perform redundant and/or complementary functions, in conjunction with other representations. Within this category, three major forms were distinguished:
  - *Natural language* – consisting of *written* text and *spoken* words (including alphanumeric characters), may be used for multiple geospatial purposes including: map feature and legend labelling, written or spoken guidance directions and vocal narration for time-based simulations (Peuquet 2002; Krygier 1994).
  - *Sound* – incorporates all *non-speech* auditory outputs, including 'earcons' (mimetic sound icons based on musical tones (see Blattner *et al.* 1989; Brewster 2003)) and abstract sounds (e.g. a computer-generated 'beep'). Krygier (1994) first identified a list of *sound variables* which help to characterise abstract sounds and can be used to determine their appropriateness for representing different geospatial data types. They are: **location**,

loudness, **pitch**, **register**, **timbre**, **duration**, **rate of change**, **order** and **attack /decay**. Non-Speech sounds are commonly used in contemporary cartography to provide (often redundant) auditory cues and feedback, with auditory map interfaces also possible. Most advances in this realm come from research into communicating geospatial information to the blind and visually-impaired (Rice *et al.* 2005; Krygier 1994).

- *Touch* – refers to the use of *haptic* feedback within a cartographic system "delivered as a stimulus through the skin and aided by kinesthetic perception of the position and movement of the joints and muscles" (Rice *et al.* 2005, p.381). Haptic representations range from tactile (physical) maps to vibratory geospatial cues from a desktop mouse or mobile phone. In 1993, Vasconcellos defined a list of *tactual variables* for application to cartographic representations, incorporating **volume**, **size**, **value**, **grain/ texture**, **form**, **orientation** and **elevation**. More recently, Rice *et al.* (2005) have experimented with combining touch and sound in what they term 'Haptic Soundscapes'.

- **Remotely sensed imagery** – although a type of representation in itself, various forms are commonly employed as environmental base maps, as well as data sources for other map and map-related representations. Comprising direct images of the earth's surface (including the ocean floor), which are "acquired by devices not in direct physical contact with the features being studied" (Robinson *et al.* 1995, p.127), these are gathered via a number of platforms, specifically aircraft (low- to high-altitude), spacecraft (e.g. satellites) and marine craft (i.e. ships and submarines). Sensors such as cameras, scanners, radar and sonar are used to capture remotely sensed imagery, with the most common representation products being: *mosaics* – assemblages of adjacent images which have had their geometric distortions reduced, but not eliminated – and *orthophotos* – planimetrically correct images, i.e. with constant scale (Robinson *et al.* 1995).

Since it is anticipated that maps may not always be appropriate for representing geospatial information within a mLBS application, particularly when device display limitations are considered (Section 2.4.2), it stands to reason that map-related representations will be of relevance to the research. Indeed, numerous researchers have highlighted the perceived importance of employing multimedia for communicating geospatial information through mLBS (e.g. Almer *et al.* 2004; Gartner 2003). Beginning with *images & graphics*, it is expected that *diagrams* will be of particular use for conveying an alternative and/or more simplified perspective of the geospatial information at hand. An example of their application within mLBS is seen in the work of Krug *et al.* (2003) who trialled representations of route profiles showing a user's progress, including their altitude, distance covered and distance remaining (see example in Figure 3.9). Similarly, *photographs* will likely also be relevant, particularly as a means for identifying specific entities distributed in space (e.g. landmarks), with Beeharee & Steed (2006) and Gartner & Uhlirz (2005) describing studies which found standard photographs and 360° photographic panoramas, respectively, to be especially useful for this purpose during wayfinding tasks with mLBS.

Moving on to *descriptions & instructions*, these are again expected to be highly useful to the research, with *natural language* of particular importance. While written words have previously proven useful within mLBS applications for the communication of route instructions and lists of geospatially distributed features (Cheverst *et al.* 2000; Chincholle *et al.* 2002; Gartner & Uhlirz 2005), among other things, spoken words are likely to be of value for both the input and output of geospatial information. Examples of mLBS research that has dealt with speech as a representation form include: Malaka & Zipf (2000) who employed speech recognition technology for dealing with spatial queries and language generation software for communicating route instructions; and Hurtig (2006) who used multimodal techniques for requesting and receiving public transport route information – incorporating speech/pen-based input and speech/map output. *Sound* and *touch* may also be appropriate in mLBS applications, particularly considering the changing nature of a user's environmental context which inevitably draws their visual attention away from the mobile device. In terms of output, realistic and abstract sounds as well as haptic cues (where supported by the technology) may indicate, for example, an upcoming turn direction – this was demonstrated with tactile representations by Sokoler *et al.* (2002) – or even provide feedback when a geospatial query returns the requested information. Furthermore, tactile forms of input may also prove useful as evidenced by the aforementioned research from Hurtig (2006), involving pen-based selection.

Looking finally to *remotely sensed imagery*, this representation form is expected to be relevant insofar as it will provide the 'base' for the image maps discussed in Section 3.2.2.1. It is unlikely that the imagery on its own (i.e. without overlaid map elements) would be of much use within mLBS applications, especially considering their high detail/resolution which is largely unsuited to small screen display technology.

3.2.2.3 Cross-cutting features

A number of representational methods exist within cartography, which cannot be classed as either map-based or map-related, but are rather techniques by which the different map and map-related representations can be assembled and presented to the user (singly, or in combination with one another). The following introduces these four important cross-cutting techniques:

- **Dynamism** – centres on the application of dynamic elements within cartographic representations in order to draw the user's attention and/or depict complex temporal and non-temporal geospatial processes and events (Buziek 1999; Kraak 2007). Fundamental to this, DiBiase *et al.* (1992) and MacEachren (1995a) identified six dynamic visual variables for application to cartographic representations: **moment/display date**, **duration**, **frequency**, **order**, **rate of change** and **synchronisation**. Dynamic representations are characterised by continuous change, which may take place with or without user action (Slocum *et al.* 2001) – a simple example being 'blinking' map symbols, which use *rate of change* and *duration* to draw user attention (Buziek 1999). The most common dynamic technique for enabling the discovery and analysis of complex cartographic information is **animation**, which refers to visual (and often auditory) representations which have been 'set in motion' (Robinson *et al.* 1995). Specifically, cartographic animations "can depict change in space (position), in place (attribute), or in time" (Kraak 2007, p.318), with the most common distinctions made between temporal and non-temporal animations. Animation is considered a natural technique for representing temporal changes in geospatial (locational and/or attribute) data, since changes in display time can be directly correlated with changes in real world time (Slocum *et al.* 2001). Examples of this include: a weather map with changing temperatures or cloud cover; and a 3D oblique view of the progression of an avalanche (Kraak 2007; Kriz 2001). Conversely, non-temporal animations hold the variable of time fixed, with two types possible: while the first demonstrates the successive build-up of entities (i.e. change in location and/or attribute, shown against display time) – an example being a progressive display of 3D city map layers (i.e. terrain → roads → land use) – the second involves changing representations/ perspectives of the same geospatial phenomena (i.e. where location and attribute are also fixed), with examples including a 3D landscape fly-through simulation and the sequential display of different quantitative maps representing a single data set (Kraak 2007; Kraak 2001).

- **Interactivity** – introduced in Section 3.2.1, this is where the user is given some degree of control over the representation, providing them with flexibility to customise their access to the underlying information, including how and when they 'view' it (Dykes 1997). Interactivity generally permits a "free question and answer exchange" between representation and user (Robinson *et al.* 1995, p.565) through the use of various interaction styles such as selection, input, query, command and direct manipulation (Lindholm & Sarjakoski 1994). It also compensates for the presentation limitations inherent in the digital computing medium, thus enabling more effective retrieval, display and exploration of complex geospatial information (Buziek 1999). Interactive tools are often supplied with animations to support greater understanding of the content (Slocum *et al.* 2001), for example: 'pause' and 'fast forward' in temporal animations; 'pan' and 'zoom' in animated maps; and 'rotate' and 'scale' in 3D terrain model fly-throughs (Kraak 2001). **Hypermedia** is a specific mode of interactivity, referring to 'nodes' of discrete, multimedia elements (e.g. text, graphics, maps, sound, animation, video), each containing various information, that are inter-connected by "links which organize the information into semantic constructs" (Lindholm & Sarjakoski 1994, p.178; Cartwright 2007). In this way users of geospatial hypermedia applications are able to *move between* linked cartographic representations, e.g. 'at the click of a mouse'.

- **Multimodality** – refers to the communication of geospatial information using multimedia representations which invoke multiple human senses, thereby providing an enhanced user experience (e.g. a vehicle navigation system employing static maps, animated graphics *and* voice commands to communicate turn manoeuvres). The basis for multimodality is thus: information is transferred to humans via different channels (or 'pipelines'), with the *visual* and *auditory* channels considered most useful to cartographic communication. Simultaneously, the human memory stores knowledge in separate modalities (information representations) distinguished by the channels to which they belong, for example: auditory – language, sound, music; and visual – maps, graphics, text, imagery, animation (Buziek 1999). While employing the concepts of redundancy, complementariness and inference to better represent the underlying information (Buziek 1999), multimodal representations are believed to enable communication and interaction that better resembles natural human behaviours (Oviatt & Cohen 2000; Slocum *et al.* 2001). Specific reasons for employing multimodality in cartographic representations include: to emphasise important information and thus encourage its storage in users' long-term memory (Dransch 2000); to avoid overloading a single sense while providing insight into complex geospatial data (Dransch 2000); to support double encoding of information (e.g. in both the visual and verbal stores) for increased memorability and thus more efficient learning (Buziek 1999; Dransch 2000); to improve the accessibility of information for diverse users and usage contexts (Oviatt & Cohen 2000); and to provide greater flexibility in accessing and interacting with geospatial information (Oviatt & Cohen 2000). Also incorporating interactivity and dynamism, **Virtual Reality** (VR) is perhaps the 'ultimate' in multimodal representation. These "multidimensional interactive models in which the [user] can participate in a multi-sensory experience" are based upon navigation through, and interaction with, an immersive 3D/3.5D/4D space incorporating visual, audio and haptic stimuli, thus reflecting the real world and capitalising on the user's natural experiences and abilities (Moore 1999, p.205; Fairbairn & Parsley 1997).
- **Adaptation** – involves 'fitting' a given cartographic representation to the current *context of use* – i.e. situation, environment, user, information (Section 2.4.3) and the technology at hand (Reichenbacher 2007) – in order to "help users to employ [geospatial] information more efficiently (usability), fitting the presentation to their needs and the limited resources … and enhancing the overall relevance" (Reichenbacher 2004, p.99). There are two basic forms of adaptation, signifying two ends of a continuum. In the context of (cartographic)

representation, these can be defined as: (1) *adaptable* – where the user is able to actively adjust, or **personalise**, the representation's characteristics (i.e. parameters) themselves, via explicit interaction; and (2) *adaptive* – where the representation's characteristics are automatically **tailored** to the user's needs, based on an passively inferred (or 'sensed') model of their context (Reichenbacher 2007; Paternò & Mancini 2000; Nivala & Sarjakoski 2003). Regardless of the technique, adaptation may occur within a cartographic representation at any of several levels, most notably: information (i.e. relevant content); presentation (i.e. representation type/form, modalities employed); technology (i.e. device-/transmission-related information encoding); and/or interaction (i.e. style, modalities, navigation support) (Paternò & Mancini 2000; Reichenbacher 2003). Reichenbacher (2007) provides examples of adaptation techniques which may be applied to map representations within a mobile context: select/filter map features to reduce map content and information density, prioritise information based on relevance, substitute equivalent presentation forms, switch between design alternatives, change the presentation/symbolisation, reconfigure map components, adapt the UI and change the encoding.

It is anticipated that each of the above cross-cutting features will be highly relevant to communicating geospatial information via mLBS and therefore the research. Specifically, *dynamism*, in the form of animation, is expected to be useful for drawing users' attention to important information and in depicting dynamic geospatial phenomena or entities. Oppermann & Specht (1999) with their 'blinking' icons, and Brachtl *et al.* (2001) with their animated 'movie' walkthrough, provide examples of such applications of the technique within mLBS. Inherent in the definition of representation, some degree of *interactivity* will be essential so that the user may gain access to the information they personally require, at their own pace. Each of the mLBS research studies cited throughout this chapter employed interactivity for this purpose, particularly in the form of hypermedia, which was likened to a "modified browser metaphor" (Cheverst *et al.* 2000, p.19; Pospischil *et al.* 2002).

Moving onto *multimodality*, this is expected to be important not only for enhancing users' understanding and cognitive storage of the geospatial information presented, but also for ensuring that users with different abilities and preferences can access it in a manner that best suits them. The use of multimodality for communicating geospatial information within mLBS applications was previously touched on with respect to one of the aforementioned research projects (Hurtig 2006). Other successful implementations of this can been seen in the work of Yue *et al.* (2005) – who combined speech and pen-based input (pointing, handwriting, sketching) for geospatial searching within a mobile guide – and Oviatt (1996) – who used the same combination of techniques for map-based queries and updates. Each study found that users generally preferred to interact with the given mLBS application using multimodal techniques, rather than unimodal interaction.

Finally, *adaptation* to contextual parameters will be appropriate for the research in order to increase the relevance (and thus reduce the volume) of information presented to the user at any one time, while minimising the amount of interaction required. Adaptation is a common theme running through much of the existing mLBS applications research, with the underlying concept of personalisation (see Section 3.2.3.2) figuring most highly. Specific research examples in this realm include: egocentric maps, which depict "geographic information from the user's perspective that can be more than the mere spatial position and could include interests, physical abilities, needs, etc." (Reichenbacher 2005a, p.152; Meng 2005b); changes in map orientation to match the direction of the user's movement when following a route (Yue *et al.* 2005); and the ability to save 'favourite' items of geospatial information (e.g. routes, addresses, landmarks) for faster subsequent access (Chincholle *et al.* 2002).

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Figure 3.3 provides a pictorial summary of the relevance attached to each of the cartographic representation forms and cross-cutting features discussed above, within the context of mLBS and the research.

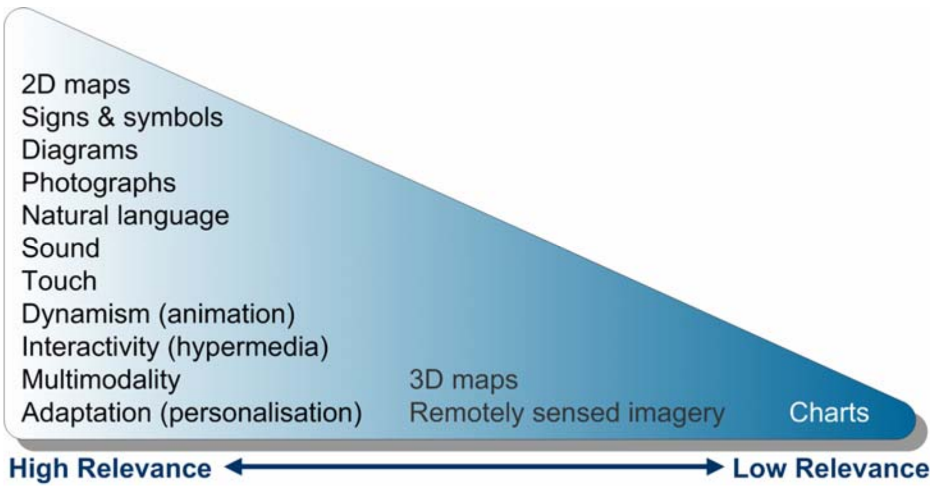

Figure 3.3 The relevance of the available cartographic representation forms/features in the context of the research.

3.2.3 Representation in mobile systems

As a precursor to mLBS, mobile devices and related services (in a more general sense) have been around for some time, and as such their usability has been discussed, tested and improved many times over, in many ways. From laptop computers to PDAs and mobile phones, concerns over the usefulness of presentation and interaction techniques to overcome observed limitations have evolved in-line with advances in the technology leading to increasingly smaller devices with widely varying capabilities. It is therefore pertinent to present a selection of the representation, presentation and interaction techniques and related methods that have been/are being explored within the wider field of mobile systems and which may additionally contribute to the current research (notably, many of these are reflected by the mLBS implementations discussed in the previous section). Categorised as either natural interaction or information presentation, the range of mobile systems techniques is listed in Table 3.2 and summarised below using examples from specific (non-mLBS) research projects.

Table 3.2 Representation techniques that have been explored within mobile systems research.

Natural Interaction	Information Presentation	
• Pen-based input	• Text	• Haptic solutions
• Speech/voice	• Graphics	• Personalisation
• Gesture	• Sound	

3.2.3.1 Natural interaction

Research in the area of natural interaction strives to incorporate familiar human actions as input techniques for communication between users and mobile systems, with the purpose of minimising the cognitive load on the user (Abowd & Mynatt 2000; Yue *et al.* 2005). Inherent in most mobile natural interaction UIs is multimodality, which offers benefits for information delivery equivalent to those described in Section 3.2.2.3, while allowing faster and more efficient human-device communication and thereby further 'humanising' the interaction process (Oviatt & Cohen 2000; Kondratova & Goldfarb 2006).

- **Pen-based input** – designed to replace mouse- and keyboard-based interaction, which are generally not suitable in mobile contexts (i.e. devices, environments, tasks); used for object selection, drawing, handwriting recognition, etc.
  - Citrin *et al.* (1997) developed a software architecture to support mobile pen-based graphical applications that were originally designed for use with 'mouse and palette' interfaces. The use of this was demonstrated through a system allowing field-based local area network designers to draw diagrams, text and command glyphs on an Apple Newton MessagePad, which were then 'recognised' (via shape, handwriting or gesture recognition) and displayed/stored in both raw and processed form.
- **Speech/voice** – for information input and/or output; aimed at overcoming the limitations imposed by the small screens (text viewing difficulties) and cumbersome interaction capabilities (time consuming keypad-/stylus-based text entry) which characterise mobile devices.

- Deng *et al.* (2002) compared the use of traditional pen-based input with a combination of speech and pen (*Tap & Talk*) for completing common personal information management tasks using a PDA. During user tests, *Tap & Talk* was found to be more efficient than (and preferable to) the pen-only technique for both creating a new appointment and writing an email.
- Motiwalla (2005) investigated the use of voice as input (automatic speech recognition) and output (Text-to-Speech) to enhance the interaction process when using PDAs or SmartPhones to access/post messages within an e-learning discussion forum.

- **Gesture** – using the hands, head, fingers, other; aimed at reducing the need for visual attention to mobile systems; generally requires sensing technology as part of the physical system.
  - Hinckley *et al.* (2000) added multiple sensors to a PDA to investigate gestural techniques including: memo recording when held like a phone; switching display modes (portrait vs. landscape) based on device orientation; 'powering up' when the device is picked up; and scrolling the display by tilting.
  - Pirhonen et al. (2002) investigated the use of hand gestures – 2D finger movement across a touch screen – accompanied by non-speech audio feedback – earcons – for the operation of a PDA-based music player, uncovering a reduction in mental demand on the user when compared with visual/pen-based methods.

3.2.3.2 Information presentation

A plethora of mobile systems research is devoted to overcoming the limitations of mobile devices relating to screen size, display resolution/colours and interaction mechanisms. Here, alterative modalities and techniques are explored in order to optimise the communication of information to users within mobile environments.

- **Text** – concerned with increasing the efficiency of text presentation within mobile systems, including improved readability and a reduction in the amount of scrolling/clicks required to access content.
  - Russell *et al.* (2001) investigated the use of a Rapid Serial Visual Presentation format for presenting text within mobile systems (i.e. one word presented at a time in the same screen space), concentrating on the effects of different text presentation speeds and font sizes on users' reading comprehension, satisfaction and preferences.
- **Graphics** – aimed at overcoming the display limitations (e.g. lack of screen real estate, limited colour depth) that adversely impact the rendering of images, drawings, maps, logos, etc. within mobile systems.

- Rist & Brandmeier (2002) investigated automated techniques for transforming graphical representations (e.g. downscaling operations, reduction of colours) to increase their suitability for display within mobile systems.
- Luo *et al.* (2002) considered colour dithering and palettization methods (e.g. Web Safe colours) to determine solutions to image rendering problems inherent within mobile devices.

- **Sound** – aimed at reducing the need for visual attention, while 'freeing up' the visual display space for other representations/tasks.
  - Brewster & Murray (2000) investigated the use of non-speech sounds, in comparison to text and graphics, for presenting real-time, dynamic information within a mobile system. Specifically they employed *SoundGraphs* (based on changes in pitch within a sound stream) to communicate changing share prices, finding large reductions in cognitive demand compared to visual-only techniques.
  - Lumsden & Brewster (2003) investigated different 3D *soundscape* techniques for presenting current affairs information options to users of a wearable system, who could then make selections using head gestures (nod direction). Among the research results, egocentric soundscapes (sounds placed at the four cardinal points – i.e. 90° apart) were found to be the most effective presentation method.
- **Haptic solutions** – generally concerned with integrating vibration content into the UI of mobile systems, thereby improving interaction when the visual display is overloaded, limited in size or not available; may be used to complement graphical and auditory feedback, discretely communicate information (i.e. without disturbing others) and draw user attention in noisy environments.
  - Chang & O'Sullivan (2005) compared audio-haptic feedback (incorporating vibration) with audio-only feedback for ring tones and key presses within a mobile phone UI, finding high user acceptance of the audio-haptic output.
  - Brewster & Brown (2004) discussed *Tactons*[4] (tactile icons) as feedback in mobile and wearable systems, whereby variations in tactile parameters (frequency, amplitude, duration and rhythm, waveform and body location) may be used to provide, for example, directional or navigational cues, information about a user's context, etc.
  - Brown & Kaaresoja (2006) investigated the use of Tactons for communicating multi-dimensional information through incoming mobile phone alerts (i.e. 'vibrotactile' messages), using a standard mobile phone vibration motor. User testing uncovered

[4] Tactons are "structured, abstract, tactile messages which can be used to communicate information non-visually" (Brown & Kaaresoja 2006, p.605).

promising results in terms of recognition rates for Tactons encoding both alert type (voice call, text message, multimedia message) and priority (low, medium, high).

- **Personalisation** – aimed at improving the usability of mobile systems while increasing the relevance of delivered content (and techniques) for individual users; concerned with building models of user goals, preferences and knowledge which are then used to adapt information to user needs; adaptation to individual device capabilities may also be undertaken; relates to the discussion of adaptation presented in Section 3.2.2.3.
  - Billsus *et al.* (2002) advocated an automated approach to personalisation, employing artificial intelligence and statistical techniques to continually model individual users' interests, with the inputs obtained both explicitly from the users themselves and inferred directly from their actions. Agents would then use these models in the selection of content to be presented to the user.
  - Samaras & Panayiotou (2002) proposed an agent-based system for personalising mobile Internet content and the presentation of such according to both the individual user's profile (e.g. interests) and the access device's profile (e.g. display capabilities). Early evaluations showed reductions in the amount of navigation required and the volume of content delivered where personalisation was applied to a WAP-based restaurant information service.

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While the focus of the current research is on the application of techniques that are already employed within Cartography (and feasible for mLBS), it is expected that many of the generic mobile interaction and presentation techniques described above may also be of use for communicating geospatial information through mLBS applications. In this respect, particular promise is seen in pen-based input techniques, speech/voice for information input and output, graphical optimisation techniques, non-speech sounds, haptic feedback and content/UI personalisation.

3.3 Existing Research

The previous sections provided essential definitions for the research while highlighting the range of representation, presentation and interaction techniques considered relevant to the useful communication of geospatial information via mLBS applications. With this information in hand, it is important to now look in more detail at the work done by others in similar and related fields in order to recognise and discuss the lessons that can be learned and where further research is required. Particular insights to be gained from such an analysis concern not only the identification of representation forms at the centre of recent mLBS research studies, but also the methodologies followed for designing particular representations and the research techniques employed to assess their usefulness.

3.3.1 MLBS case studies

Since the mid 1990s, a number of prominent academic and consortium-based projects have been undertaken in the realm of mLBS, many of which have, at least to some extent, considered user acceptance and/or issues of use as priorities. This following discussion highlights a representative selection of these in terms of their aims and research products, paying specific attention to the cartographic representation techniques employed and the insights offered by the user-focused research methods employed. In all, seven case studies are described featuring projects completed by a variety of university and governmental groups over the past decade.

3.3.1.1 Project descriptions

Cyberguide

Working in the field of context-aware computing, the Future Computing Environments Group within the Graphics, Visualization and Usability (GVU) Centre at Georgia Institute of Technology was one of the pioneers of early mLBS with the project known as Cyberguide (1995-1997). The original aim of Cyberguide – a location-aware handheld tour guide for directing visitors around the GVU Laboratory, the University and surrounding neighbourhoods – was to build a mobile application that usefully leveraged information about a user's context (focusing on location and orientation), in order to support their tasks (Long *et al.* 1996a). Additional aims included the provision of a flexible infrastructure for context-aware computing (Abowd *et al.* 1997b) and to assess the impact of mobile technology for a specific task (i.e. navigation and information access) through rapid and inexpensive prototyping (Abowd *et al.* 1997a). The system's UI was dominated by a central map (Figure 3.4).

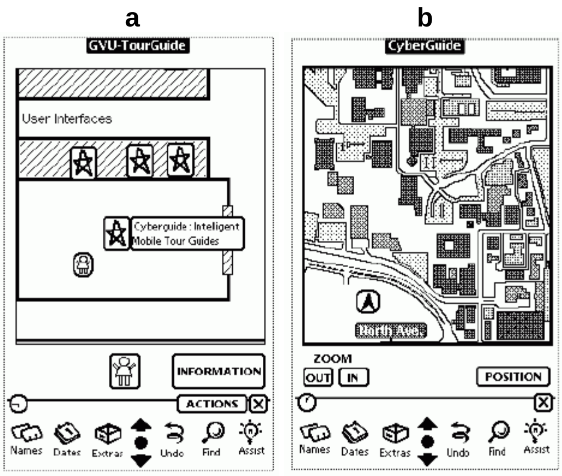

Figure 3.4 Maps showing the user's position (and in the second map orientation) within prototypes for: (a) indoor Cyberguide and (b) outdoor Cyberguide (Long *et al.* 1996b).

HIPS/Hippie

Between 1997 and 1999, HIPS (Hyper-Interaction within Physical Space) was funded by the European Commission to study new technologies and interaction modalities that would allow museum visitors to explore and "navigate both the physical space and a related information space at the same time" (Benelli *et al.* 1999; Broadbent & Marti 1997, p.88). The final system supported the user before, during and after their visit with pre- and post- functionality accessed via the desktop Web, while a PDA-based system called Hippie (Figure 3.5) provided services at the museum (Oppermann *et al.* 1999). A major innovation of HIPS was its application of a user-centred design methodology to the development of a tourism-based multimedia application. Whilst only limited information could be obtained regarding specific results (Oppermann & Specht 1999; Specht & Oppermann 1999), according to the research literature the focus of HIPS/Hippie was on the provision of non-geospatial content.

Figure 3.5 Text-based information within Hippie informing of the user's current and previously visited exhibits and new tour proposals – the latter is made accessible by clicking on the animated notification icon (Oppermann *et al.* 1999).

GUIDE

Developed by the Distributed Multimedia Research Group within Lancaster University's Department of Computing between 1997 and 1999, GUIDE was a prototype adaptive hypermedia-based tourist guide for the city of Lancaster, which sought to "overcome many of the limitations of the traditional information and navigation tools available to city visitors" (Cheverst *et al.* 2000, p.17). In realising this aim, researchers explored the use of up-to-date contextual parameters – both personal and environmental – for tailoring tourist and guidance information and simplifying patterns of user interaction (Cheverst *et al.* 2002; Cheverst *et al.* 2001). The final prototype supported user tasks such as information retrieval, creation and navigation of city tours (Figure 3.6), communication with the tourist information centre and accommodation booking (Cheverst *et al.* 2000).

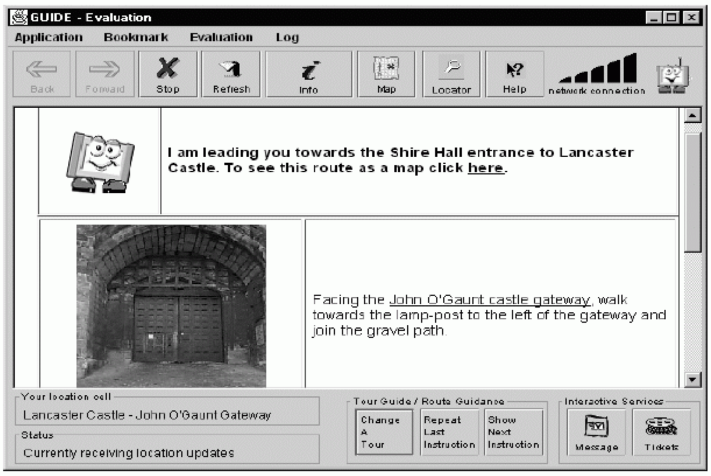

Figure 3.6 Textual guidance instructions presented within GUIDE, accompanied by an image and textual information related to the user's current location and a link to view a map of the route (Cheverst *et al.* 2000).

CRUMPET

CRUMPET (Creation of User-friendly Mobile services Personalised for Tourism) was a European Union (EU) project conducted between 2000 and 2002, having two aims: (1) to implement, validate and trial tourism-related, value-added services for nomadic users; and (2) to evaluate the use of agent technology in terms of user-acceptability, performance and best-practice (Crumpet Consortium 2001; Schmidt-Belz & Poslad 2003). The final CRUMPET prototype – a multi-agent, personalised, location-aware tourism service (Schmidt-Belz *et al.* 2003) – made use of geospatial and personal contextual parameters to offer 'proactive tips' (which unobtrusively drew user attention to nearby objects of interest) and adaptive, personalised maps (Zipf 2002). Indeed maps (in particular Focus Maps, introduced in Section 3.2.2.1) played a central role in the service (Figure 3.7).

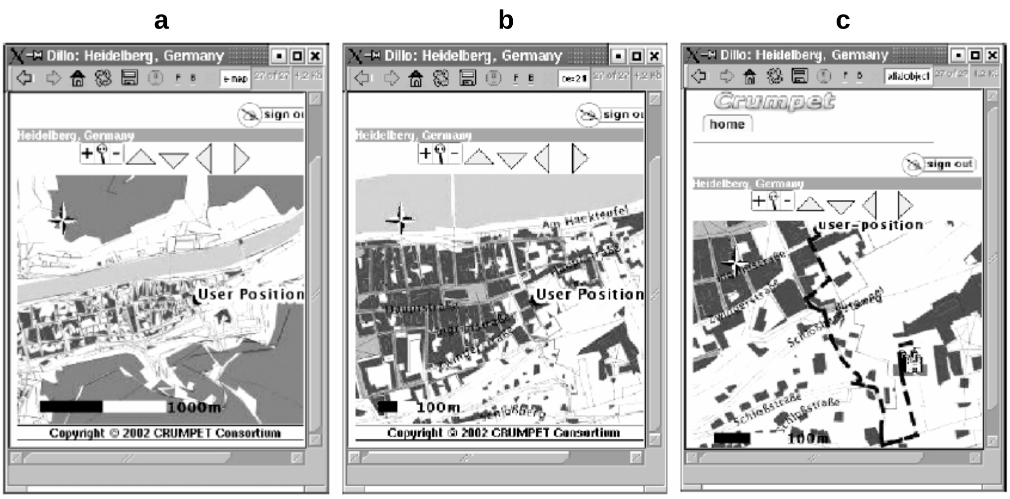

Figure 3.7 Focus Maps within the CRUMPET interface showing: (a) an overview of Heidelberg's old town; (b) the same map zoomed in; and (c) a tour from the user's location to an attraction (Schmidt-Belz & Poslad 2003).

Lol@

Researchers from the Department of Cartography at the Technical University of Vienna contributed to the cartographic components of Lol@ (Local Location Assistant) – a PDA-based prototype mLBS application for guiding foreign tourists along a pre- or self-defined tour of Vienna's first district (Gartner & Uhlirz 2001). The Lol@ project (2000-2002) had several aims, most notably to evaluate the capabilities of 3G communication technologies for mLBS, and also to demonstrate that the application of multimedia techniques could increase the acceptance of mLBS and thus the efficiency of cartographic communication processes (Gartner 2003). The resulting prototype was based around a map metaphor (Figure 3.8) , with a browser metaphor employed for accessing non-map information (Pospischil *et al.* 2002).

Figure 3.8 A 'detail' map within the Lol@ interface showing a landmark silhouette, category map symbols and a tour route (Gartner & Uhlirz 2001).

WebPark

The EU-funded WebPark project (2001-2004) set out to create a robust, interoperable, value-added mLBS platform for the provision of personalised, relevant, on-demand geospatial and non-geospatial information to support mobile users within coastal, rural and mountainous recreational areas (Krug *et al.* 2003; Edwardes *et al.* 2003). The final WebPark product was a mobile service that delivered information to tourists and professional users via a PDA or mobile phone (Figure 3.9). The project made important inroads into map adaptation and generalisation techniques for mLBS, aiming to maximise the relevance of component map representations for their purpose.

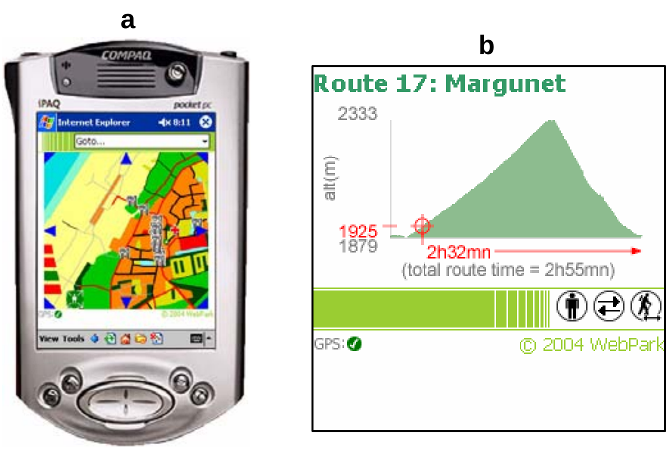

Figure 3.9 (a) Map and (b) route profile representations within the WebPark service (WebPark 2005).

GiMoDig

The final project to be addressed is GiMoDig (Geospatial info-Mobility service by real-time Data-integration and generalisation), which was conducted between 2001 and 2004 as part of the EU's Information Society Technologies programme. Coordinated by the Department of Geoinformatics and Cartography at the Finnish Geodetic Institute, GiMoDig aimed to develop: (1) seamless "[geo]spatial data delivery from national primary topographic databases for mobile use"; and (2) "methods for real-time generalisation and data integration of [geo]spatial data" (Sarjakoski 2003, p.6); with an additional research challenge being the development of map design principles for intelligent, context-aware topographic maps implemented on small displays (Nivala & Sarjakoski 2005; Sarjakoski & Nivala 2005; Nivala *et al.* 2003). Combining the disciplines of Cartography and HCI, researchers followed a user-centred design approach to develop a prototype service and methods for delivering geospatial data to mobile users in real time. An additional product was the cartographic design, including a symbol library which supported adaptive map symbols for different users in different mobile use contexts (see Figure 3.10).

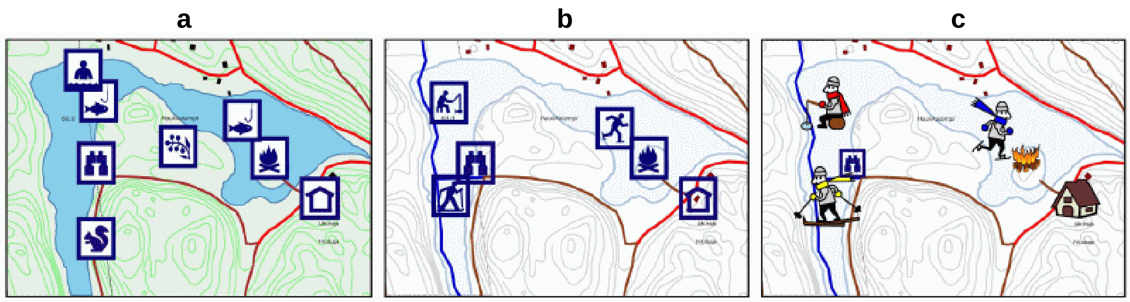

Figure 3.10 Example maps from the GiMoDig map service showing personalisation of their style and symbolisation, based on season and user age group: (a) summer, 46+ years of age; (b) winter, 18-45 years of age; and (c) winter, 0-17 years of age (Nivala & Sarjakoski 2005).

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The preceding descriptions highlight the variety of factors that have driven mLBS-related research in the past, with most projects experiencing multiple motivating factors throughout their lifecycles. Supporting the arguments made in Section 2.5, four of the featured projects (Cyberguide, CRUMPET, Lol@ and WebPark) were at least initially aimed at trialling new technologies. Similarly, all seven projects were fundamentally concerned with creating a (prototype) service for a specific application domain – overwhelmingly tourism within a defined region – albeit each endeavouring to incorporate some degree of value and support for the end user within the final system. In most cases (Cyberguide, HIPS, GUIDE, CRUMPET, WebPark and GiMoDig), this was driven by a further objective to investigate and implement the adaptation of content and (less so) information presentation forms to current contextual parameters – i.e.

context-awareness. From a cartographic perspective, Cyberguide, GUIDE and WebPark were additionally motivated by the desire to support users' navigation and localisation tasks, while GiMoDig and Lol@ addressed questions of delivering and communicating geospatial information to users, respectively.

With each project largely achieving its stated aims, all made valuable contributions to the emerging body of knowledge concerning mLBS applications and their usefulness. The following sections provide a more detailed account of those aspects of the case studies' considered relevant to the current research, beginning with the communication of geospatial information.

3.3.1.2 Cartographic representation

Table 3.3 presents the cartographic representation forms and cross-cutting features employed by each of the mLBS-related case studies when conveying geospatial information to users. This information, and the summary that follows, were derived from the publicly-available literature referenced throughout Section 3.3.1.1.

As shown in Table 3.3, most of the cartographic representation forms/features identified in Section 3.2.2 were variously utilised within each of the different case studies – indeed this occurred even in the earliest projects (Cyberguide, HIPS and GUIDE), where geospatial information was arguably considered more important as an input parameter (i.e. location as context) than an output. A technique common to all projects – and also the most dominant geospatial information representation within each interface – was, unsurprisingly, the map. Individual maps employed by each project generally took the form of combined *base* and *thematic maps*, incorporating the user's position and that of features and objects in the surrounding environment, with the researchers (mostly) endeavouring to observe traditional cartographic design principles, and in some cases undertaking specialised *map symbol* design (e.g. Cyberguide's single symbol conveying user location and orientation; Lol@'s landmark silhouettes; and GiMoDig's map symbol library). Apart from the earliest projects, the maps also incorporated *route representations* in the form of additional map symbology and graphics. Furthermore, most of the maps possessed some degree of *interactivity*, ranging from basic pan and zoom functions (e.g. Cyberguide) to hyperlinked map symbols presenting additional information (e.g. Lol@). The final map representations incorporated in the case studies were the *3D maps* employed within WebPark. These provided a 3D view of the user's position (including altitude) and progress along a route.

Table 3.3 The cartographic representations techniques employed by various mLBS-related projects.

Geospatial Information Representations	Cartographic Forms	Cross-cutting Features
Cyberguide (1995-1997)		
A central map used to support user navigation and knowledge of physical surroundings, incorporating: • pan and zoom functionality; • a single symbol conveying user location and orientation; and • POI symbols, distinguishing those visited from those not visited; hyperlinked to information about the object being represented.	• Base / thematic maps • Map signs & symbols	• Interactivity • Adaptation
HIPS / Hippie (1997-1999)		
Selection and multimodal presentation of information, automatically adapted / personalised to the current context (device, network, location) and user model (knowledge, interests, browsing history); integrated with: • maps – to support user orientation and guidance; featuring user location and nearby exhibits; • spoken language – to provide guidance for pre- and self-defined tours (incorporating nearby and visited objects); and • sound (earcons) and 'blinking' icons – to draw attention to nearby items of potential interest.	• Base / thematic maps • Map signs & symbols • Diagrams • Natural language (spoken) • Sound	• Dynamism • Interactivity • Multimodality • Adaptation
GUIDE (1997-1999)		
Adaptive hypermedia, based on user models and context, incorporating: • maps – for navigation; choice of overview and detail scales; • thumbnail images of nearby objects – to aid identification and/or user localisation; and accompanied by related text (e.g. street name); • text-based instructions – for navigation, accompanied by images and information related to the current location; and • sorting of attraction lists based on current accessibility and previous visits.	• Base / thematic maps • Route maps • Map signs & symbols • Photographs • Natural language (written)	• Interactivity • Adaptation
CRUMPET (2000-2002)		
Interactive maps including user location, sights of interest and/or tours; personalised / adapted according to the user model (demographics, interests, abilities), user location and current task; adaptation applied to: • map style (culture-specific); • feature generalisation; • map orientation; and • map focus (i.e. Focus Maps).	• Base / thematic maps • Route maps • Map signs & symbols	• Interactivity • Adaptation

Table 3.3 (cont.) The cartographic representations techniques employed by various mLBS-related projects.

Geospatial Information Representations	Cartographic Forms	Cross-cutting Features
Lol@ (2000-2002)		
Central maps incorporating: • multimodal interaction (clickable icons/links/buttons, menu selection, spoken commands); • overview and detail scales (distortion of the y-axis in overview maps to enlarge the view area); • interactive routes and route segments, user position (shown as a circular 'area'), places already visited; and • category and dedicated (e.g. recognisable landmark silhouettes) map symbols, with hyperlinks to multimedia content. Also, multimedia information about routes (images, text and audio instructions).	• Base / thematic maps • Route maps • Map signs & symbols • Photographs • Natural language (written, spoken)	• Interactivity • Multimodality • Adaptation
WebPark (2001-2004)		
Geospatial content personalised / adapted to the location, time and user profile (demographics, interests and automated analysis of the user's spatio-temporal behaviours); represented as: • interactive maps, cross-sections / profiles and 3D terrain models – for visualising user position and routes; and • thematic maps – for visualising wildlife distributions. Also, maps and text-based descriptions of 'geospatial scope' categories for setting the geospatial context of species-related queries.	• Base / thematic maps • Route maps • Map signs & symbols • Diagrams • 3D maps	• Interactivity • Adaptation
GiMoDig (2001-2004)		
Context-adaptive maps with an accompanying map symbol library; level of detail, map style and symbols generalised and personalised according to: • device; • user identity (user-specified language and age group); • use case; and • time (season).	• Base / thematic maps • Route maps • Map signs & symbols	• Interactivity • Adaptation

Moving on to map-related representations, Table 3.3 identifies that four of the seven case studies documented the use of techniques other than maps and map signs & symbols. Firstly, both HIPS and WebPark made use of *diagrams*, with the former applying these in a relatively subtle manner as animated icons drawing the user's attention to objects within their vicinity, and the latter employing more sophisticated 2D terrain cross-sections, having a similar function to the associated 3D terrain models. Secondly, *photographs* were employed by two projects, with both GUIDE and Lol@ using images to assist users in determining their location and/or identifying nearby objects. Thirdly, three of the case studies made use of context-aware *natural language* for the representation of route guidance information: while GUIDE employed primarily *written text* and HIPS used *spoken words*, Lol@ utilised both in support of the navigation task. Finally, the aforementioned animated icons in the HIPS interface were accompanied by the only example of non-speech *sounds* within the range of projects. These were in the form of earcons, having the same purpose as the animation of drawing the user's attention.

With respect to the Cross-Cutting Features identified in Table 3.1 and elaborated in Section 3.2.2.3, each was covered by the various projects. To begin with *dynamism*, this was perhaps the least employed feature, with only one example documented in the form of HIPS' animated icons (described above), which used the dynamic variables 'rate of change' and 'duration' to draw users' attention to information, based on geospatial triggers. Mentioned briefly with relation to map representations, *interactivity* was inherent in each of the prototype systems (to differing degrees), although specific non-map examples of interaction for accessing geospatial information were not detailed in the literature. In general terms, however, interaction (particularly through hypermedia) appears to have been variously employed to enable users to: manipulate map views; access more detailed information about objects distributed in geo-space; search for and sort objects using geospatial parameters; define route start, stop-off and/or end locations; and specify personal characteristics for use as adaptation parameters. True *multimodality* was employed by just two of the case studies, combining the visual and auditory modalities. While HIPS used multimodality to minimise the need to look at the device's screen, thus keeping the user's visual attention "free for the physical environment" (Oppermann & Specht 1999), Lol@ implemented it (along with multimedia in general) in an attempt to "increase the acceptance of [mLBS] applications in terms of user appreciation" (Gartner 2003, p.392). Although not considered multimodal, other projects incorporated visual multimedia into their geospatial information representations, capitalising on some of the same benefits attributed to multimodality (e.g. provision of information redundancy; emphasis of important information leading to storage in long-term memory; and flexibility of geospatial information access and interaction). An example of this was WebPark's provision of a choice between maps, cross-sections and 3D terrain models for visualising position and progress along a route.

The final cross-cutting feature – *adaptation* – was applied throughout the various interfaces. As introduced in Section 3.3.1.1, the constraints of the mobile medium led each of the projects to propose and/or implement context-awareness, in order to simplify patterns of interaction and reduce the cognitive effort required by untrained users during use (Broadbent & Marti 1997; Zipf & Richter 2002). By far the most emphasis in this respect was on the dynamic selection and display of non-geospatial content according to contextual parameters. In some cases, however, this also involved adaptable or (more commonly) adaptive maps, which were incorporated into interfaces both to represent and simplify often complex geospatial information. To this end CRUMPET, WebPark and GiMoDig featured dynamic generalisation and/or personalisation of map style, behaviour, symbols and content to contextual parameters such as current location, task(s), time, device and the user's profile (including demographics, interests, abilities and previous geospatial behaviours). Of particular note, CRUMPET introduced the concept of Focus Maps (see Figure 3.7), whereby the map areas/aspects deemed to be of current interest to the user were displayed in a dominant manner[5], thus drawing attention (i.e. 'focus') to these while easing the map reading process. Further adaptation involved a small range of map-related representations (although little information was published regarding these) including: written/ spoken route directions with only relevant objects incorporated; diagrams and images related to the current location; and text-based lists sorted according to relevance. To obtain the contextual parameters enabling these various adaptations, most projects employed simplistic means (e.g. asking the user for input; making assumptions; relying only on location). In some projects, however, intelligent agents were also employed to gather the relevant information – not only by automatically detecting the user's current location and the location of objects in the surrounding environment, but also by learning from the user's past behaviours to ascertain their current interests and preferences (e.g. GUIDE, CRUMPET).

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As identified previously, it is important to ensure *usefulness* in the communication of geospatial information through mLBS applications, in order to meet users' needs and expectations and ultimately contribute to the overall success of the end-product. The design of the cartographic component of the UI is therefore paramount, with one of the most important aspects arguably being the selection of representation, presentation and interaction technique(s) to be employed. During this process there are many factors to consider, most notably the context of use – i.e. end user needs, preferences, abilities, tasks and usage environment – as well as more practical considerations, such as the capabilities of the delivery medium, data format availability, time constraints, developer expertise and so on. While the above discussion provides a comprehensive summary of the cartographic representation techniques employed within each of the case studies, unfortunately limited information could be found concerning the selection of and justification behind these – apart from the dominant use of maps seemingly based on traditional practices and researcher-biased assumptions (as opposed to the needs of the end user):

[5] Accomplished through varying degrees of map feature generalisation or omittance (with more detail shown in the most relevant area), and 'fading out' colours with distance from the region of interest.

> *"maps are of major importance [for mLBS applications] as they express a lot of information in a single representation" (Zipf & Richter 2002, p.35).*
>
> *"[in the context of mLBS] maps play an important role, as they are the most effective method for presenting and transmitting spatial information" (Uhlirz 2001).*

Whatever the reasoning behind the researchers' choices, however, it appears that little emphasis was placed on determining the suitability of specific cartographic representation forms for the tasks to which they were applied; except perhaps in the case of GiMoDig where early usability testing of national topographic maps on mobile devices was conducted with the aim of identifying their main advantages and obstacles prior to implementation. Similarly, there seems to have been minimal exploration or comparison of alternative cartographic techniques for representing the same geospatial information, with the only clear examples relating to map components:

- CRUMPET considered culture-specific map colour schemes and context-dependent map orientations.
- Lol@ discussed different mapping techniques for (a) supporting user orientation – including varying orientations (north up vs. largest route extension parallel to longest screen side), changes in scale across the display, inclusion of recognizable landmark silhouettes and y-axis distortion to enlarge the view area – and (b) conveying the accuracy of the user's position – including symbolisation using a circular 'area' vs. a point symbol.

In spite of this, all of the projects *were* specifically concerned with meeting end user needs within their final system design and in doing so (at least in some cases), identified requirements relating to the representation of geospatial information within the proposed mLBS application. This is discussed further in the next section, which focuses on the case studies' overall treatment of use and user issues.

3.3.1.3 User-focused research methods

Almost all of the mLBS case studies implemented some formal method of pre-design user requirements gathering, often involving potential users, the main purpose of which was to determine **what** content/information was required for the service, with less emphasis on **how** it should best be communicated to users – refer to the left-hand column of Table 3.4. Specific instances where (cartographic) representational decisions were made based on the collected user requirements include: HIPS – where a preference for more information media, including maps, navigation and signs was uncovered; and WebPark – where researchers identified an interest in visual media for orientation and navigation, an apparent need for thematic maps and route profile visualisations, and a general aversion to audio alerts and spoken content.

Table 3.4 User-centred methods employed by the various mLBS-related projects (derived from the literature referenced throughout Section 3.3.1.1).

Pre-Design User Requirements	System Evaluation
Cyberguide (1995-1997)	
Maintained an 'applications focus'.	The entire project was based around rapid, iterative prototyping, producing numerous prototypes varying in certain critical features. • Usability testing was undertaken on each prototype, involving real users. • User feedback and researcher reactions were incorporated into subsequent iterations, including modifications to the hardware and software, to improve functionality.
HIPS/Hippie (1997-1999)	
Requirements Analysis to identify the limitations of traditional museum/ tourist information systems and define end user characteristics, information needs and usage scenarios. Involved potential users and stakeholders.	Early evaluations provided feedback on the Hippie concept as well as recommendations for improving content and the UI: • Formative – Human Factors experts and a domain expert. • Summative – domain experts (artists, educators, curators). Evaluations were planned involving real users interacting with the prototypes, to measure task completion times, success rates, errors and satisfaction. Little information regarding the results of this could be found.
GUIDE (1997-1999)	
Ethnographic study to collect end user information requirements, involving: • interviews with staff at Lancaster's Tourist Information Centre (TIC); and • observation of the information needs of TIC visitors.	• Expert walkthrough for a first-pass evaluation of system usability; involved experts from user-centred design and computer-supported learning. • Field trials involving real users, to validate and refine the initial set of requirements and measure the quality of the user experience.
CRUMPET (2000-2002)	
• The researchers contended that users could only confidently express their needs and requirements once they have had personal experience with innovative technology. • User requirements were determined in retrospect, following prototype construction and evaluation.	A standardised usability questionnaire in conjunction with field trials involving real users, to validate the system and approach: • users were surveyed on their needs and habits, as well as the usefulness/value of the overall system.
Lol@ (2000-2002)	
• A formal user needs analysis was considered 'out of scope'. • Assumptions of tourist behaviour were derived from other research projects (notably Cyberguide and GUIDE), written tour guides and electronic navigation tools.	• An early, non-functional prototype was presented to the project team for feedback and suggestions for refinement. • A trial of the system was planned for mid-2002, including the identification of usability issues by students of a UI design and usability course. No information on the conduct or results of this trial could be found.

Table 3.4 (cont.) User-centred methods employed by the various mLBS-related projects (derived from the literature referenced throughout Section 3.3.1.1).

Pre-Design User Requirements	System Evaluation
WebPark (2001-2004)	
Questionnaires with/shadowing of park users assessed end user needs and preferences for specific information.	A field-based evaluation of the prototype, involving real users, focused on the initial user experience/perceptions and technology capabilities. • Maps, map functionality and route profiles were tested, among other things. • Little information on the conduct or results of the evaluation could be found.
GiMoDig (2001-2004)	
• User requirements, relating to topographic data sets, mLBS and mobile services in general, were anticipated via a comprehensive 'desk study' into existing services, literature and external study results. • Field-based usability testing of national topographic maps on mobile devices was conducted with potential users.	HCI research methods were employed throughout, with user requirements updated and issues corrected via iterative prototyping: • Heuristic and expert evaluations of maps within the prototypes, involving project members and other cartographic experts. • Intuitiveness of POI symbols evaluated by users. • Usability testing of prototypes with real users; no information on the conduct or results of this process could be found.

In terms of users' specific geospatial information requirements, GiMoDig was the only project to actively concentrate on gathering this type of data prior to the design of their prototype service. While the desk-based user requirements analysis identified common user groups and created a representative categorisation of usage scenarios for mobile map data, the user testing of topographic maps uncovered (among other things): expected benefits in the combination of external information with map data; a desire for maps to display the user's current location, alternative routes, route characteristics and the location of other users; the need for map orientation to adjust to the direction of travel; and a general classification of use contexts for the adaptation of maps. Additional to this, the gathering and analysis of user requirements by the various projects generated other less specific, yet valuable findings relating to the communication of information in general through mLBS applications. The formal ethnographic study within GUIDE, for example, revealed requirements for supporting the information needs of users such as the provision of: sufficient flexibility in the information access to cater for different user preferences; user-controlled interaction with the system; tailoring of content and its presentation to the personal and environmental context; support for dynamic, time-critical information; and support for interactive services. Similarly, WebPark's needs assessment identified a requirement for users to maintain control over the information content and its delivery (e.g. push vs. pull, visible vs. audible), as well as their own privacy and security. Finally, the HIPS researchers provided justification for the widespread practice of collecting users' information preferences and behaviours for typical scenarios of use, identifying that such details not only provided "insights about needs, difficulties and motivations people have in particular contexts", but also served to identify "the features of potential users that may be exploited to adapt the system's behaviour" (Broadbent & Marti 1997).

Considered common practice for assessing the utility and usability of a computer-based system, the right-hand column of Table 3.4 summarises the techniques employed by each of the case studies for evaluating their prototype service. While formal evaluations involving real users provided an opportunity for each project team to assess the suitability of the cartographic representations employed, it appears that very few undertook this in a focused and comprehensive manner (if at all), and certainly none of the case studies recounted the comparison of alternative cartographic representation forms. In fact most of the evaluations were aimed at assessing generic system usability only, excepting those conducted by WebPark and GiMoDig which additionally targeted their component maps/route profiles and maps/map symbols, respectively. Unfortunately little information was available relating to WebPark's evaluation findings, the only noteworthy result being that test users considered the "display of [their] position on different media (map, profile or DTM)" to be "innovative" (Krug *et al.* 2003, p.29). Slightly more insight was gained for GiMoDig, however, whereby the heuristic and expert evaluations identified issues with: map symbol colours and thicknesses, distinctions between map symbols, legibility of map features, and association and harmony of symbol colours between different maps; while the POI symbol intuitiveness tests uncovered usability-related problems in users' understanding of what certain symbols represented. Notably, neither of the projects' published literature discussed real user impressions of the utility, effectiveness and efficiency of, or levels of satisfaction with, the cartographic representation forms employed.

Although not their focus, a number of case studies uncovered issues during their broader system evaluations that related directly to the cartographic components of their prototype services. One of these was Cyberguide, where negative user feedback was encountered regarding: the high level of detail in its maps (considered too much for maintaining context when using a small screen); the absence of dynamic information in the map presentations; and the lack of support provided for following routes and finding POIs. Similarly, test users of CRUMPET generated a list of requirements for map representations, including: greater detail so that the representations more closely matched the real world; the inclusion of textual route descriptions (i.e. additional to route maps); simple and direct map manipulation/interaction for zooming, panning and displaying/hiding specific objects; and alternative map orientations (north-up vs. orientation in the direction of travel). Finally, findings from GUIDE's evaluations provided vindication for their decision to include maps for navigation: "from early trials with the system it soon became clear that a significant portion of visitors want to view a map at some point in their visit" (Cheverst *et al.* 2000, p.20).

Despite minimal emphasis being placed on cartographic representation techniques, most of the projects succeeded in improving the usefulness of their systems, overall, by evaluating potential design solutions (in the form of prototypes) against the user requirements identified prior to the design, analysing the outputs of these evaluations and making improvements to the design/prototype based on their findings. This overall process of user requirements gathering, context of use specification and iterative design and evaluation – commonly referred to as human- or user-centred design (UCD) – is often used in the development of applications which require the adaptation of new technologies (Broadbent & Marti 1997). With this knowledge, the different projects were categorised according to their application of UCD activities:

- formally adopted UCD as the project methodology – HIPS and GiMoDig;
- followed an informal UCD process – GUIDE and WebPark;
- implemented iterative prototyping and evaluation only (both formal UCD activities) – Cyberguide and CRUMPET (the latter also gathered user requirements but only after designing, developing and evaluating the system); and
- did not appear to incorporate any formal UCD activities – Lol@ (although a usability evaluation was planned, no published record was found regarding this).

Where followed (even if only in part) UCD not only provided the projects with a framework for ensuring usefulness in their final systems, it also assisted in the generation of valuable insights and recommendations for the design of mLBS applications and mobile systems in general. In cartographic terms, a particularly important outcome from the projects comprised the steps taken towards defining design and adaptation guidelines for maps presented on small screen devices in mobile contexts (e.g. CRUMPET, WebPark and GiMoDig) – a component of cartographic theory that is currently lacking (Voller *et al.* 2005). And for mLBS applications in general, user demand for/acceptance of context-aware information systems was confirmed (Cyberguide, HIPS and GUIDE), while a particularly important application design recommendation was made:

> *"Designers need to be careful when deciding to pre-empt the information requirements of users based on current context … when we restricted the information available to visitors, such that they could only access information on the attractions at their current location, some visitors became frustrated because they could not query the system on things visible in the distance"* (Cheverst et al. 2000, p.24).

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From the above discussion it is clear that researchers in the field of mLBS consider use and user issues to be of great importance to the design of useful mLBS applications. It is evident, however, that there has been a general lack of pre-design focus on establishing user requirements for the communication of geospatial information in particular, combined with minimal comparison and evaluation of (alternative) cartographic representation, presentation and interaction techniques for specific geospatial tasks. The next section continues the review of existing research by describing one further project which identified similar needs for mLBS research, ultimately taking an approach focused on advancing cartographic theory.

3.3.2 Mobile cartography

Building on the experiences of research projects such as those discussed above, Reichenbacher (2001) set out to elaborate a conceptual framework for the emerging cartographic research field he termed 'mobile cartography'. In doing this he had a number of aims:

- to extend the theories and approaches previously applied in isolation within the broader field of Cartography to the application domain of mobile computing;
- to emphasise the need and potential of adaptation methods within the realm of mobile cartography; and
- to elaborate adaptive methods for the visualisation of geospatial information for mobile usage (Reichenbacher 2003; Reichenbacher 2004).

From the outset, Reichenbacher identified adaptation to context parameters as the core element of mobile cartography (Reichenbacher 2001), hypothesising that by introducing adaptation mechanisms into geovisualisation services (akin to mLBS for the purposes of this review), the usability of geospatial information on mobile devices could be significantly improved (Reichenbacher 2004). This would be accomplished, he claimed, by offering "visualisations of [geospatial] information with the greatest possible ***relevance*** to the mobile user" in their current context, in order to support their activities within 'geo-space' (p.62). Reichenbacher took a comprehensive approach to context modelling, identifying several interdependent dimensions for the purposes of mobile cartography – *situation (location and time)*, *user*, *activities, physical environment (e.g. weather conditions), information and system (network bandwidth, device characteristics)* – and made first steps towards the formalisation of context parameters for mobile users (Reichenbacher 2007; Reichenbacher 2004). During his investigations into adaptive geovisualisation design, Reichenbacher adopted a generic User Model – based on a 'mobile user stereotype' and mobile geospatial information usage scenarios – along with a Task Model (modelled using Activity Theory), consisting of basic mobile user actions having geospatial relevance (i.e. locating, navigating, searching, identifying and checking), which he claimed were "more likely [than a user model] to be the common ground for adapting to" (Reichenbacher 2004, p.70). He also identified four domains for adaptation to context – content, presentation, UI and technology – acknowledging that his research was limited to the adaptation of content and the presentation form only (Reichenbacher 2003).

Despite his claims that "depending on the usage context and the information content of the answer [to a mobile user's problem], a map might not be the adequate presentation form" (p.87) and that "there are usage situations in which an alternative modality is more appropriate than the visual" (p.96), Reichenbacher (2004) limited his research scope to the investigation of adaptive mobile maps and map-like *visualisations*, stating that "the visual remains vital for cartography" (p.7). In pursuing this he identified a range of map adaptation objects (i.e. aspects that can potentially be adapted), grouping these under: features, interaction, functions, layout, style, graphics and text. He then went on to identify, among other adaptation strategies, numerous graphical means for visually emphasising the importance, order, accessibility and/or (data) quality of map features in a given context (see Figure 3.11 for example map views):

- highlighting/emphasising using a different or brighter colour (colour, hue, value);
- emphasising symbol or outline size (size);
- enhancing the contrast between feature and background (colour, value);
- increasing feature opacity while decreasing opacity elsewhere, and vice versa (opacity, transparency);
- focusing a feature while blurring others (clarity, focus, crispness);
- enhancing the level of detail;
- animation (e.g. blinking, rotating, increasing/decreasing size);
- overlay of transparent buffers/zones; and
- change in map scale (Reichenbacher 2004; Reichenbacher 2007).

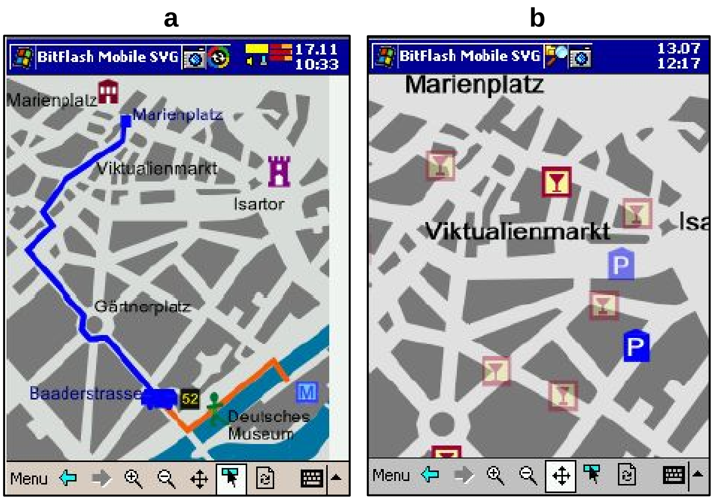

Figure 3.11 Examples of mobile map adaptation to specific user actions within mobile cartography: (a) navigation, incorporating colour highlighting; and (b) check object states, incorporating feature opacity (Reichenbacher 2004).

The research products from Reichenbacher's study into mobile cartography were twofold. In practical terms he developed a very basic mobile geovisualisation service prototype – consisting of adaptive mobile maps enabling the display of POIs, landmarks, routes, locations (people/objects/events) and search results (people/objects/events) – which yielded recommendations for the design of mobile maps:

- low information density;
- high generalisation degree;
- primacy of relevance over completeness;
- poster-like style;
- unobtrusive map base;
- drastically enlarged minimal dimensions;
- no fine design elements from paper maps – no patterns and contours;
- colour as main design element (value and saturation), but not too many colours in the same map;
- thrifty use of text (only sans-serif fonts); and
- self-explaining, pictogram-like symbols (Reichenbacher 2004, p.134).

Perhaps more important, however, were the study's theoretical findings, including a new and comprehensive conceptual framework for mobile cartography (Figure 3.12) and a definition for the field:

> *"theories, methods, and technologies of dynamic and adaptive cartographic visualisation of geographic information and its interactive use on mobile devices where visualisation is adapted to either one or all components of the actual usage context (location, time, user, activities, information, and system)"* (Reichenbacher 2004, p.60)

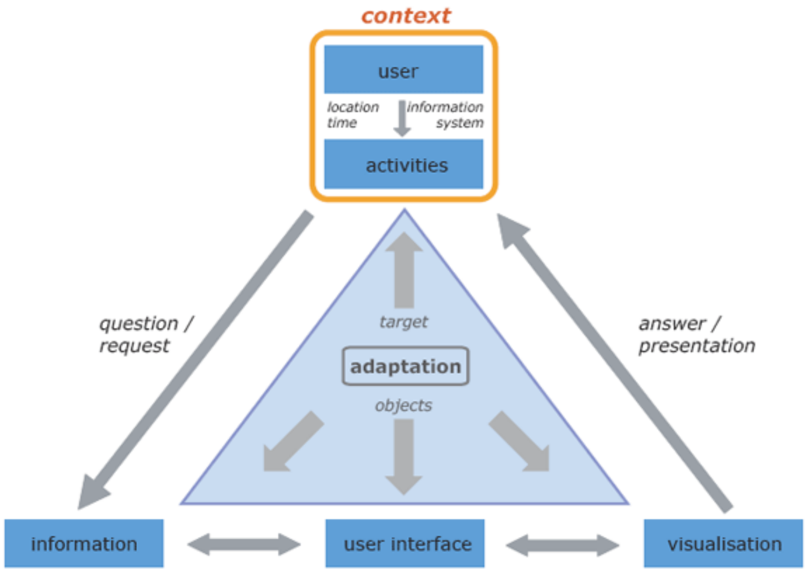

Figure 3.12 The conceptual framework of mobile cartography (Reichenbacher 2004, p.62) – "an instrument for the design of useful and usable geovisualisation services" (p.iii).

Through his research, Reichenbacher made numerous advances on previous approaches within the field of mLBS applications. In particular, his study was concerned not only with providing support for mobile users' geospatial activities, but also with guaranteeing usefulness in mobile geovisualisation services in particular: "most projects and commercial solutions implement what is technically feasible. It is not reflected whether it is sensible, useful or appropriate for the mobile environment" (Reichenbacher 2004, p.53). In terms of specific results, he provided a detailed treatment of (autonomous) adaptive geovisualisation for mLBS, recommending the formalisation of context (and undertaking initial steps towards this) so that specific design rules may eventually be associated with recognised contexts. Furthermore, he incorporated cartographic representation needs into his scenario-based identification of mobile geospatial information usage and potential user requirements for new geovisualisation services with adaptation capabilities.

By his own admission, Reichenbacher's work was an introduction to "a broader view of cartography for mobile users" whereby the proposed Multimedia Cartography framework and adaptive geovisualisation concept "are still far from being exhaustive and can be refined in many dimensions" (Reichenbacher 2004, p.152). Specific areas where the research leaves openings for further investigation may be identified. First, while identifying the need to apply appropriate cartographic representation forms to each given context and suggesting that alternative techniques, incorporating multimodality and multimedia, may improve the overall efficiency of the communication process, Reichenbacher limited his research to visual and largely map-based representations, thus ignoring the many other representational possibilities. Next, his purposeful restriction of the study to adaptive geovisualisation within the domains of *presentation* and *information content* only neglected the UI of the service – a domain that is arguably vital to the access, behaviour and display of component cartographic representations. Finally, the theoretical approach of Reichenbacher's research – combining Activity Theory, Context Theory, HCI, Cognitive Theory and scenario-based design – whilst thorough and informative, did not involve any interaction with the potential users of mobile geovisualisation services (e.g. for verification of the user-focused research findings) nor did it focus on user-specific needs, preferring instead to concentrate on basic mobile user actions. This was seen as a particular drawback, with user requirements identified solely through scenario-based design and Activity Theory, and no formal evaluation of the adaptation techniques (apart from a subjective judgement performed by Reichenbacher himself).

Before discussing where the current research lies with respect to mobile cartography and the mLBS case studies, it is important to round out the review of existing research by revealing the lessons to be learned from a field that can in many ways be considered the pre-cursor to mLBS.

3.3.3 Vehicle navigation systems

Vehicle navigation systems (VNS) – also known as satellite navigation or route guidance systems – comprise digital technologies installed within automobiles, that assist drivers with routing and navigation tasks through an accurate knowledge of their location and the location of objects around them. Although traditional VNS differ from mLBS in important technological respects (e.g. dedicated devices, comparatively larger screens, sophisticated positioning techniques, ample power supplies), there are obvious similarities between the two mobile application domains, particularly when mLBS applications centred on *personal navigation*[6] are considered. Coupling this with the large body of research concerning the presentation of geospatial information within VNS, it is thus relevant to look briefly at the insights offered by this field for the design of useful cartographic representations for mLBS applications.

Initially proposed in the 1960s, with the first systems built during the 1980s, today's commercially-available VNS comprise numerous components in their provision of route planning and guidance functionality: multiple positioning methods (e.g. gyroscopes, compasses, dead reckoning and/or GPS); digital map databases; map-matching; wireless connections enabling the incorporation of real-time data (e.g. traffic, weather); and multimodal human-machine interfaces (HMIs) providing visual, audio and even haptic user interaction and guidance

6 A class of mLBS that are primarily concerned with determining the location of a user and guiding them along their requested route, taking into account the available modes of transport (Rainio 2001).

(Zhao 1997b; Rainio 2001). While each of these has been the subject of much research over the past two decades, perhaps the most intensive work has concerned the usability and utility of the HMI component of VNS. Undertaken within the realm of human factors research, numerous facets of the HMI have been studied, with a focus on improving driver safety – by minimising the visual and cognitive load on the user – as well as maximising system performance and ensuring comfortable and effective use (Burnett & Porter 2001; Zhao 1997a). The following provides an overview of the main research areas within the field of VNS (based on Burnett 2000):

1. **Voice Interface** – spoken guidance (i.e. 'turn-by-turn') messages.
   - The benefits of using the auditory modality in conjunction with visual displays to reduce the need for drivers to look away from the road scene.
   - The advantages and limitations of digitised (i.e. pre-recorded, more natural) vs. synthesised (able to incorporate greater geospatial content) speech output.
   - The inclusion of landmark information within manoeuvre instructions over strictly ego-centred directions and absolute distances.
   - Issues in the collection/maintenance of landmark information and the effective presentation of such through voice messages (and visual displays)[7].
   - The timing of turn manoeuvre messages, including whether they should be based on fixed distances and/or vehicle speed.
2. **Visual Interface** – displayed guidance information.
   - The benefits of using the visual modality to explain complex turn manoeuvres – e.g. by showing turn arrows, intersection shapes and distance to manoeuvre. [8]
   - The relative advantages and disadvantages of large, complex displays (commanding greater visual attention) vs. small, simple displays (resulting in more navigational errors).
   - The value of turn-by-turn guidance (i.e. simple symbol/voice systems) over map-based displays in reducing navigational errors and distraction from the driving task.
   - The appropriateness of maps in certain situations.
   - The positioning of the display with respect to the driver's natural line of sight.
   - The potential of Head Up Displays for minimising load on the visual modality – "allow[s] the user to continue attending to the outside scene whilst taking in information more quickly from a display" (p.3.1.7).
3. **Control Interface** – mechanisms for inputting to the system (i.e. for data entry, option selection, information request/repeat and movement through the system).

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[7] Supplemented by Ross (2003).
[8] Supplemented by Zhao (1997a).

- The limitations and benefits of different types of manual control – e.g. finger joysticks, pushbuttons, toggle switches, rotaries, touch screens.
- The need for certain/all control functions to be disabled when a vehicle is moving.
- The potential of speech recognition technology to reduce visual and mental demands by enabling drivers to operate certain navigation functions 'hands- and eyes-free'.
- The need to make those control functions of highest priority to the user more readily accessible within the interface.
- The potential for haptic (i.e. tactile and kinaesthetic) cues to remove reliance on the visual and auditory systems, provide more 'natural' interaction and ultimately increase usability and acceptance.[9]

While abundant guidelines and recommendations for maximising the usability and safety of VNS have resulted from such research (see Nowakowski *et al.* 2003 for a full list of references)[10], it is useful to present a selection of those specifically related to cartographic information needs, representation forms and interaction techniques, which may prove applicable to mLBS applications:

- Ensure a consistent, simple, non-distracting interface design that makes minimal use of the human visual sense (Green 1996; Zhao 1997a; Dingus *et al.* 1998; Burnett 2000; Burnett & Porter 2001).
- The display content should be limited to the necessary information only – i.e. the next manoeuvre, distance to the next manoeuvre, applicable road names and manoeuvre direction/angle (Green 1996; Zhao 1997a; Dingus *et al.* 1998).
- Turn-by-turn guidance instructions should be provided using multimodal techniques – specifically a complementary combination of visual display and voice output (Green 1996; Dingus *et al.* 1998; Burnett 2000).
- Landmarks (e.g. traffic lights, petrol stations, churches, post offices), in addition to distance-based information, should be included within guidance instructions (Green 1996; Zhao 1997a; Burnett 2000; Ross 2003).
- The maximum text-based display character height should be based on the 'James Bond Rule' – i.e. "the visual angle subtended by a character (its height divided by the viewing distance) [should] be greater than or equal to 0.007 radians (Green 1996, p.157; Zhao 1997a).

9 From a more recent publication by Burnett & Porter (2001).

10 Note, the reference contained within this paper for the content of all guideline sets is now located at www.umich.edu/~driving/guidelines/guidelines.html (last accessed on 12 June 2007).

- Speech recognition should be avoided for safety-critical inputs – at least until the technology becomes more reliable for multiple users and noisy environments (Zhao 1997a; Burnett & Porter 2001).
- Interaction with the system while driving should be limited or prevented (Zhao 1997a; Dingus *et al.* 1998; Burnett 2000).
- Those navigation functions likely to be used frequently during a journey and/or that have the greatest impact on driver safety should be made readily accessible and easy to perform (Zhao 1997a; Burnett 2000).
- Maps should only be used as an additional information source and not as the sole guidance tool, with symbolic displays (e.g. large turn arrows) and voice instructions (e.g. "turn left in 50m") more appropriate for this purpose (Burnett 2000; Rogers 2003; Zhao 1997a; Dingus *et al.* 1998).
- Viewing of detailed route maps (recommended for certain situations – e.g. to assist in route planning; for an overview of the current location with respect to landmarks and the final destination) should be restricted to when the vehicle is not in motion (Zhao 1997a; Dingus *et al.* 1998; Rogers 2003).
- Where maps are displayed, for navigation or other:
  - 3D perspective views (similar to what a driver sees through the windshield) should be considered in place of traditional 2D 'bird's eye' views (Spoerri 1993; Zhao 1997a).
  - Map orientation should be 'north up' during planning and overview tasks, but should adapt to the driver's spatial orientation (i.e. 'heading up') when following a route (Mashimo *et al.* 1993; Green 1996).

Particularly relevant to the current research is the emphasis within VNS research on taking a human factors approach to the design of systems, including the techniques employed for representing, presenting and interacting with the underlying geospatial information. Like mLBS, early work in VNS was characterised by technology-driven development before the importance of ensuring usefulness in the final product was realised (Rogers 2003). Since then, a focus on UCD has prevailed, resulting in systems that have high levels of consumer acceptance (e.g. Tom Tom, Navman, Garmin products). In particular, the importance of determining and analysing system-specific user needs for geospatial information and its representation has been highlighted – refer to Green (1996), who noted regional differences in direction-giving and preferred presentation techniques between Japan and the US – while Ross & Burnett (2001) provide similar vindication for iterative system design and evaluation through their comprehensive review of VNS evaluation methods, recommending as a minimum (for ubiquitous computing products in general) user-based testing involving real tasks in real contexts, followed by redesign based on the results. Considering this and the results of such user-centred studies, the implications of VNS research for mLBS design are well summarised by the following:

> *"A key lesson or challenge … then is to approach each application as a unique situation; designing the user experience accordingly rather than always assuming that a map is required and then solving the inherent problems with this."* (Rogers 2003, pp.5-6)

3.4 Implications for the research

Having set the scene for the useful communication of geospatial information through mLBS applications, and explored the achievements of existing and related research, it is now appropriate to discuss the overall implications of this, thus defining the research focus and approach to be taken by the current study.

A key motivation for the current research is the need to ensure the usefulness (utility and usability) of the techniques employed to communicate geospatial information through mLBS applications to non-expert users. Evident from the preceding discussions, such a viewpoint is widely upheld by others working in similar and related fields: "a mobile map will not be accepted by its user unless it is immediately usable" (Meng & Reichenbacher 2005, p.5). However with much of the existing research generally focused on the design and development of specific cartographic representation forms (predominantly maps), the overall system design (i.e. with little emphasis on the geospatial components), or some disjointed combination of both, it may be argued that a new approach is required which consolidates the two perspectives by seeking to ensure the usefulness of the **cartographic UI** for mLBS applications – encompassing the selection/design of techniques for representing, presenting and interacting with required geospatial information *and* methods of access to such. It is here that the current research is positioned, with a focus on users and their experiences with the cartographic UI as opposed to more technical, implementation-based issues.

Looking to specific aspects of the study, an important message to be taken from the existing research is that, in order to ensure their usefulness, the cartographic UIs of mLBS applications need to support (and adapt to) user-based aspects of the mobile context, in particular users' geospatial information requirements and tasks, as well as their interests, knowledge, preferences and cognitive abilities. It may be argued, however, that apart from a small number of studies concerned with trialling different representation forms to support users' navigation and wayfinding tasks (Gartner & Radoczky 2007; Gartner & Uhlirz 2005; Rakkolainen & Vainio 2001; Laakso *et al.* 2003) the majority of existing mLBS applications have employed particular cartographic representation techniques out of convenience, technical feasibility and/or novelty, rather than any detailed consideration of their suitability to the users and tasks they are intended to support; nor has their suitability been thoroughly evaluated within the end product. A need can therefore be identified for determining the utility, or *appropriateness*, of specific cartographic representation forms for a range of users and tasks (beyond navigation and wayfinding), in addition to ensuring their usability. While this may be accomplished to some extent through "empirical research … to find mappings from typical activities to most commonly used information types and presentations" (Reichenbacher 2004, p.153), the diversity of possible mLBS users and uses signals a necessity to trial and assess the suitability of selected cartographic representations for each given application. Moreover, an expectation that different representational approaches may be appropriate for the same task, depending on the current context of use (i.e. user, situation, environment, information), highlights the importance of comparing *alternative* representation, presentation and interaction techniques during design.

With an outstanding need for cartographic guidelines addressing the effective design of 'mobile maps' (Voller *et al.* 2005; Gartner & Uhlirz 2005), it is therefore not surprising that much of the existing research has concentrated on the design and development of map-based representation forms for communicating geospatial information via mLBS applications: "maps remain the most popular communication language of spatial information also for mobile applications" (Meng 2005b, p.5). Indeed, an entire book has been devoted to the subject, entitled *Map-based Mobile Services: Theories, Methods and Implementations* (Meng *et al.* 2005). Acknowledging this, it seems appropriate to build on such work, rather than repeat it, by exploring the potential of *additional* techniques for mLBS-based cartographic communication, with the range of representation forms and cross-cutting techniques considered relevant to the research identified in Section 3.2.2. In particular, the research will seek to address a perceived need for more applied research comparing alternative representation forms with one another, in order to determine which techniques – or combinations thereof – are most appropriate and useful for given users and tasks[11]. In addition, based on the general acceptance that adapting the presentation to the current context is required for mLBS applications "in order to improve [their] intelligence and usability" (Nivala & Sarjakoski 2005), the potential of this for the cartographic UI of mLBS will also be considered, both in terms of adaptation *within* particular representations and that *between* alternative techniques.

[11] While it is acknowledged that new techniques not previously applied to cartographic representation may yield novel and useful approaches for cartographic UIs within mLBS applications, this is considered outside the scope of the current research.

A final and particularly compelling lesson from both the existing mLBS-based research and the field of VNS, is the value of taking a user-centred approach for the design of useful cartographic UIs. This involves the application of methods traditionally associated with desktop computing UI design to the realm of mLBS, with Sarjakoski & Nivala (2005) providing justification: "a map on a mobile device can be treated as a graphical user interface (GUI), from which it follows that the methods used in human-computer interaction (HCI) can also be brought to cartography" (p.108). Following this lead, the current research will adopt a UCD methodology, beginning with the determination of user requirements for mLBS applications. Unlike the mLBS-based studies, however, which mostly sought to determine *content*-related requirements prior to commencing their design activities, the focus here will be on gathering comprehensive user needs for geospatial information, cartographic representations *and* access to such – i.e. the complete cartographic UI. Similarly, each of these aspects will be used to iteratively evaluate and improve the resulting design, with a focus on comparing and assessing the suitability of alternative representation techniques for specific users and their tasks, prior to commencing development of the final product. And finally, unlike the activity-driven approach taken for mobile cartography, a key component of the research will be the involvement of real users throughout the entire UCD process in order to address their individual needs and characteristics for mLBS.

3.5 Chapter Summary

Through an investigation of existing work within and relating to the field of mLBS application use, this chapter has defined the scope of the research, in the process addressing the questions: (1) what representation, presentation and interaction techniques are available for communicating geospatial information via mLBS applications and which of these should be explored for investigating usefulness? and (2) what are the limitations and benefits associated with existing user-centred approaches for the communication of geospatial information via mLBS? The box below summarises the major themes covered. Overall the analysis yielded a number of requirements for further research to be addressed by the current study, including: the need to ensure the usefulness of the entire cartographic UI within a mLBS application; to determine the usability and utility of alternative cartographic representation techniques for specific users and tasks; to explore the potential of adaptation to context both *within* particular representations and *between* alternative techniques; and to take a user-centred approach to the design of useful mLBS applications, incorporating early definition of users, their goals, tasks, preferences and abilities and evaluation of the resulting design with real users so that its usefulness may be validly assessed. The next chapter describes the UCD methodology chosen to guide the research activities.

- Cartography is concerned with the representation of geospatial information, encompassing the concepts of presentation and interaction.
- The representations considered relevant to mLBS within the context of the research are characterised by relatively low interactivity, both public and private use and the presentation of known geospatial information.
- The available cartographic communication techniques can be classified as:
  - Map representations – base maps, thematic maps, navigational maps & charts, image maps, 3D maps, map signs & symbols;
  - Map-related representations – images & graphics, descriptions & instructions, remotely sensed imagery; and
  - Cross-cutting features – dynamism, interactivity, multimodality, adaptation.
- Communication techniques and methods investigated in the wider field of mobile systems include:
  - Natural interaction – pen-based input, speech/voice and gesture.
  - Information presentation – text, graphics, sound, haptic solutions and personalisation.
- Several research projects have considered user acceptance and/or issues of use as priorities in their investigations into the delivery of geospatial information via mLBS. While much can be learned from their outcomes, a number of areas for further investigation were identified, including:
  - determining and evaluating the suitability of specific cartographic representation forms for the tasks (and users) to which they are applied;
  - exploring and comparing alternative cartographic techniques (i.e. beyond map forms) for representing the same geospatial information;
  - collecting pre-design user requirements relating specifically to the communication of geospatial information; and
  - ensuring usefulness in the design of the entire cartographic UI for each given mLBS application.
- Additional to this, vehicle navigation systems offer numerous lessons for the communication of information to mobile users, particularly in terms of design rules for voice, visual and control interfaces and user-centred methods employed to test and ensure utility and usability in the end system.
- Based on the existing research analysis, the scope for the current research was established, involving a UCD approach that is focused on satisfying the aforementioned research requirements.

4 User-Centred Research Design

4.1 Introduction

"Users are central to [m]LBS and so [m]LBS applications should be designed based on a user-centred view" (Jiang 2006, p.714).

In Chapter 2 it was established that in order to ensure the successful communication of geospatial information via mLBS applications, the usefulness of the cartographic UI – and in particular the techniques incorporated for representing, presenting and interacting with geospatial information – must also be ensured. In general terms, if the usefulness (usability and utility) of a system is optimised, the benefits will include: increased productivity – through effective operation; reduced errors – caused by inconsistencies, ambiguities, etc.; reduced training and support – through reinforced learning; and improved acceptance – through satisfaction and ease of use (Maguire 2001). An approach being increasingly applied to the design of mLBS applications (Chapter 3), User-Centred Design (UCD) was selected as the overarching methodology for the research. This offered particular value as a means of informing the development of comprehensive cartographic UI design models for a mLBS application, at a conceptual level of design.

The chapter begins by providing an overview of the principles of UCD and its activities (Section 4.2). Following on from this is a discussion of qualitative and quantitative social research strategies and how they relate to UCD (Section 4.3). In Section 4.4, the qualitative plan for the research is introduced and its major activities presented. The chapter concludes with a discussion of 'credibility' in qualitative social research (i.e. ensuring the accuracy and rigour of the results) and how this will be addressed by the study (Section 4.5).

4.2 User-Centred Design Methodology

UCD is an approach employed in computer systems design, having been developed under the premise that in order to ensure the usefulness (and thus commercial success) of a system, all design activities should position the end user as their focus so that the final product is easy to use and ultimately meets their needs (Gould & Lewis 1985). Essentially it aims to address the fundamental questions: '*How do I understand the user?*' and '*How do I ensure this understanding is reflected in my system?*' (Holtzblatt & Beyer 1993, p.93). In their review of current UCD practices within the

HCI industry, Vredenburg *et al.* (2002, p.472) developed a useful working definition for UCD as incorporating "the active involvement of users for a clear understanding of user and task requirements, iterative design and evaluation, and a multidisciplinary approach". The term UCD is often used interchangeably with others such as human factors engineering, ergonomics and Usability Engineering (UE), creating confusion for newcomers to the area (Rubin 1994). As Ehrlich & Rohn (1994) point out, however, while UCD refers to the "overall endeavour of making products easier to use" (p.74) the other labels, in particular UE, refer to the particular techniques and activities employed to satisfy UCD aims.

The ideals and techniques of UCD originated from the early works of researchers Gould and Lewis (1985) and Norman and Draper (1986), with the former proposing the following three basic principles: (1) an early focus on understanding users and their tasks; (2) empirical measurement of product usage by *representative users*; and (3) an iterative cycle of design, test and measure and redesign. Since that time, UCD has become the subject of much research and literature, having come to be viewed by many as an integral factor in the development of successful commercial software products (Bias & Mayhew 1994; Butler 1996; Mayhew 1999; Nielsen 1993; Myers 1994; Rubin 1994). In 1999 an international standard was established, entitled 'ISO 13407 Human-Centred Design Processes for Interactive Systems', providing guidance for UCD by way of describing the rationale, planning, principles and activities of its practice (Jokela *et al.* 2003). Developed by a board of international researchers and practitioners in the field, this standard discusses four main activities of UCD that are carried out iteratively until the defined objectives (i.e. in terms of usefulness) have been met. These are presented in Figure 4.1 and briefly described below:

- **Understand and specify the context of use** incorporating user characteristics (e.g. knowledge, skills, experience, education, training, attributes, habits, preferences, capabilities) user tasks (including goals and system use) and environment of use (technical, physical and social), in order to support user requirements specification and provide a basis for later evaluation activities.
- **Specify the user[1] requirements** using the previously defined context of use (in particular user tasks), in order to evolve measurable criteria against which the usefulness of the product will be evaluated, and to define user-centred design goals and constraints.

[1] In a commercial product, the additional definition of various organisational and other non-user stakeholder requirements is equally important to the design process (implied within Figure 4.1). With the current research focused on the usefulness of cartographic UI design models for the *users* of mLBS applications, however, such requirements are not considered by the study.

- **Produce design solutions** based on the established design goals, guidelines and constraints and incorporating HCI knowledge (relating to visual design, interaction design, usability, etc.). This is an iterative process of design producing low- to high-fidelity prototypes to support evaluation at different stages of the system development lifecycle.
- **Evaluate designs against requirements** throughout development, employing appropriate prototypes and applying the task-based criteria developed previously. This stage is important for determining the degree to which the user objectives have been met and for obtaining feedback relating to design refinements. (Jokela *et al.* 2003; Maguire 2001)

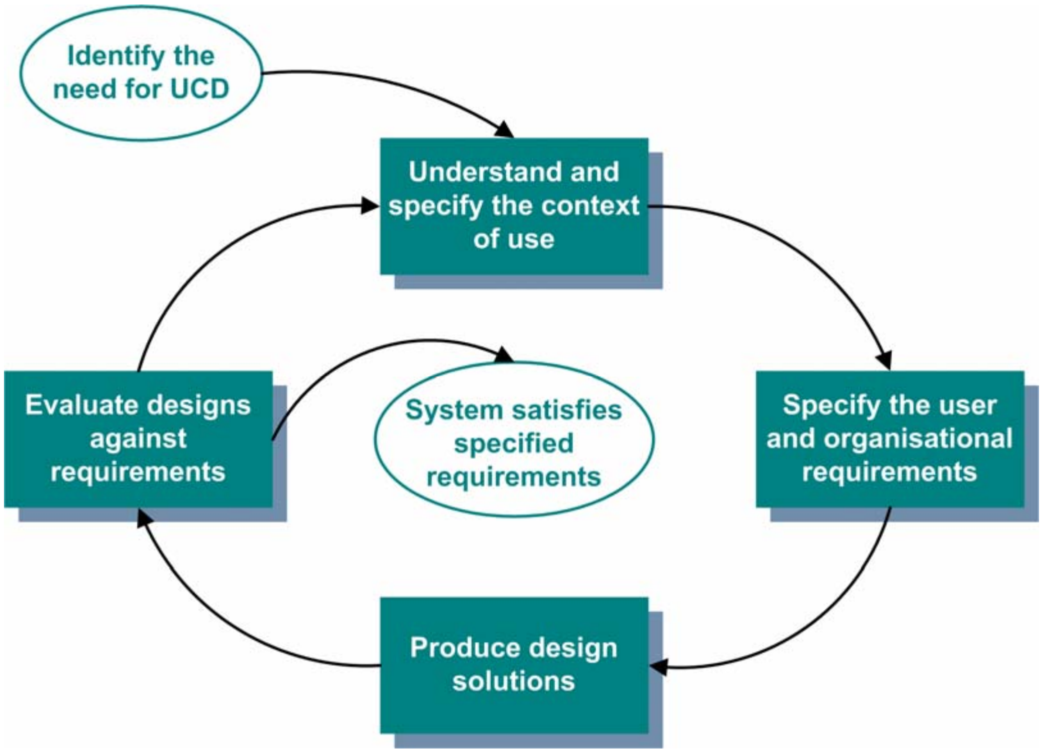

Figure 4.1 The main activities of UCD (adapted from ISO 13407 in Jokela *et al.* 2003).

As Jokela *et al.* (2003) identify, ISO 13407 does not aim to outline detailed methods for completing these activities, with such descriptions already contained within numerous methodology publications. There are in fact a multitude of methods available for conducting UCD, with Table 4.1 providing an illustrative selection, grouped by the main activities identified above. It is not within the scope of this research to provide detailed discussions of each of these methods – please refer to the cited references for more information on techniques of interest. Detail will be provided, however, for the specific methods considered and selected for the research, both later in this chapter (at a high-level) and within the individual methods/results chapters that follow.

Table 4.1 Methods for UCD (adapted from Maguire 2001; Mayhew 1999; Butler 1996; Holtzblatt & Beyer 1993; Rubin 1994; Nielsen 1992; Carroll 2000).

Understand and specify the context of use	Specify the user and organisational requirements	Produce design solutions	Evaluate designs against requirements
• Survey/interview of existing users • Focus groups • Contextual observations/ interviews • Diary keeping • Task analysis	• User requirements interviews • Focus groups • Personas • Scenarios of use • User/task models	• Usability goal setting • Design guidelines and standards • Scenario-based design • Parallel design • Prototyping	• Usability Inspections • Usability testing • Satisfaction questionnaires • Post-experience interviews

Apart from its software engineering origins, the ideals of UCD are grounded in a number of social science disciplines, most notably *cognitive psychology* – the study of human perception and cognition, *experimental psychology* – the use of empirical methods to measure and study human behaviour, and *ethnography* – the study, analysis, interpretation and description of unfamiliar cultures (Mayhew 1999). In general, UCD aligns closely with the field of social scientific research, which is particularly noticeable in terms of the correlation between specific UCD techniques and social research data collection methods, as will become apparent. Thus it is pertinent to provide a brief overview of the approaches and methods of social scientific research.

4.3 Aspects of Social Research

The basic premise of scientific research is to gain knowledge about something using a structured and systematic approach. *Social* scientific research in particular, relates to the pursuit of new and original knowledge about the social world or, put more simply, it is research that is "for, about, and conducted by people" (Neuman 1997b, p.16). As opposed to the natural sciences – e.g. biology, chemistry, physics, zoology – which deal with the physical and material world, social research is conducted in the realm of the social sciences – e.g. anthropology, psychology, political science, sociology – and involves the study of people, their beliefs, behaviours, interactions and institutions (Neuman 1997b). There are two traditional approaches to undertaking social research, *qualitative* and *quantitative*, which are mainly distinguished by the particular data collection and analysis techniques they employ. They are not, however, mutually exclusive concepts, with several overlaps in terms of the types of data (qualitative – expressed as words, pictures, objects; quantitative – expressed as numbers) and the research styles involved (Neuman 1997b). A basic comparison of the two approaches is provided in Table 4.2, with the following sections defining each further in terms of the techniques employed for the collection of data and its subsequent analysis.

Table 4.2 Qualitative vs. quantitative research approaches (adapted from Neuman 1997b, p.14).

Qualitative	Quantitative
Construct social reality, cultural meaning	Measure objective facts
Focus on interactive processes, events	Focus on variables
Authenticity is key	Reliability is key
Values are present and explicit	Value free
Situationally constrained	Independent of context#
Few cases, subjects	Many cases, subjects
Thematic analysis	Statistical analysis
Researcher is involved	Researcher is detached

Not necessarily always the case in quantitative research (e.g. usability testing, which can involve quantitative analysis and is primarily concerned with usage in context).

4.3.1 Qualitative research strategies

Qualitative research strategies and methods were developed within the social sciences as specific tools to aid in the study of social and cultural phenomena, grounded in the perspectives of the people involved (Myers 1997b). They help researchers to understand a phenomenon within its specific social and institutional context, incorporating alternate viewpoints from different participants (Kaplan & Duchon 1988). Becoming more common in the field of Cartography (Suchan & Brewer 2000), qualitative research represents an exploratory approach to studying social issues and involves interpretive strategies of analysis such as ethnography, grounded theory, case study, phenomenology and narrative, for organising the rich, descriptive information obtained (Creswell 2003; Patton 2002; Denzin & Lincoln 2000; Strauss & Corbin 1998). Some of the more common data collection techniques employed for conducting qualitative research include:

- **Interviews** – Similar in principle to a quantitative survey interview (see Section 4.3.2), this technique involves social interactions using open-ended questions (may be unstructured) and probes to obtain subjective, in-depth information about participants' experiences, perceptions, opinions, feelings and knowledge. Interviews may be conducted on an individual or a (focus) group basis (Patton 2002; Suchan & Brewer 2000).
- **Participant observation/field studies** – A flexible and immersive process derived from ethnography, whereby participants are studied in their natural setting over a period of time. This technique yields detailed, first-hand observational data relating to activities, behaviours, actions, conversations, interactions, processes and other observable aspects of the human experience. The researcher may interact with participants as a participant observer and/or as an interviewer (Patton 2002; Kjeldskov & Graham 2003a).
- **Documents** – Involves the study of written and other visual materials, including publications, reports, diaries, correspondence, photographs, maps, videotapes and artistic

works. This technique may also incorporate open-ended written responses to quantitative survey questionnaires (Patton 2002; Suchan & Brewer 2000; Strauss & Corbin 1998).

The depth and detail with which issues are studied through qualitative research offers advantages in terms of increasing the understanding of individual cases and situations. Additionally, the unconstrained approach of qualitative research enables participants' own categories to be captured and used when describing the data. The small numbers of participants and cases involved, however, reduces the ability to generalise findings. Moreover the sheer volume of qualitative data and its (often) lack of standardisation can make analysis a daunting and difficult undertaking (Patton 2002).

4.3.2 Quantitative research strategies

In general terms, social quantitative research involves the objective collection of data in order to test a theory or hypothesis, using specific indicators/variables. Measurements are ideally systematic, producing precise, quantitative information about the social reality involved. Furthermore, quantitative methods involve the collection and statistical analysis of data using predetermined instruments. Originating within the natural sciences, a number of quantitative research strategies have been adopted by the social sciences, with the following representing the most common techniques for data collection:

- **Experiments** – Comprise a test of the impact of a treatment or intervention on an outcome, where all other influential factors are controlled, in order to address a well-focused question or hypothesis. Involving both treatment and control groups in either laboratory or real-life situations, this method includes both true experiments – i.e. random assignment of subjects to treatment conditions – and quasi-experiments – i.e. non-random designs (Creswell 2003; Neuman 1997b).
- **Surveys** – Involve a numeric description of trends, attitudes or opinions, generalised from sample results for an entire population. Surveys can include cross-sectional and longitudinal studies, with data collected using systematic survey methods such as closed questionnaires or structured interviews (Creswell 2003; Neuman 1997b).

The nature of quantitative research, with its rigorous measurement techniques and general involvement of large numbers of participants, brings analytical advantages such as simple comparison and statistical aggregation of the data, and thus the ability to generalise findings to a larger population. It may be argued, however, that by categorising the social data into predetermined categories, and hence harbouring preconceptions, the varying perspectives and experiences of the people under quantitative study can never be adequately understood (Patton 2002).

4.3.3 Mixed method research strategies

The respective advantages and disadvantages of qualitative and quantitative approaches elicit differing levels of importance, depending on the problem at hand. In some areas of study, quantitative research will clearly dominate qualitative research as the approach of choice, and vice versa. In many cases however, a *mixed methods* approach is taken, combining techniques from each, in order to ensure meaningful and comprehensive results (Patton 2002). Mixing methods in this way not only serves to reduce the respective limitations and biases of the two approaches, it also enables the results of each technique to be used to inform subsequent techniques (Creswell 2003). This is commonly how UCD operates, with the combination of various techniques enabling the collection and analysis of both qualitative and quantitative data (often simultaneously). This is particularly important to the specification of use contexts and user requirements (the first two activities in Figure 4.1), in accordance with which design activities proceed and against which resulting designs are iteratively evaluated and refined. Table 4.3 provides an example of mixing methods via a UCD approach, presenting a potential path through the methods listed in Table 4.1, along with the qualitative and/or quantitative techniques they may involve (note that the activity 'Produce design solutions' does not require specific data collection or analysis).

Table 4.3 Mixing methods through UCD.

Activity		Method	Data Collection		Analysis	
			Ql	Qn	Ql	Qn
A	**Understand and specify the context of use**	Survey of existing users		Surveys (questionnaire)	✓	✓
B	**Specify the user requirements**	User requirements interviews	Interviews		✓	
C	**Produce design solutions**	N/A	--	--	--	--
D	**Evaluate designs against requirements**	Controlled usability testing	Interviews, participant observations	Experiments	✓	✓

Ql – Qualitative, Qn – Quantitative

4.4 High-Level Qualitative Research Plan

Comprehensive models exist for implementing a UCD methodology, complete with detailed discussions of optimal activities, including both qualitative and quantitative methods for data capture and analysis (see Nielsen 1993; and Mayhew 1999 for examples). The developers of these models acknowledge, however, that it is not always feasible to employ every activity and technique, due to time, budget and other resource constraints (Mayhew 1999). The goals and scope of the current study were considered accordingly, with the decision ultimately made to approach the UCD research methodology from a qualitative perspective, involving the collection of both qualitative and (to a lesser extent) quantitative user data at each stage, with only qualitative methods employed for their analysis.

The justifications for conducting largely qualitative research were twofold. The first concerned the broadness of undertaking a comprehensive UCD methodology involving numerous data collection and analysis phases, coupled with the limited resources available to the study in terms of personnel, money and time. In this respect it was not considered feasible to conduct a full quantitative inquiry at each stage of the research, since this would require a large population of users from which random probability samples could be taken. Indeed, the user population sourced for the research (refer to Sections 5.2.3 and 5.4.1.1) was considerably smaller than that normally required for a quantitative study (i.e. offering limited breadth for any quantitative data collection and analysis) and was therefore more suited to taking a qualitative approach, through which rich data could be generated for small sets of individual participants.

The second level of justification involved the nature of the research problem, with the UCD methodology intended to inform a comprehensive conceptual design process, leading to the definition of cartographic UI models offering high usefulness to their end users. As opposed to quantitative research, which generally aims to test a hypothesis or theory through the use of standardised measures and predetermined categories of analysis, qualitative inquiry offers particular benefits to the study through its exploratory approach, allowing issues and themes to *emerge* from more open-ended user data (Patton 2002). In this way, the outcomes (i.e. the usefulness of the design models) can be firmly grounded in the perspectives of the end users. Moreover, the focus of qualitative inquiry on studying participants in great depth can promote a better understanding of the variations between individual users and their contexts of use, including their characteristics, needs, experiences, behaviours, feelings and thought processes.

Even with a qualitative approach to research, it is possible (and, in some cases, arguably necessary) to quantify participant data in preparation for interpretative analysis (Strauss & Corbin 1998). Indeed, this was considered appropriate for the current study in order to summarise particular user group characteristics and later measure usability within the cartographic UI design models. At this point it should be reiterated that the use of limited sample sizes and qualitative techniques of analysis negated the ability to use inferential statistics which would have allowed generalisation of the research outcomes beyond the participants under study. This presented no problem for the research, however, with the design models intended to provide a conceptual foundation and insights for developing useful cartographic UIs for mLBS applications, as opposed to broadly applicable instructions for their design.

Looking then to the specific activities planned for the research, here guidance was taken from the comprehensive and widely accepted UCD approach presented by Mayhew (1999) in her book *The usability engineering lifecycle: a practitioners handbook for user interface design*. With this comprising a detailed specification of the recommended UE tasks for developing fully functional products, however, not all of the activities described were relevant to the conceptual level of design required by the research objectives. Therefore, a smaller subset of activities and methods was selected for the study, which were considered sufficient for achieving the required aims while adhering to Gould & Lewis' (1985) base principles for UCD (Section 4.2). The final UCD research plan is presented in Figure 4.2, followed by a brief discussion of the major activities and qualitative/quantitative methods involved. For a more comprehensive discussion of each of the major research phases, including the alternative data collection and analysis techniques considered, refer to the detailed methods in Chapters 5 through 10.

4.4.1 Pre-design activities

The research plan presented in Figure 4.2 is divided into two major stages. Outlined below, the pre-design stage was concerned with determining user-centred requirements for the cartographic UI of a mLBS application.

4.4.1.1 Phase I: user profiling

Following the selection of an application area and associated user group upon which to focus the study, this activity employed a social survey – in the form of an online questionnaire – to collect data towards a description of the target users in terms of the specific attributes, behaviours and attitudes they possessed that were relevant to the application area. A qualitative analysis of the results (comprising a mix of both qualitative and quantitative data) then served to generate a comprehensive User Profile defining the characteristics, use contexts and preferences to be addressed by the cartographic UI design models, while providing a foundation for the user task analysis. Refer to Chapter 5 for a detailed description of the user profiling methods and results.

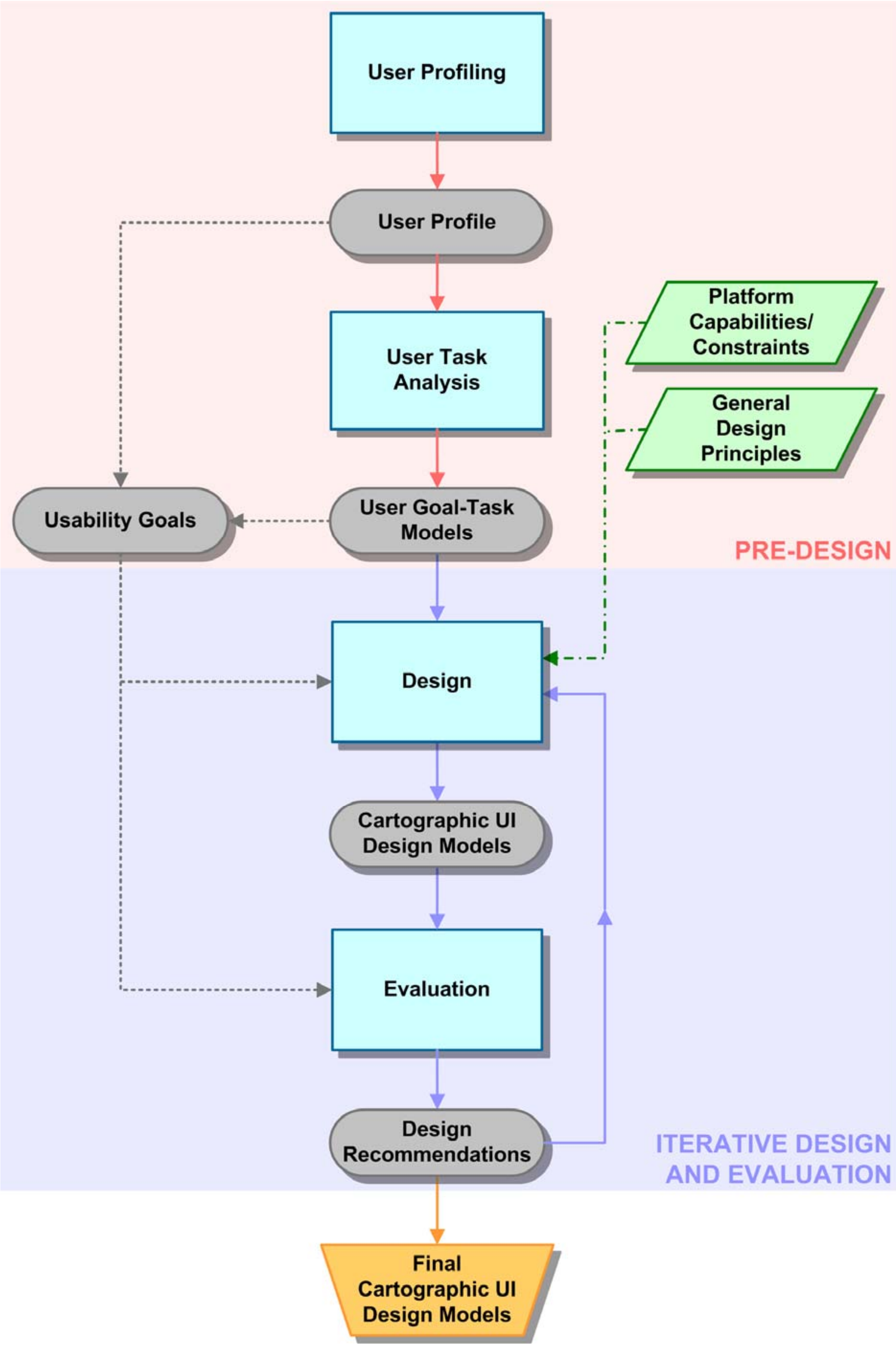

Figure 4.2 The UCD-based research plan.

4.4.1.2 Phase II: user task analysis

Building on the established user profile, this activity involved the conduct of Critical Incident interviews with representative members of the user population to collect qualitative data relating to their geospatial goals, tasks, information requirements and usage environments – relative to the selected application area. A qualitative goal-driven data modelling approach was then undertaken in order to understand and specify the range of goals, tasks and requirements described by the interview data, culminating in the development of detailed goal-task models, user personas and scenarios of use. Along with the user profile, each of these outputs was used to set qualitative usability goals for the design, while driving the design activities. Refer to Chapter 6 for a detailed description of the user task analysis methods and results.

4.4.1.3 Usability goal setting

Prior to beginning any design activities, a number of qualitative usability goals were derived from the user profiling and user task analysis outcomes, and prioritised in order to focus and provide a basis for all ensuing design decisions (see Section 7.2). While the conceptual level required for the design negated the need to define additional quantitative usability goals (i.e. for use as functional product evaluation acceptance criteria), a number of quantitative measures were established and employed for the second evaluation phase (see Section 9.2.2).

4.4.1.4 Platform capabilities/constraints & general design principles

Following the selection of a technology platform through which to develop and demonstrate the cartographic UI design models, its capabilities and constraints were determined and documented in order to define the scope of possibilities for the design activities (see Section 7.3.4). Additional to this, relevant UI and cartographic design principles and guidelines were gathered and reviewed, in preparation for their application throughout the design activities (see Section 7.3.5).

4.4.2 Iterative design and evaluation activities

Described below, the second major stage of the research was concerned with developing, assessing and revising the cartographic UI design models through a process of iterative design and evaluation.

4.4.2.1 Phase III: preliminary design and evaluation

Once the pre-design activities were complete, the physical design commenced. Comprising a process of scenario-based design, this employed the established User Profile, goal-task models, user personas and scenarios of use to drive the development of the basic structure for a set of 'preliminary' design models. Following this, more detailed design activities specified the functionality and components relating to a selection of the identified user goals and tasks, including the trial of alternative techniques for representing, presenting and interacting with the underlying geospatial information. As part of the design process, a low-fidelity prototype was created to both specify the cartographic UI design models and enable their evaluation.

With the preliminary design models in hand, informal usability testing was conducted using the prototype, whereby representative users were asked to compare and evaluate the relative usefulness of the cartographic UI and its alternative techniques for representing, presenting and interacting with geospatial information. Interpretive analysis of the qualitative data collected during the evaluation sessions was then used to assess the models' usefulness and make recommendations for improving their utility and usability. Refer to Chapters 7 and 8 for detailed descriptions of the preliminary design and evaluation methods and results.

4.4.2.2 Phase IV: design refinement and evaluation

Utilising the results of the preliminary design evaluation, the design models were revised and the prototype updated. At the same time the models' functionality was extended in order to support a number of additional user tasks and provide further representation, presentation and interaction techniques for assessment. A second and final evaluation phase was then undertaken involving more formal usability testing, again requiring representative users to compare and evaluate the usefulness of the cartographic UI and its individual components. During this evaluation, however, a small number of quantitative measures were collected, in addition to the qualitative observational and verbal data. As for the previous evaluation, interpretive analysis of the evaluation data was used to assess the models' usefulness and make recommendations for improving their utility and usability. Refer to Chapters 9 and 10 for detailed descriptions of the design refinement and evaluation methods and results.

4.4.2.3 Final results

Concluding the UCD methodology, the cartographic UI design models were revised for the final time, addressing the recommendations generated by the second evaluation. Following this they were graphically presented, incorporating a single, high-level model describing the interrelationships between the major design components, as well as several detailed models communicating the specific inputs, outputs and interaction flows considered useful for achieving a focal set of user goals and tasks – including their associated cartographic representation, presentation and interaction techniques. Additional to this, a number of general recommendations were made for designing useful mLBS applications. Refer to Chapter 11 for the final results.

4.5 Credibility of the Research Results

A final aspect for consideration which is important to any academic research methodology is that, in order to produce credible research outcomes, the 'validity' and 'reliability' of the research design must be ensured. Having originally developed within the quantitative social research arena, *validity* (whether each indicator involved in the study measures what it is intended to) and *reliability* (the repeatability of the results) are closely related to the numeric/statistical character of the data involved (Neuman 1997b). Where qualitative techniques for data analysis are applied, however, these concepts hold different connotations and emphases, with authors in the field of qualitative inquiry generally agreeing that "reliability and generalisability play a minor role" (Creswell 2003, p.195; Janesick 2000; Patton 2002). In general it is contended that, apart from limited checking for consistent patterns of theme development between different investigators on a team, or generalising parts of multiple case analysis to other cases, these terms basically do not apply within qualitative social research (Creswell 2003). With reference to the concept of reliability, Janesick (2000) and Patton (2002) cite the idea of *rigour* as being more relevant to qualitative inquiry (i.e. through rigorous data collection techniques and systematic analysis strategies), identifying that the value of qualitative research is in the uniqueness of the findings related to an individual or group and thus the idea of repeatability is meaningless. Similarly, the concept of validity within qualitative research is generally taken to relate more to *accuracy* – i.e. whether the findings are trustworthy/authentic/credible from the viewpoint of (a) the researcher, (b) the participant and/or (c) readers of an account (Creswell 2003) – being essentially about "description and explanation and whether or not the explanation fits the description" (Janesick 2000, p.393).

In order to maximise the credibility of qualitative research results, Creswell (2003) suggests a number of strategies for performing accuracy checking on the outcomes of a qualitative study, recommending the use of at least one of the following:

1. **Triangulation** – the use of disparate data sources, different investigators, multiple interpretation theories or multiple methods in order to build a justification for identified themes (definition supplemented by Janesick 2000).
2. **Member checking** – allowing the participants involved to assess the accuracy of the findings (descriptions, reports, themes).
3. **Rich, thick description** – conveying findings using sufficient detail to express the experiences shared.
4. **Clarification of researcher bias** – statement through 'self-reflection' of the bias brought to the study in order to create an open and honest narrative.
5. **Presentation of negative/discrepant information** – inclusion of findings that do not agree with the identified themes, thus adding to the study's credibility.

6. **Prolonged time spent in the field** – allowing an in-depth understanding of the phenomena being studied, including rich detail about the people and the site.
7. **Peer debriefing** – a review of the study findings by peers to ask questions and validate the conclusions drawn.
8. **External audit** – an independent review of the entire study conducted throughout, or at the end of, the research.

With the current study reliant on qualitative techniques of analysis in order to identify themes, patterns, understandings and insights from the data, the concepts of rigour and accuracy were paramount to ensuring the credibility of the final cartographic UI design models. As such approaches for optimising each were incorporated into the individual methods employed throughout the research (refer to Chapters 5 to 8). In this respect, Creswell's strategies of triangulation, member checking, thick description, clarification of researcher bias, presentation of discrepant information and peer debriefing proved to be most useful.

4.6 Chapter Summary

This chapter has set out the general plan by which the research developed cartographic UI design models for the communication of useful geospatial information to the non-expert users of a mLBS application. Summarised in the box below, the plan was based on an accepted UCD methodology, employing various data collection techniques from the realm of qualitative and quantitative social research. In terms of data analysis, qualitative techniques were employed for the interpretation of all user data in order to evolve themes, patterns, understandings and insights. This began with the definition of the user population's characteristics, goals, tasks and information requirements (related to a selected application area) and continued throughout the development and iterative evaluation/revision of a comprehensive set of conceptual design models. At each stage of the UCD process, particular effort was made to ensure the credibility of the findings and thus that of the final design models.

The following chapters present the conduct of the four major phases planned for the UCD research methodology, including the techniques employed by each for data collection and analysis, as well as the results obtained. This begins with a discussion of user profiling in Chapter 5, followed by user task analysis in Chapter 6, preliminary design and evaluation in Chapters 7 and 8 and, finally, design refinement and evaluation in Chapters 9 and 10.

- User-Centred Design (UCD) is a philosophy employed for the design of useful computer systems, incorporating "the active involvement of users for a clear understanding of user and task requirements, iterative design and evaluation, and a multidisciplinary approach" (Vredenburg *et al.* 2002, p.472).
- ISO 13407: Human-Centred Design Processes for Interactive Systems provides guidance for UCD by describing the rationale, planning, principles and activities of UCD practice.
- Specific UCD data collection techniques align closely with methods from both qualitative (interview, field study, documents) and quantitative (experiment, survey) approaches to social scientific research.
- The UCD approach selected for the study (based on Mayhew 1999) represents a mixed methods approach to social scientific research, incorporating both qualitative and quantitative techniques for data collection, while the data analysis was entirely qualitative, catering to the limited resources available and the conceptual nature of the research problem.
- The research plan is divided into two stages, which together involved four major phases and several associated activities:
  - Pre-design – user profiling (Phase I), user task analysis (Phase II), usability goal setting, platform capabilities/constraints and general design principles.
  - Iterative design and evaluation – preliminary design and evaluation (Phase III), design refinement and evaluation (Phase IV) and final results.
- Credibility is an important consideration for any academic research, with the concepts of accuracy and rigour being applicable to qualitative research designs such as that detailed here (as opposed to the quantitative concepts of validity and reliability). A number of accepted techniques for performing accuracy checking were applied to the research outcomes in order to maximise their credibility.

5 Phase I: User Profiling

5.1 Introduction

A key consideration for this research was the complexity and undesirability of designing a cartographic UI suitable for every possible user. As such, general user requirements had to be established in order to define a global style and approach to the design of cartographic representations for mLBS. As the first step in understanding and specifying the context of use for the proposed mLBS application, the process of user profiling was aimed at defining the characteristics of the target user population. A central UE method, 'user profiling' consists of three general components (Mayhew 1999), which provided the basic structure for this chapter:

1. **Define the target user population** (for a specific mLBS application area), who will be the potential end users of the system (Section 5.2).
2. **Obtain a current description of the target user population** in terms of the following characteristics (Sections 5.3 and 5.4):
   - physical – demographics, problems with eyesight;
   - knowledge and experience – geospatial/technological skills and abilities, task experiences;
   - goal and task – frequency of travel, task structure; and
   - psychological – attitude, motivation.
3. **Analyse and describe the data**, drawing high-level conclusions regarding geospatial design requirements. Summarise separate user profiles for each significant category of users in terms of general needs and internal variations (Section 5.5).

5.2 Defining the Target User Population

Knowledge of the intended users of a system is essential to User-Centred Design, and for this reason the selection of a representative user group upon which to focus the research investigations was required. As previously established, the multitude of potential mLBS applications lend themselves to a wide range of users within the general population (Section 2.3.2), the majority of whom can be considered 'non-experts' due to their lack of formal geospatial knowledge, training, experience and information use (Section 2.5.2). Since it would be impossible for a project of this scale to incorporate user-input from the 'entire population' of potential users (not least due to the fact that such a group remains ill-defined), the decision was made to restrict the target user population to a manageable size and definition by concentrating on a particular mLBS application area, which could then be used to provide an initial description of the users as input into the research.

5.2.1 Selecting an application area

To determine an appropriate mLBS application focus, consultations were undertaken with key members of Webraska (the Industry Partner for the research), whose market directions were considered relevant to the selection of the target user group[1]. This was performed in conjunction with a review of the application areas at the centre of recent mLBS research and commercial implementations so as to identify existing realms that may benefit from the research products. Here it was found that not only were the majority of related mLBS research projects focused on mobile *tourism*-type applications (Section 3.3.1), an abundance of commercial mLBS applications currently targeted holiday-related travel markets both in Australia and worldwide (see Table 5.1 for a selection) – not to mention the fact that tourism information is largely geospatial (Almer *et al.* 2004), thereby providing a great deal of scope for exploring useful representations. All of these factors supported major aspects of Webraska's market direction, whereby they and several of their Australian customers and partners were increasingly focusing on the delivery of travel-/tourism-based mLBS (refer to 'Webraska Navigation' and 'Whereis® Mobile' in Table 5.1). As such, the research's application area was initially established as 'holiday-related travel'.

Table 5.1 Selected existing travel and tourism mLBS applications.

Product	Location	Description
AvantGo Travel Guide	Global	Add-on to the AvantGo service providing travel itineraries, directions, maps, weather, city guides, etc. my.avantgo.com/travel/
Lonely Planet CityPicks	Global	Destination guides including recommendations for restaurants, bars, nightlife, shops and hotels.
My Streetdirectory.com PDA	Singapore	Street directory maps featuring location saving, POIs and GPS tracking www.streetdirectory.com/pda/
Telmap Navigator	Global	Mobile navigation system incorporating POIs, festivals, events, traffic, restaurant reviews, weather, etc. global.telmap.com/asp/products/mobile_navigation.html
Vindigo City Guide	USA	Location-based city information including restaurants, bars, museums, movies, ATMs and public transport. www.vindigo.com/demo/demo01.html
Webraska Navigation	Europe	GPS navigation system incorporating POIs, speed camera alerts and real-time traffic. nav.webraska.com
Whereis® Mobile	Australia	Provides maps, turn-by-turn directions and the ability to locate a range of nearby services. www.whereis.com/whereis/personalMaps/whereisMobile.do

[1] With the research comprising an ARC Linkage-Project, and Webraska as the industry partner for this, it was expected that they would/should benefit from the research outcomes.

Further consideration of the application area served to provide greater focus, including its restriction to 'holiday-related travel within Australia', which was based on both the location of the research itself (Melbourne, Australia), and its support by an Australian Research Council Linkage Grant. Moreover, additional refinement came from the knowledge that domestic tourism formed the dominant share of the Australian tourism market (Maurer *et al.* 2006), resulting in the final application area: 'domestic holiday-related (DHR) travel'.

5.2.2 Initial description

Although the data collection for the current and subsequent research phases were designed to provide a clear definition of the target user population, it was considered appropriate to develop an initial description of potential user characteristics, along with their high-level goals and tasks in order to further control the study's scope and enable a suitable user group to be more easily identified.

5.2.2.1 Characteristics

To begin, an initial delineation of the DHR traveller's characteristics was undertaken, again in conjunction with Webraska. The decisions made (i.e. the initial selection criteria for users), and the reasoning behind each, are shown in Table 5.2.

Table 5.2 Potential target user characteristics.

Characteristic	Justification
Ethnicity	
Australian residents	The research was focused on 'domestic' travel; hence end users would be primarily residents of, and travellers within, Australia.
Age group	
25-40	An estimated age range, based on the perceived applicability of the travel habits listed below; this was intended to assist in scope limitation for the research.
Travel habits	
As a holiday-related activity	The application area of interest involved 'holiday-related' travel, and as such end users were required to undertake travel for this purpose.
To distant, often unfamiliar locations	People who travelled only on short journeys and/or to familiar locations were unlikely to obtain sufficient benefit from a DHR travel mLBS to make them regular users.
On a regular basis (e.g. annually)	People who travelled regularly were more likely to find use in (and thus pay for) a DHR travel mLBS, than those who travelled infrequently.
Predominantly overland (i.e. not by air)	It was anticipated that a DHR travel mLBS would be of major benefit for navigation-type tasks, enroute to a destination; this would be most useful when users were travelling overland (e.g. by car).
Other	
Technologically capable	Since the technology and applications involved in mLBS were relatively new to the Australian market, it was anticipated that the first end users of the research product would be relatively familiar with the related technologies.
Generally time poor	MLBS are intended to save people time during common activities; hence it was likely that end users would be people who generally embrace time-saving resources.

5.2.2.2 Goals and tasks

As highlighted by Brown & Chalmers (2003), holiday-related travel (i.e. tourism) is largely characterised by carrying out tasks in pursuit of open-ended goals[2], without the need or presence of rigid aims. Indeed, the purpose of much tourism is simply to 'experience' a new location, which may require little to no planning whatsoever. There are however a number of high-level tasks and associated goals that can be attributed to the use of geospatial information in mobile environments (and for tourism in particular), which were expected to be relevant to the target user population. These were compiled from a number of sources and are presented in Table 5.3. (note, there is a many-to-many relationship between the goals and tasks listed in the table, with coloured symbols used to highlight these associations).

Table 5.3 High-level tasks and related goals of DHR travellers (based on von Hunolstein & Zipf 2003; Infopolis2 1999; Brown & Chalmers 2003; Reichenbacher 2004).

Goal	Task(s)	Description	Example(s)
Orientation	◆ Localisation	◆ Determine own position	◆ Where am I?
	■ Proximity	■ Determine distances and directions to specific objects or persons	■ Where's the closest bus stop? ■ In what direction is the hotel?
	♦ Themes	♦ Determine position of object groups	♦ Where are all the restaurants from here?
Overview	◆ Localisation	◆ Recognise own position within local area	◆ What's around me?
	■ Proximity	■ Determine distances to multiple items of interest	■ How far away are the amenities I will need?
	✦ Events	✦ Identify isolated occurrences in local area	✦ Are there any road closures along my route?
Navigation	◆ Localisation	◆ Recognise own position along route	◆ Where am I on the map?
	■ Proximity	■ Determine distance and direction to destination	■ How far to go until I reach the 'Big Pineapple'?
	● Wayfinding	● Route from point A to point B	● How do I get back to the caravan park?
Exploration	● Wayfinding	● Follow an undefined route	● What will I see if I drive east?
	✦ Events	✦ Identify time-critical phenomena	✦ Are there any festivals on while I'm here?
	♦ Themes	♦ Determine available activities within local area	♦ What water sports can I do while I'm here?
Planning	● Wayfinding	● Pre-define a route to follow	● I want to see these attractions today ...
	✦ Events	✦ Identify time-dependent activities / occurrences	✦ When does the museum open? ✦ What time does Dad arrive?
Self-education	● Wayfinding	● Follow a personalised tour	● I'll walk the 'heritage trail' to learn more about the town.
Information discovery	⅄ Identification	⅄ Recognise objects of interest and identify related attributes	⅄ What is there to see and do? ⅄ What is the best way to get there?

[2] Refer to Section 6.2 for a comprehensive definition of the terms 'goal' and 'task'.

Seven open-ended goals are listed in Table 5.3, which were additionally categorised according to their relationship to the three major stages of the travel experience – pre-trip, on-trip and post-trip – with some taking place at multiple stages (von Hunolstein & Zipf 2003; Infopolis2 1999):

- Pre-trip (preparation and decision-making):
  - **Planning**; e.g. determining a route to the destination.
  - **Overview**; e.g. obtaining a mental picture of the destination's layout.
  - **Information discovery**; e.g. obtaining knowledge about activities at the destination.
- On-trip (tracking and decision-making):
  - **Orientation**; e.g. determining the current location with respect to landmarks.
  - **Navigation**; e.g. moving between physical locations.
  - **Overview**; e.g. experiencing and learning the layout of the destination.
  - **Exploration**; e.g. discovering the features of the destination.
  - **Self-education**; e.g. gaining familiarity with the destination through exploration.
  - **Information discovery**; e.g. obtaining new information about the destination.
- Post-trip (assessment):
  - The experiences gained from the travel are fed back into future travel, thus influencing how tasks will be undertaken in pursuit of each goal.

Based on this categorisation, and with respect to the target user population, it was anticipated that each of the above goals and related tasks would be found within the user profiling and user task analysis data. In particular, it was expected that the target users would undertake *localisation* tasks both before – to obtain an overview of the location of their destination and/or stopping points along the way – and during their travels – for the purposes of orientation, overview and navigation, so as to determine where they were at a given point in relation to recognisable landmarks and/or a destination (e.g. an attraction). Similarly, *proximity* tasks were expected to be important for users to obtain an overview of their destination/stopping points (in terms of the layout of features) prior to departing, and for orientation, overview and navigation goals throughout the trip by enabling their position to be used to conduct targeted searches (e.g. for specific places of interest) within their own "action space" (von Hunolstein & Zipf 2003). *Wayfinding* tasks were expected to be employed before the trip for planning purposes, such as determining an optimal route for visiting a set of attractions at the destination, and for navigation, exploration and self-education when at a destination, in order to 'discover' and thus become familiar with the area.

Time is an important component of geospatial information and as such it was anticipated that the target users would undertake *event*-related tasks both before – to satisfy planning goals, such as using time-critical/-dependent information (e.g. opening hours) to schedule visits to a list of attractions – and during their travels – for purposes of exploration and overview to determine actual conditions (e.g. traffic) enroute to, or at, a destination. *Identification* was also expected to take place at each stage of travel: beforehand, when planning a trip to an unfamiliar location, and during, when users needed to find out where things were and to make decisions based on new information they had gathered along the way. Finally, *theme* tasks were mainly likely to be important during the trip, for the dual goals of orientation and exploration. This was anticipated when users had an activity 'type' (or theme) in mind and wished simply to explore a location based on the goal of locating a desired 'social zone' (Brown & Chalmers 2003; von Hunolstein & Zipf 2003).

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With the potential characteristics, goals and tasks of the target user population now described, the next step was to gain access to such a group to begin the data collection. In this respect there were two considerations: first, locating an appropriate user population and second, sampling a set of representative users from within this.

5.2.3 Sourcing an appropriate population

Even with an initial description of end users in hand, it can be difficult to identify and gain access to representative users when designing new and innovative products (Mayhew 1999), or in this case, cartographic representations for mLBS. This proved to be the case here. A solution was found, however, after consultation with one of Webraska's partners – Sensis Pty. Ltd., a leading Australian information, advertising and directories business – who expressed interest in the potential research products and saw benefits in having access to the data that would arise from the study. Sensis subsequently offered access to a large number of people who were part of their *evaluator database*, consisting of users who had opted to participate in product testing after visiting one of the Sensis product websites (White Pages® *OnLine,* Yellow Pages® *OnLine,* CitySearch® or Whereis™). While there was no guarantee that the evaluators within this database would fulfil the criteria set out in Table 5.2, they were deemed to be an appropriate 'pool' from which representative samples could be sourced, keeping in mind that the pre-defined user characteristics were intended to be flexible. Specific desirable characteristics of the Sensis database included:

- Australian residents;
- unrestricted in terms of age;
- members of the general public; and

- users of online directories (i.e. technologically capable).

5.2.4 Sampling considerations

In order to determine the characteristics of the user population, a refined sample (or sub-set) was required. The concept of sampling maintains that the responses and characteristics of a 'representative' sample should accurately reflect those of the target population (de Vaus 1995).

There are numerous methods of sampling, divided into two categories: probability and non-probability samples. Probability sampling uses random processes to produce unbiased samples that truly represent the population. This set of techniques – including simple random, systematic, stratified and cluster sampling – enables the application of powerful statistical analyses on the data and provides for generalisation of results to an entire target population. Conversely, non-probability, or purposeful, sampling does not incorporate principles of random selection and therefore cannot make use of inferential statistics from probability theory. Purposeful techniques include: extreme/deviant case, intensity, maximum variation, homogeneous, typical case, critical case, snowball, criterion, theoretical, confirming/disconfirming case, stratified purposeful, opportunistic/emergent, politically important case, convenience and quota sampling (Aldridge & Levine 2001; de Vaus 1995; Neuman 1997a; Patton 2002). Taking into consideration the research's qualitative purpose of defining and describing the target user population for a DHR travel mLBS, purposeful sampling was deemed to be the most suitable strategy for the ongoing study, in particular *criterion* and *opportunistic* sampling.

5.2.4.1 Criterion sampling

This type of non-probability sampling, whereby cases that meet some pre-determined criterion of importance are studied, is often employed in exploratory and qualitative research, the purpose being not to generalise to a larger population, but to gain a deeper understanding of specific cases that are likely to be information-rich (Aldridge & Levine 2001; Patton 2002; Neuman 1997a). This form of sampling is particularly useful in research of this nature since the data yielded may influence subsequent data collection techniques. It must be reiterated, however, that where criterion sampling is applied there can be no generalisation of the results, nor can levels of precision be calculated (Aldridge & Levine 2001).

5.2.4.2 Opportunistic sampling

Patton (2002) describes an emergent flexible design as an integral component of qualitative inquiry and goes on to extend this to sampling methods, highlighting the opportunistic sampling technique. Whilst not a tangible process, this type of sampling involves often spontaneous decisions that take advantage of "unforeseen opportunities" (Patton 2002, p.240) after the collection of data has begun. Such events took place during this phase of the research, whereby the opportunity was presented to obtain contrasting user profile data from members of the geospatial community (i.e. participants with varying levels of domain expertise). At the time of this sampling decision, it was acknowledged that any information collected from the additional participants had the potential to skew the data. Since the purpose of collecting information on these geospatial 'experts' was to observe their differences to the other participants, it was intended from the outset that the data would remain separate from the target user population so that objective and comparative conclusions could be drawn.

The final sampling procedure followed for this stage of the research is described in Section 5.3.2.3 as part of the data collection process.

5.2.5 Expert versus non-expert users

Before continuing, it is useful to provide a distinction between the two groups sampled using each of the aforementioned methods, and in the process redefine some important terms used throughout this research.

In Social Research, the terms 'expert' and 'non-expert' are used regularly, to distinguish between sub-categories of users with widely opposing levels of knowledge about and/or skills in a particular domain. For example, this research could have used the term 'experts' to refer to seasoned travellers within Australia (i.e. travel experts), with 'non-experts' indicating people who rarely undertake domestic travel. As established in the previous section, however, the two sub-categories of users employed in the research were not intended to be distinguished in this way. Instead it was more pertinent to distinguish between them as experts and non-experts in the area of geospatial experience and knowledge, as per the definition provided in Section 2.5.2. Hence the term 'experts' (or more specifically 'domain-experts') is used from this point on to refer to those users from within the geospatial community – i.e. people who have been trained in and/or have worked in the field of geospatial information. Similarly, the term 'non-experts' is employed for the users sourced from the Sensis database, who had not necessarily had any formal training/experience with geospatial information.

5.3 Data Collection

5.3.1 Surveys in Social Research

Once the target user population was defined, and an appropriate user group located, it was possible to begin collecting data in order to define a current description of that population. This second component of user profiling (as introduced in Section 5.1) is typically performed via social survey (Mayhew 1999), which was the technique selected for the study. Of the possibilities for conducting a social survey – most notably interviews with parties knowledgeable about the user population or questionnaires distributed to actual users – the survey questionnaire was the instrument chosen to gather the data. This was in part due to the relative ease of data collection, based on time constraints and logistics, and also the view that it would prove a more reliable and accurate method of data collection than would in-depth interviews with 'subject matter experts' (Mayhew 1999). Additionally, since the target user population was initially only loosely defined, sourcing interviewees who were sufficiently familiar with the user population was not deemed feasible.

The items (or variables) measured using a questionnaire can be classified into four types (Aldridge & Levine 2001; de Vaus 1995), which generally map to the characteristics being sought for the target population in the following ways (Section 5.1):

- Attributes (physical characteristics; knowledge);
- Behaviours (goal and task characteristics; experience);
- Beliefs; and
- Attitudes/Opinions/Preferences (psychological characteristics).

It was established early on that the user profiling was concerned with determining user *behaviours* and *attitudes* relating to tourism-based travel and related location-based information (including a high-level description of their goals and tasks, which is addressed in Chapter 6), with some consideration also given to pertinent user *attributes*, such as age and sex. *Beliefs* (i.e. intellectual judgements) were considered to be largely unnecessary to the user profiling data collection since the research was more interested in the manifestations of users' beliefs during travel – in the form of their behaviours, attitudes and (in some cases) attributes – rather than in the beliefs themselves. For example, a person may *believe* that it is safer to drive on main roads, leading to their *behaviour* of only travelling via main roads, the latter being what the research is really interested in. With this in mind, the questionnaire was designed to include only behaviour-, attitude- and attribute-type questions. The major steps undertaken to administer the user profile questionnaire are outlined in the following sections.

5.3.2 Questionnaire development and distribution

According to Aldridge & Levine (2001), the questions in a questionnaire should be designed using the "sociological imagination", so that they are meaningful, sensitive, precise, searching and salient to the respondents, who will then be more likely to answer as truthfully and fully as possible. Furthermore, the language used must be simple and unambiguous, with explicit clarifications and examples provided, where appropriate. Open-ended questions should be employed sparingly, in order to introduce variety, elicit relevant information, encourage the expression of individual points of view, prompt new and unexpected ideas, and generate illustrative quotations. De Vaus (1995) provides a simple checklist to avoid problems with the wording of specific questions, asserting that the overall questionnaire should have: a clear, coherent and sensitive layout; an introduction (including guidance for completion); instructions for individual questions; introductions to separate, logical sections; a clear numbering system; easily answerable, factual questions at the beginning; difficult and/or potentially sensitive questions at the end; clear instructions for filter ('skip' or 'go to') questions; and a conclusion.

5.3.2.1 Drafting the questionnaire

With all of this in mind, a draft questionnaire was developed incorporating eight distinct sections, each designed to elicit specific types of information:

- **Introduction**

  A brief introduction to the research and questionnaire, with instructions for its completion.

- **SECTION A – General Information**

  Five closed questions, relating to participant demographics and experiences with geospatial information, designed to gather attribute-type data.

- **SECTION B – Travel Habits**

  Eight closed questions designed to gather behaviour-type information relating to participants' recent holiday-based travel activities.

- **SECTION C – Travel Information**

  Four questions (three closed and one open-ended), relating to participants' use of geospatial information while travelling on holidays, designed to gather behaviour-type data.

- **SECTION D – Location-Based Travel Needs**

  Eight questions (seven closed and one open-ended) designed to gather attitude-type information relating to participants' geospatial information needs/preferences while travelling on holidays.

- **SECTION E – Mobile Phone and Computer Skills**

  Ten questions (nine closed and one open-ended), relating to participants' current use of mobile phones and computers, designed to gather attribute-, behaviour- and attitude-type data.

- **SECTION F – Comments**

  One open-ended question designed to gather any additional information participants' chose to offer relating to the questionnaire's subject matter and clarity. This had the potential to gather attribute-, behaviour- and/or attitude-type data.

- **SECTION G – Contact Details (Optional)**

  An optional section providing users with the opportunity to participate further in the research.

Included at the beginning of each section was a reference to a glossary of important terms, defining the major concepts used throughout the questionnaire. In this way, potentially ambiguous terms could be described to instil a common meaning for all respondents.

5.3.2.2 Pilot testing and questionnaire revision

Pilot testing is conducted on a questionnaire for a number of reasons. In terms of quantitative surveys, the main purpose is to assess the statistical reliability and validity of the indicators incorporated into the questionnaire (de Vaus 1995). For a more qualitative survey such as this however, the reasons are less formal, being to ensure that the questionnaire is understandable and operates effectively. De Vaus goes on to discuss various criteria against which questions and questionnaires should be evaluated during a pilot test, with the following considered most relevant to the research:

1. **Variation:** the questions should yield responses containing sufficient variation to ensure useful and comparable results.
2. **Meaning:** the respondents must be able to collectively understand the questions, and the reviewer their responses.
3. **Redundancy:** should be minimised by eliminating multiple questions that measure the same entity.
4. **Non-response:** the danger of this may be reduced by ensuring questions are clear, non-intrusive, provide for sufficient responses, do not repeat previous questions, are visibly relevant to the questionnaire's purpose, are not excessively long to answer and the layout does not lend itself to questions being 'missed'.
5. **Flow:** the questions must fit together, with smooth transitions between sections.
6. **Timing:** it must not take an unreasonably long time to complete the questionnaire (related to point 7).
7. **Respondent interest and attention:** respondents will become bored, possibly providing unreliable answers, if the questionnaire is too long and/or if there is no variety in the question types and formats.

The Online Evaluation Resource Library (OERL - National Science Foundation 2005), which provides resources for project evaluation design, conduct, documentation, and review, recommends that the participants used in pilot testing should not be involved in the formal questionnaire administration. Aldridge & Levine (2001) agree, going on to explain that a pilot test should be conducted on people resembling the participants involved in the final data collection and not friends or colleagues – who may not be representative of the target user population and are also unlikely to provide impartial feedback. Identifying that there are no "universally accepted rules" for questionnaire design and evaluation, the OERL suggests a general protocol for pilot testing:

(a) **Edit** – expert evaluation by three to six individuals; revise questionnaire.

(b) **Early Pilot** – completion of questionnaire by four to eight individuals, possessing similarities to target respondents, who are asked to 'think aloud' regarding their responses; revise questionnaire.

(c) **Full Pilot** – completion of questionnaire by ten to fifteen individuals possessing similarities to target respondents, ensuring comparable conditions to those anticipated for the actual data collection; collect feedback; revise questionnaire.

Whilst supporting 'Full Pilot' testing of questionnaires, the Australian Bureau of Statistics (1999) contends that insufficient time or resources may prevent this phase from being undertaken, in which case, as a minimum, a 'skirmish' (or pre-testing) – equivalent to the *Early Pilot* phase – should be completed.

Aldridge & Levine (2001, p.90) identify that a questionnaire that is to be piloted should be "as good as you can make it", only requiring refinement, not transformation. Additionally, they cite the likelihood that limited resources may mean only small-scale pilot testing is possible (in opposition to de Vaus' (1995) recommendation of between 75 and 100 respondents), asserting that provided the testing is intensive, it will still yield valuable information relating to questionnaire improvements. These and the above guidelines were followed during the pilot testing of the user profiling questionnaire. The 'Edit' phase constituted several revisions of the initial draft following feedback from the research supervisors as well as eight Sensis staff (from the Marketing, Online Sites and Location and Navigation divisions). Six individuals, similar to members of the user population (as per Section 5.2.3), were then utilised for the 'Early Pilot' phase – note, only two participants were observed, with the others providing detailed written comments.

The feedback obtained from the 'Early Pilot' was considered to have sufficiently identified all major problems with the questionnaire's clarity and hard-copy operation, which were then rectified accordingly. A 'Full Pilot' testing the operation of the on-line version of the questionnaire was unfortunately not possible due to extreme time constraints placed on the research. By the time the online site was prepared (at least 10 months behind schedule due to factors external to the research), the only feasible evaluation was intensive testing by the researchers, which uncovered and rectified a number of technical issues. The omission of a 'Full Pilot' was not considered a major oversight for the research, however, since the questionnaire's clarity had previously been tested and ensured.

5.3.2.3 Questionnaire distribution

Due to the nature of the non-expert user group selected for the user profiling (i.e. members of the Sensis evaluator database, recruited via the Web), the delivery mechanism selected for the questionnaire was *online* with the Web URL to be distributed via email to a sample of users from the Sensis database. The online questionnaire's content, structure and presentation were developed as part of the research. Sensis developers were then responsible for its branding (i.e. providing a Sensis 'look and feel'), form submission programming, online publishing and testing.

Purposeful criterion sampling (see Section 5.2.4.1) was selected for this and ongoing phases of the study in order 'to gain a deeper understanding of specific cases that are likely to be information-rich'. For the user profiling in particular, this sampling technique was applied in an abstract way, since the ultimate aim was to identify the characteristics of potential users of a DHR travel mLBS, yet the available user population was arguably too generic to be considered the 'target' population. The application of criterion sampling was thus:

- The questionnaire was sent to all users in the Sensis database who (a) had an email address; (b) matched the age criteria (25-40 years of age); and (c) had registered to test Sensis products within the last 2 years (increasing the likelihood that their email addresses would be valid).
- Of all the users sent the questionnaire, those who completed it were considered to have demonstrated an *interest* in the research, and thus were considered potentially 'information-rich cases'. These users subsequently constituted the main user profiling 'sample', as well as embodying the 'target user population' for the research.

A 'Call for Participation' email containing a link to the questionnaire website and a Plain Language Statement explaining the research and questionnaire (refer to Appendix A, Sections A.1 and A.2 respectively) were forwarded to the appropriate users, who were given between two weeks and one month to respond. Each time a user (from this point on referred to as a 'participant') completed and submitted the questionnaire, a text file containing their responses was compiled and emailed. The number of participants in the original 'mail out' was 242, with 46 of the email addresses found to be invalid (bringing the total number of 'successful' mail outs to 196). This was considered sufficient to yield a reasonable number of responses – assuming a conservative response rate of ten percent (Mayhew 1999) – and to constitute a valid sample size, considering the depth of information being gathered (Patton 2002).

For the opportunistic sampling of domain-experts, a hardcopy version of the questionnaire was produced and distributed to suitable individuals (along with a cover letter and Plain Language Statement), being returned via reply-paid envelope. These participants came from two sources: (1) attendees of a presentation (based on the research) held during the 2003 Spatial Sciences Coalition Conference in Canberra, Australia – approximately 30 people; and (2) Geospatial Science postgraduate students from RMIT University – approximately 15 people. As identified earlier, the responses obtained from the domain-experts were kept separate from those of the target user population. The final (online) questionnaire is reproduced in Appendix A, Section A.3.

5.4 Statement of Results

As outlined at the beginning of the chapter, user profiling is intended to establish and describe those characteristics of the target user population which are relevant to the design. This section provides such a description for the questionnaire respondents (and thus the target user population), which was ultimately used to drive the decisions made during the design of the cartographic representation models for a DHR travel mLBS. Whilst primarily concerned with the non-expert users, characteristics of the domain-experts are also presented here, where relevant. The purpose for their inclusion was to highlight similarities and differences between the two user categories and thus provide additional input into the design, since it was likely that the ultimate end user group would include both types of user.

The following results are structured to provide an emergent, yet comprehensive picture of the target user population. The use of a qualitative narrative was adopted to achieve this and is the reason that the presentation of results does not follow the same structure as the questionnaire itself. Note that where questionnaire results were no longer considered relevant (e.g. due to changes in the study focus), these have been omitted from the ongoing research.

5.4.1 Physical characteristics

5.4.1.1 Sample size

Prior to describing the users, it is necessary to provide a picture of the sample itself. Whilst the initial expectation was for a response rate of ten percent (which would have yielded around 20 respondents), the actual response was far better. In all, 67 participants responded to the online questionnaire, totalling almost 35% of those it was considered to have successfully reached (note, this figure does not include the domain-experts, 17 of whom participated in the questionnaire). As stated in Section 5.3.2.3, these participants comprised the target user population and are thus the focus of the results and figures presented below (unless otherwise stated).

5.4.1.2 Target user population attributes

Only a small number of attributes were collected for the target user population in order to describe their 'physical' characteristics. Among these were the demographics of age, gender and state of residence, with other characteristics (e.g. occupation) not considered relevant to the research. Additional information was sought regarding whether users possessed any vision-related problems pertinent to the viewing of computer screens (small or large), which would prove an important consideration for the upcoming design and evaluation.

Whilst demographics were not strictly used as a means of selection for participants from the Sensis database, gender was the only truly independent demographic measured as it was not included in the initial user criteria (Section 5.3.2.3). In all, two-thirds of the respondents were male, amounting to a 2:1 gender imbalance, which was expected to be of importance to the later analysis. A similar proportion of males to females (11:6) was found for the domain-experts.

The most dependent demographic variable to be measured was age, due to its use as a criterion in selecting participants. The final age spread is shown in Figure 5.1. Whilst it may have been expected that all respondents would fall within either the '25-30' or '31-40' age categories, six percent were found to be between the ages of 41 and 50. The reason behind this was the age categorisation used within the Sensis database, which did not match the criteria defined for the user group (25 to 40 years of age). Those categories which coincided with the study criteria were '25-34' and '35-44', explaining the presence of older respondents. Rather than remove these people from the user population, however, it was deemed that their interest in the research warranted a 'relaxing' of the age criteria since they would likely provide additional depth to the design process (note, their initial exclusion was primarily a means of narrowing the research scope). In terms of domain-experts the age spread was broader, covering the additional categories of '18-24' and '51+'. Like the target users, though, the majority of these respondents were between the ages of 25 and 50 (76% altogether).

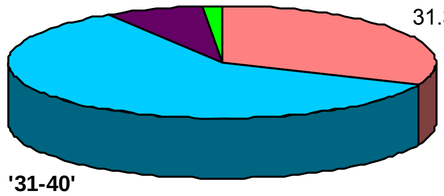

Figure 5.1 Age spread.

The variable relating to state of residence was considered partially dependent, mainly due to the nature of the Sensis evaluator database. When members of the public add their details to this product testing database they are informed that the testing takes place in Melbourne, Victoria with interstate and rural evaluators encouraged to provide comments and suggestions to Sensis via an online form, rather than registering. This has the likely effect that most evaluators in the database reside in Victoria. Related to this was the additional dependency added by the location of the research (again, Melbourne), which was made clear to respondents in the Plain Language Statement distributed with the questionnaire. These factors may help to explain the pattern observed whereby the vast majority of respondents (84%) lived in Victoria. Similarly, and again due to the sampling procedure, the majority of domain-experts also lived in Victoria (59%).

The final physical attribute measured showed that the majority of respondents had no notable problems with their vision that would affect their viewing of a computer screen (including 61% who stated that they had no problems at all and 31% who did not respond to this open-ended question and were thus assumed to have no problems). Of the five respondents who cited vision problems, four were required to wear glasses when viewing a computer screen (particularly "where fine detail is used") while a single respondent cited nearsightedness, however did not consider this a problem with respect to computer screen viewing. The majority of domain-experts reported no vision-related issues (76%), with two of the four respondents who did have problems citing issues with "near focus" and viewing small screens. It is interesting to note that none of the respondents identified that they were colour blind. This is despite the fact that around 8% of all males and 0.4% of females are afflicted by some form of inherited colour blindness (or colour vision deficiency), not to mention those individuals with acquired colour vision abnormalities (Martin *et al.* 2000; StLukesEye.com 2004). This could be an anomaly of the sample or else may have resulted from the phrasing of the question – *Do you have any problems with your vision that may affect your viewing of a computer screen (large or small)* – which perhaps did not sufficiently prompt respondents who did not realise that colour blindness can affect a computer screen's viewing. Nonetheless, the significant frequency of colour blindness within the larger population was planned to be taken into account during the design phase.

5.4.2 Knowledge and experience

5.4.2.1 Target user population attributes

In order to describe the target user population's relevant knowledge, skills and abilities, a number of attributes were gathered relating to experience with geospatial information and its use, as well as experience with the range of technologies associated with geospatial information and mLBS in particular.

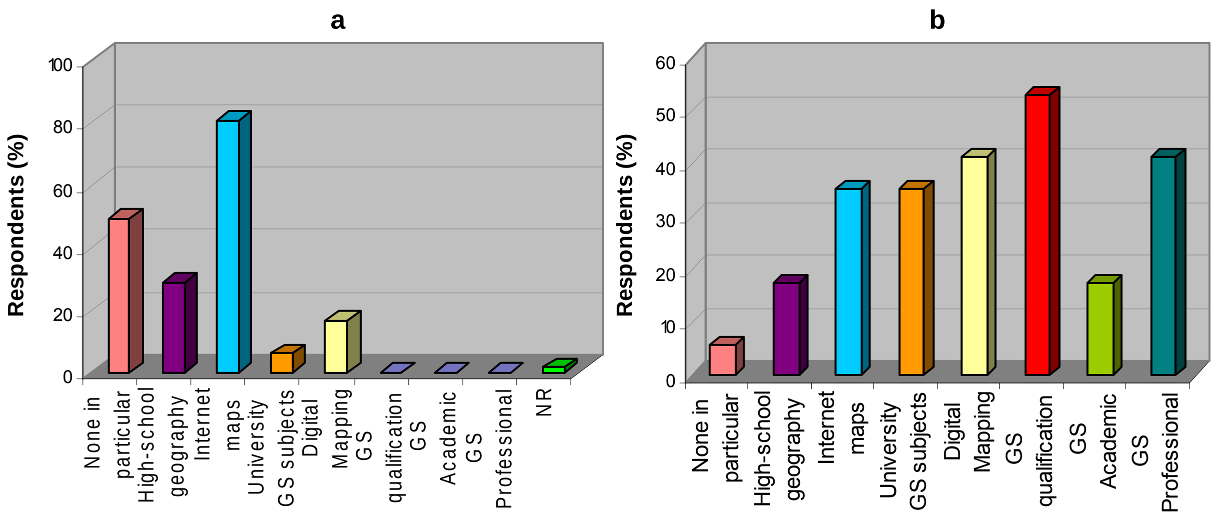

Figure 5.2 Experience with geospatial information for (a) the target user population and (b) the domain-experts.

Respondents were initially asked to describe their training and/or qualifications with respect to geospatial information, with the ability to select from multiple pre -defined options. As shown in Figure 5.2a, none of the target user population were formally qualified and/or worked within the geospatial field, although a small percentage (6%) had taken at least one related University-level course/subject, including Geography and Surveying. A large number of respondents were, however, familiar with the use of Internet maps (80%), with some (16.4%) being experienced with digital mapping software (e.g. GIS, CAD). About half the respondents admitted to not having particular experience with geospatial information, using it only during their day-to-day activities. As a comparison, Figure 5.2b shows the attributes of the domain-experts. Not surprisingly, almost all of these respondents were either qualified or working in the geospatial field, or both. Experience with digital mapping software and Internet maps were also high here (41% and 35%, respectively), and only one respondent claimed to be relatively inexperienced with geospatial information. The structure of this question requires comment, however. Despite being able to select multiple options, it is possible that some respondents selected only their 'highest' level of experience with geospatial information, and thus the data may be somewhat non-representative in terms of the 'lower' experience levels (a scale which is loosely embodied along the x-axis of the charts).

To augment this information, respondents were asked to provide an opinion-based assessment of their own abilities with respect to map reading and navigation. Figure 5.3 displays the results of this 'self-rated' variable, which utilised a response scale ranging from 'always experience this' to 'never experience this', with statements structured in such a way as to minimise 'response bias' [3]. In general, most respondents reported that they had few, if any problems reading navigational maps, determining the direction of North, following supplied route directions/distances and getting lost at/retracing steps to unfamiliar locations. Only slightly more problems were reported with respect to map orientation and providing route directions/distances, particularly when these were written or spoken (as opposed to landmark-based). Much can be highlighted within this data – particularly with respect to implications for the design phase – for example the high number of respondents who admitted to turning navigational maps to face their direction of travel (almost 65%), and the relative proportions of males and females who did this (58% of males and 77% of females). Further discussion of such issues is provided in Section 5.5.

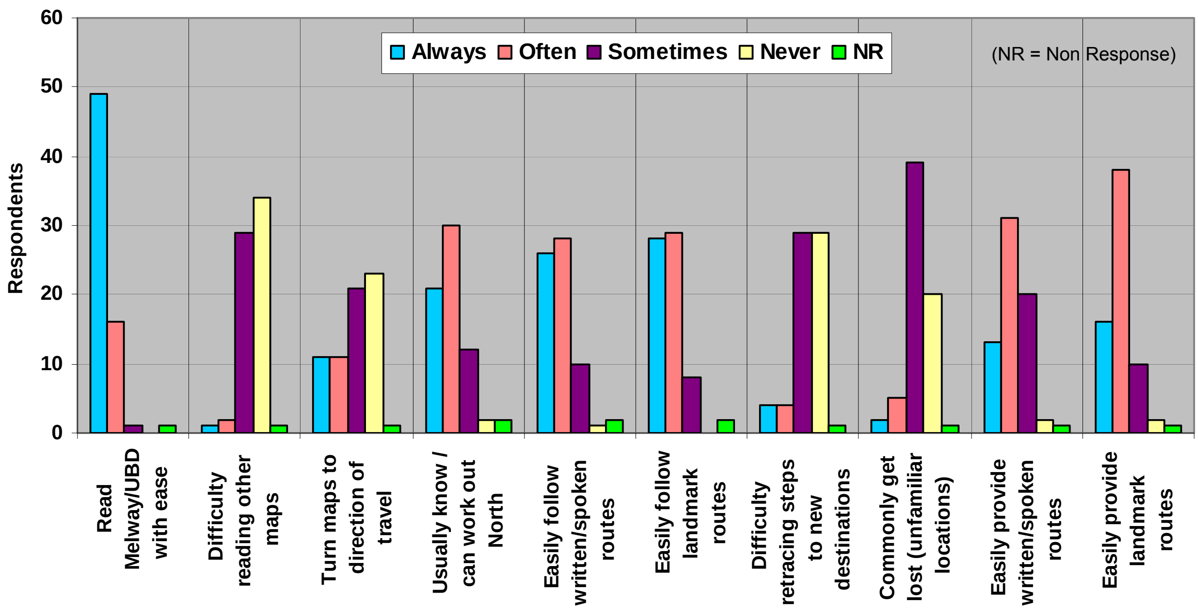

Figure 5.3 Self-rated abilities with maps and navigation.

To better visualise this data, a new variable was created from the responses, which attempted to categorise the self-perceived geospatial abilities of each respondent in the target user population in terms of day-to-day map reading and navigation tasks. This was done for every statement by

3 If each statement in a scaled question is written so that a favourable (e.g. 'Agree') response is always selected on the left- or right-hand side of the scale, respondents may select 'Agree' each time, without carefully considering the individual statements (Kirakowski 2000).

assigning a number between one and four to each response category, (where 1 = low geospatial ability and 4 = high geospatial ability). These 'scores' were then tallied for each respondent and used to classify whether they rated themselves as having high geospatial ability, low geospatial ability, or some level in between. Note that this variable was not based on a true Likert scale and thus cannot be considered a statistically valid measure; rather it was simply included to provide an indicative summary of the data in Figure 5.3. With this in mind, Figure 5.4 shows that most of the respondents rated themselves as having relatively high geospatial abilities, with only one rating themself comparatively below average. In general it would seem that the target user population had a relatively high ability level in terms of map reading and navigation, however this assessment cannot be considered very reliable. The nature of the question – *What are your experiences with map reading and navigation generally like?* – lends itself to 'socially desirable responses', whereby respondents may answer inaccurately/untruthfully in order to "make themselves look good" (Kirakowski 2000). While there was no indication of the degree to which this phenomenon affected the results, it was kept in mind during the analysis.

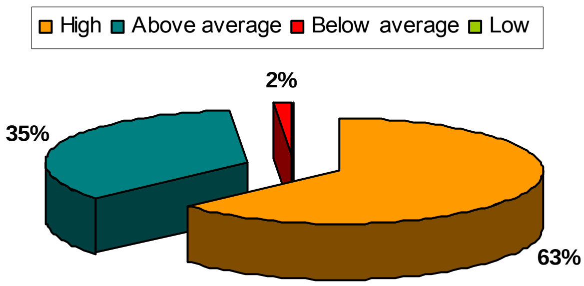

Figure 5.4 Self-rated geospatial ability.

In terms of technological experience, attributes were gathered relating to the use of mobile phones, SmartPhones, computers (desktop and handheld) and vehicle navigation systems (VNSs). These factors were considered especially important as inputs for the cartographic UI design models, which were highly dependent on users' prowess with these mLBS-related technologies.

The vast majority of respondents (90%) currently owned and/or used a mobile phone or SmartPhone, with 84% of these being regular users (at least once per day). Additionally, of the remaining respondents, all but one had used a mobile or SmartPhone previously. For those who had experience with such phones, 94% had made use of a mobile or SmartPhone for purposes other than voice calls. Figure 5.5 illustrates the types of non-voice uses employed as well as the popularity of each amongst the target user population. SMS was clearly the most popular use (almost 100% of respondents), with alarm/event notification, games and phonebook functionality being next in line (between 70% and 80%). Notably, multimedia uses were well-represented within the user group (e.g. photos/video, MMS, music/radio, SMS, etc.) – an important consideration for this research. Additional non-voice uses highlighted by the respondents were calculators, calendars and daily organisers. Similar figures relating to mobile and SmartPhone ownership/use were obtained for the domain-experts, although a smaller proportion of these respondents were frequent phone users (65%). Comparatively fewer of the domain-experts had used a mobile or SmartPhone for non-voice purposes (88%), with less non-voice types of usage also employed (e.g. phones had not been used for MMS, Email or phonebook). Again, SMS was the most popular (100% usage), followed by alarm/event notification and games (47% and 40%, respectively).

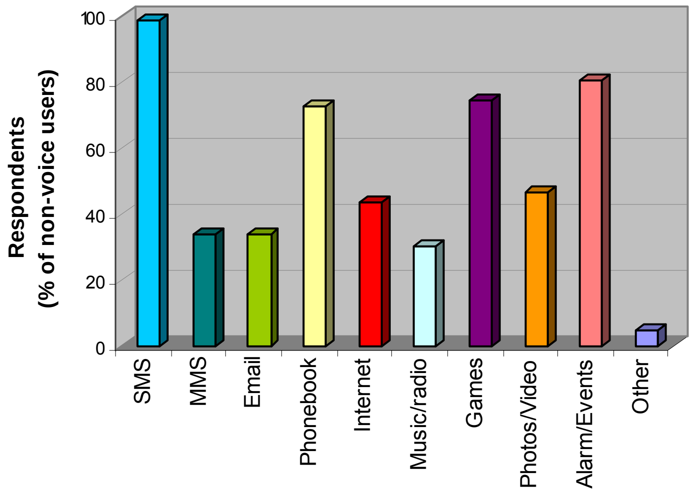

Figure 5.5 Non-voice usage of mobile and SmartPhones.

Computer usage attributes were collected with individual respect to desktop/laptop computers, handheld computers and SmartPhones. When asked about their frequency of use for each of these computer types, all but one respondent claimed to use a desktop and/or laptop at least once per week (however it is likely that this person also used a desktop/laptop regularly and simply missed this question, based on a subsequent response). In comparison, only 22% of respondents used a handheld computer on a regular basis (i.e. at least once a week). Finally, 34% of respondents used a SmartPhone, for the most part all day, everyday, however a small number claimed more infrequent use (2-3 times per week to less than once a month). The domain-experts also demonstrated 100% usage of desktop/laptop computers on a regular basis, however handheld computers were next popular (24% of respondents), followed by SmartPhones at 6% (equating to one respondent). It must be noted that some respondents reported confusion over answering this question and so the results should be viewed with some scepticism as to their accuracy, particularly with respect to the use of handheld computers and SmartPhones.

When asked about the actual uses for which they employed their computer(s), the categories were narrowed to desktop/laptop computers and handhelds/SmartPhones. In Figure 5.6, it can be seen that each computer type was used for a variety of purposes by the target user population with again desktop/laptop computers being the most commonly used type. Internet access, Email, word processing and spreadsheet tasks were the most popular uses for desktop/laptop computers (over 90% of respondents each), while the most common tasks for handhelds/SmartPhones were calendar/address book and games (36% and 24%, respectively). Other uses of computers (in particular desktop/handheld) were identified by a number of respondents, including photo editing, web design, graphic design, software development and networking/support. The results for the domain-experts were almost identical; however they displayed less variety in the use of handhelds/SmartPhones (being limited to calendar/address book, games and writing programs). Additional uses for handhelds/SmartPhones were also given, including GPS/mapping and GIS applications.

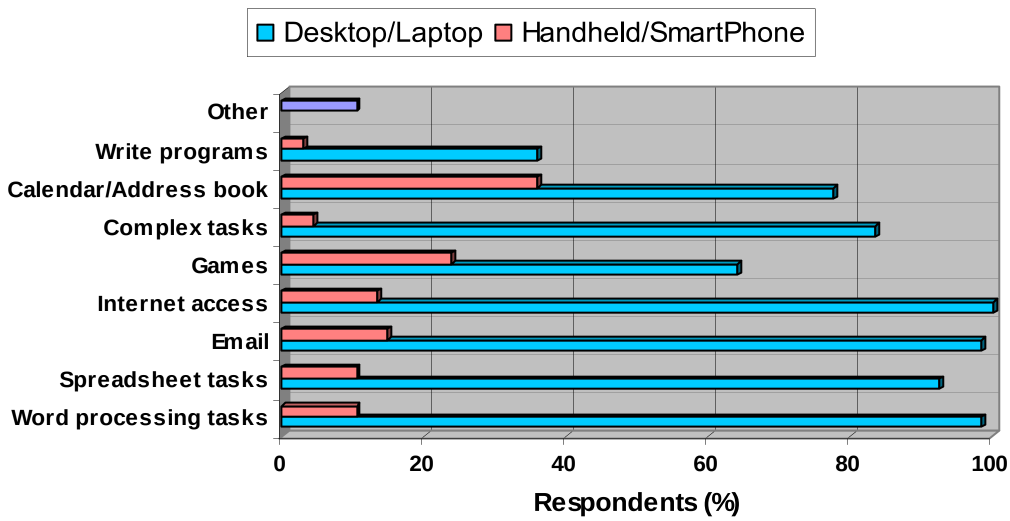

Figure 5.6 Computer usage types.

In order to ascertain some more specific skills, respondents were asked whether they had ever connected a handheld computer to a mobile phone. Of the 57 respondents who claimed to have used a handheld computer before, 33% had connected it to a mobile phone – with Infrared, cable and Bluetooth displaying similar levels of popularity (58%, 53% and 42%, respectively). Comparatively, ten of the 17 domain-experts had used a handheld computer, with only two of these having connected it to a mobile phone, both using a cable. Additional information was sought regarding the use of VNSs, with 11 respondents having used a VNS whilst travelling. Of this number seven (64%) found the VNS useful, while three found it limited in usefulness and one did not find it useful at all. Of the three domain-experts who had used a VNS, all found it useful to some extent.

5.4.2.2 Task-related behaviours

With this range of respondent attributes in hand, it is now pertinent to describe those experiences and behaviours more specific to the DHR travel focus of the research. To begin, when asked about the types of location-related information they commonly used before and/or during their holiday travels, respondents were presented with a number of pre-defined options. Of these, navigation directions, accommodation, location of tourist attractions and weather reports were used by over half of the respondents (Figure 5.7). Less popular were public transport (PT) systems and traffic conditions, the latter form of information not being widely or readily available in Australia at the time. Similar results were obtained for the domain-experts, with the location of services also being popular information.

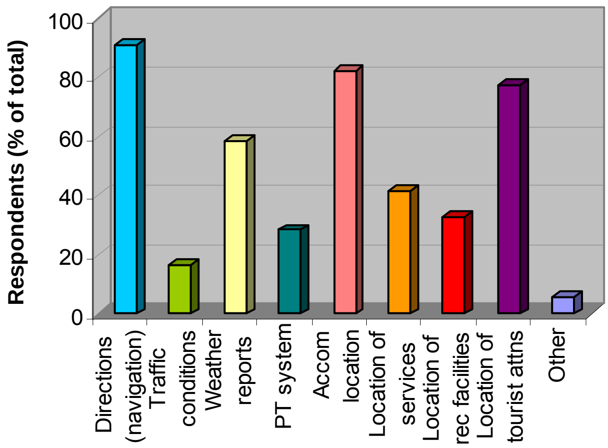

Figure 5.7 Location-related information usage.

A related question collected information about respondents' use of specific navigation aids while travelling. Over 80% commonly used street directories and/or Tourist maps, with Internet maps/directions and Street/traffic/tourist signs also common (Figure 5.8). Additionally, around half of the respondents used State road maps and/or their memory to help them navigate. Notably, only one respondent regularly used a handheld GPS for navigation with another single respondent using a VNS. Again the domain-experts' results were mostly similar; however State road maps were employed more commonly and Internet maps/directions less so. Over 40% of these respondents also regularly relied on their intuition to aid navigation.

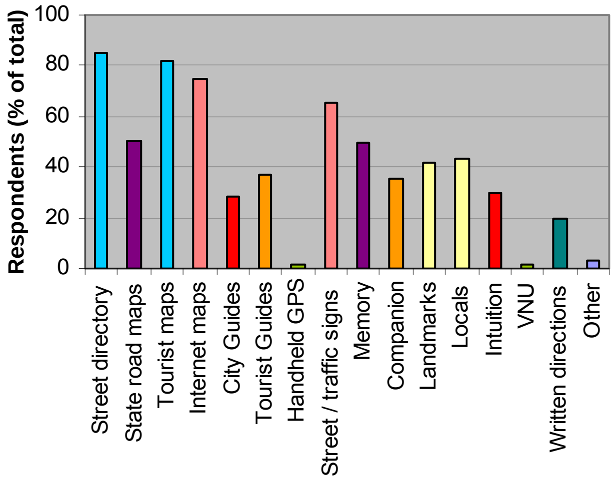

Figure 5.8 Navigation aid usage.

A third area of data collection concerned the other types of information that respondents commonly used to make decisions whilst on holiday. Again, prescribed responses were presented, with the option of providing additional information types. A high proportion of respondents (over 65%) regularly made use of tourist brochures/guidebooks, friends' recommendations, websites/online directories and Tourist Information Centres (Figure 5.9). Around 40% also sought local knowledge to aid in their holiday decision-making. Additional information types included 'Entertainment Books' and proximity to certain requirements (e.g. places to eat). Equivalent results were obtained for the domain-experts, who cited 'Tour guides' as an extra information source.

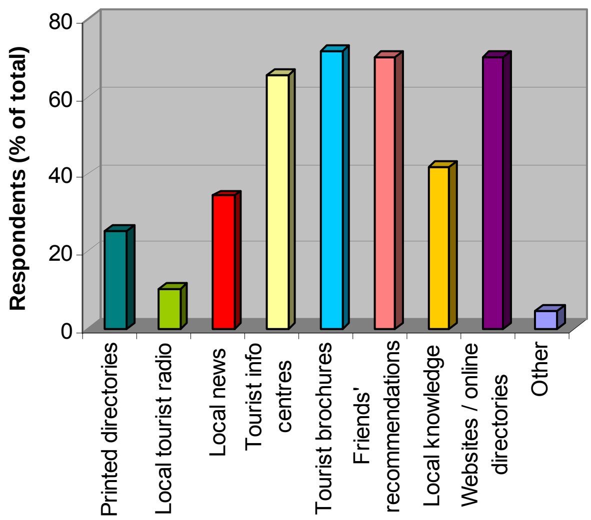

Figure 5.9 Other information used.

In order to gather more open-ended data, respondents were asked to document any problems they had experienced while finding their way and/or making decisions during their DHR travels over the past two years. A large proportion of participants responded to this question, numbering 45 (out of 67) from the target user population and 14 (out of 17) from the domain-experts. A number of major themes were distilled from the comments provided and are described in Table 5.4, with their occurrence illustrated in Figure 5.10.

Table 5.4 Problems encountered during DHR travel (by theme).

Theme	Sub-theme	Example(s)
Signage (roads)		"Lack of street signs in most Australian cities" "In some situations, signage is a problem, e.g. major roads not identified on a regular basis"
Wayfinding	Navigation, routes	"Getting there the shortest way" "Remembering how to retrace my steps"
	Orientation	"Sometimes I have trouble orienting myself because I can't find land marks"
	Streets/ landmarks	"Some signs have changed or landmarks been taken away, e.g. building not there any more, etc." "Have trouble finding streets/landmarks"
Information/ data	Access	"Arriving late at night, there is no where to get directions or a map" "What local events may be on and that interest me"
	Accuracy/ Completeness	"I have on occasions found poorly described directions, such as incorrect names, incorrect spelling, wrong suburb names, missing information, etc." "… little information relating to street numbers is provided in street directories or maps on the web"
	Currency	"New roads not marked on old maps" "Outdated maps, e.g. new roads, changed traffic conditions in cities"
Services	Finding/ locating	"Car breakdown and finding a service to fix" "Location of public transport (e.g. train stations)"
	Quality/access	"Accommodation too expensive or too dirty" "Unreliable public transport"
Traffic		"Estimating holiday traffic congestion"
Time limitations		"Not enough information available, limited time"

"target user population" "domain-experts"

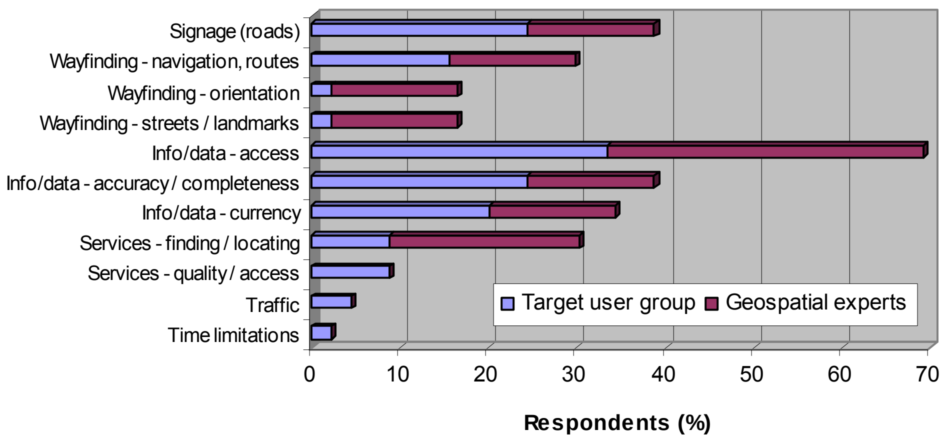

Figure 5.10 Occurrence of travel-based issues in the data.

In total 11 distinct sub-themes were identified, some of these being grouped under broader theme headings to display their linkages (see Table 5.4). The most common theme encountered, for both user groups, was *information/data access*, which was considered to be a problem by 15 of the target user population and five of the domain-experts. Here, respondents cited particular issues with accessing local knowledge and events, and service-related information. The next most problematic were the issues of poor *road signage* and *information/data accuracy and completeness*, each raised by 11 of the target user population and 2 domain-experts, with the latter mainly centring on inaccurate or erroneous online and printed materials, and inadequate maps. Issues were also frequently encountered with *information/data currency* (including outdated maps and brochures), *navigation* (such as optimal routing and taking wrong turns) and *finding /locating services*. Problems cited by proportionally more domain-experts than those in the target user population included *orientation* and *locating streets and landmarks*, while three issues were identified only by the target user population: *quality of/access to services*, *traffic* and *time limitations*.

5.4.3 Goal and task characteristics

The respondents' goals (objectives) and tasks (work performed in pursuit of a goal) whilst undertaking DHR travel were of central importance to the user profiling activity. It is these behaviours – essentially users' plans and actions – that formed the structure around which the cartographic representation models were ultimately designed. In order to describe the respondents' high-level travel behaviours, a small yet comprehensive set of goal and task behaviours were measured, with respondents asked to recall any DHR travel they had undertaken during the last two years.

The most important behaviours measured here were the frequency, distance and duration of travel undertaken by the respondents. To begin, the vast majority of the target user population had taken between one and three holidays within the last two years, with a smaller, yet considerable number having taken between four and six holidays (Figure 5.11). Few respondents (nine in total) had taken more holidays than this. The holiday frequencies were similar for the domain-experts, although none had taken more than 12 holidays within the past two years.

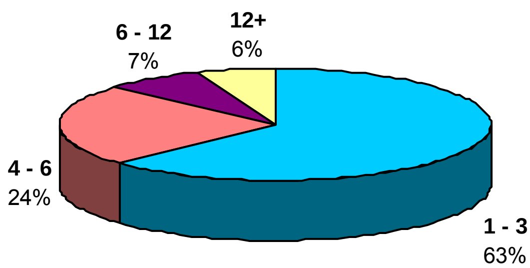

Figure 5.11 Holiday frequency (last two years).

'Holiday distance' referred to the most common distance respondents travelled to reach their holiday destinations, simplified to either *inter*state, *intra*state or both (Figure 5.12a). Notably, the majority (39%) travelled each distance equally, while the interstate-only travellers outnumbered the intrastate-only travellers (33% and 20% respectively). The results for the domain-experts proved somewhat different, with most travelling intrastate most commonly (41%) and 24% being interstate-only travellers (the remaining 35% commonly travelling both distances).

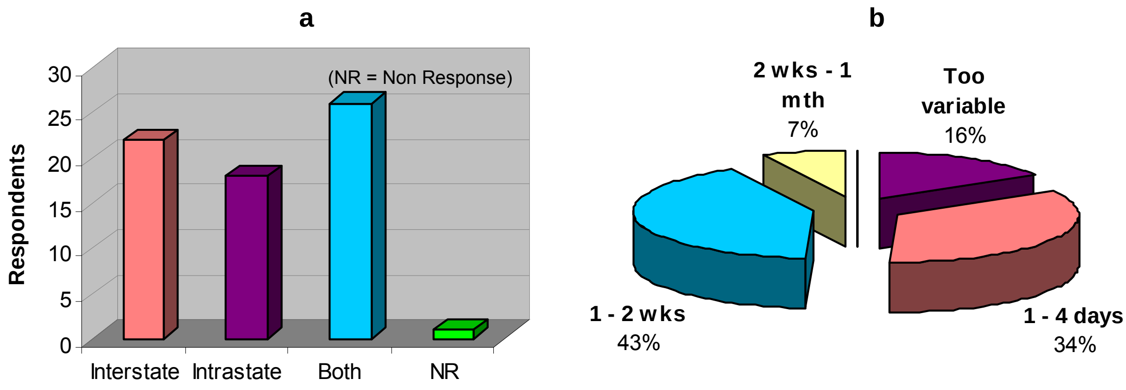

Figure 5.12 Holiday (a) distance and (b) duration (last two years).

When asked the average length of their holidays, most respondents reported that they usually stayed between one and two weeks, with one to four days being the next most popular (Figure 5.12b). A substantial number (16%) maintained that their holiday durations were too variable to classify. The domain-experts produced similar, yet more pronounced results, with half taking one to four day holidays while the rest took one to two week holidays.

Familiarity was also an important variable, providing information regarding the amount of DHR travel undertaken to previously unknown destinations. Respondents were not only asked to state whether any of their recent travels had been to previously unknown destinations, but also to estimate the proportion of this 'unfamiliar' travel. The results for the target user population were grouped into logical categories and are presented in Figure 5.13. For the 54 respondents who had travelled to new destinations within the last two years, the most common proportion of new destinations was between one-quarter and one-half of total destinations (estimated by 23 users), followed by less than one-quarter being new destinations (12 users). Grouping the remaining categories together, a notably large number of respondents (17) estimated their proportion of new destinations to be over one-half of their total (seven users claimed 100% new destinations). The results for the domain-experts were similar, with 71% having travelled to unfamiliar destinations within the last two years and the most common proportion of new destinations being between one-quarter and one-half. The main difference from the target user population was in the small number of domain-experts whose holidays were to new destinations more than half the time (only two respondents).

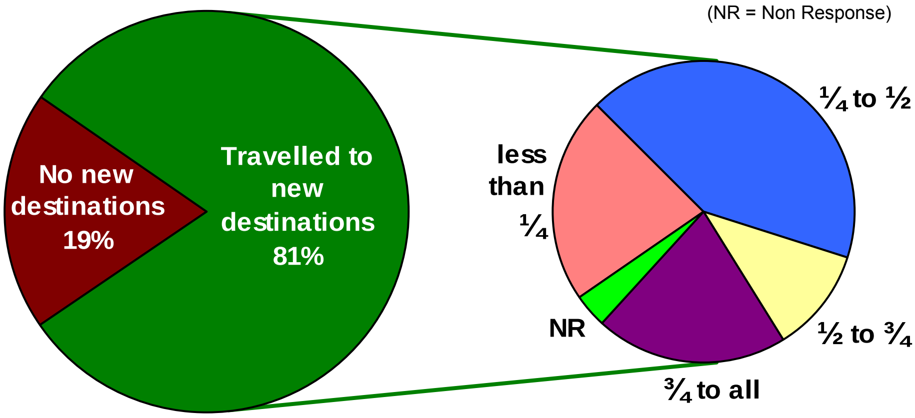

Figure 5.13 New destinations, by proportion of total travel.

Since navigation is (generally) an important aspect of travel, information was collected regarding respondents' transportation modes both to get to, and when at, their holiday destinations. Respondents were able to select more than one mode of transportation for each travel category, however they were asked to select the *most common* mode(s) they used. Figure 5.14 displays the results for the target user population. The most common form of transportation for both travel categories was by private automobile (car, truck, etc.), with the next most common being aeroplane for travel **to** destinations and foot for travel **at** destinations. Public transport was also popular at destinations. Other modes of transport provided by the respondents included: walking or hiking **to** a destination and skiing or limousines **at** a destination.

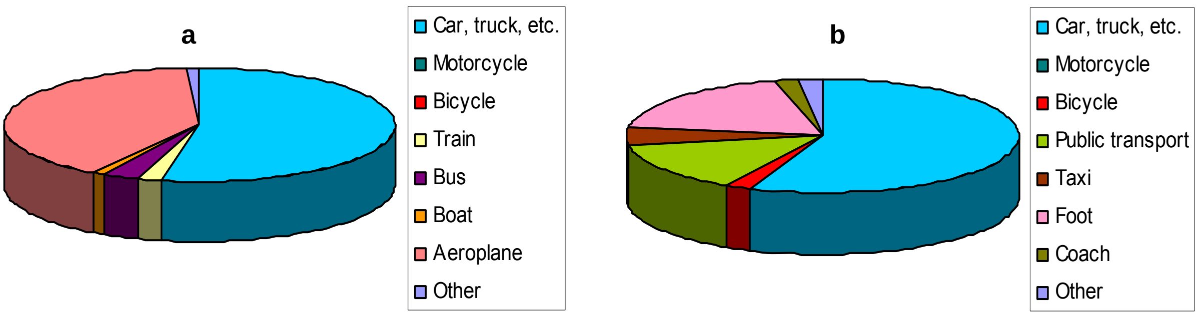

Figure 5.14 Most common modes of transportation (a) to get to and (b) when at holiday destinations; by relative proportion of respondents.

Another important characteristic of DHR travel is the need for accommodation. As such, participants were asked about their accommodation choice/booking behaviours, with the majority (61%) choosing and booking their accommodation prior to leaving on holidays. Conversely 10% chose and booked their accommodation upon arriving at their destination and 16% tended to use both methods. Only a single respondent chose their accommodation prior to leaving on holidays and booked upon arrival, while a further respondent used a different method altogether (not provided).

The final goal and task characteristics to be measured were the main activities respondents participated in during their recent travels. A number of pre-determined responses were provided, however respondents were encouraged to suggest additional activities. Figure 5.15 illustrates the response rate for the predefined activities and shows that sightseeing (all types) and visiting friends and relatives were the most popular holiday activities for the target user population. Scenic driving and shopping were next in line, with over 50% of respondents having taken part in each during their recent holidays. The remaining activities were partaken to varying degrees, ranging from extreme sports undertaken by one respondent, to arts/music festivals enjoyed by 23 respondents. Several additional activities were provided, including: dining out, winery visits/tasting, historic building tours, markets, cooking school, fishing, visiting aboriginal sacred sites and walking along the beach. An additional activity supplied by the domain-experts (who exhibited a similar pattern to that in Figure 5.15) was camping.

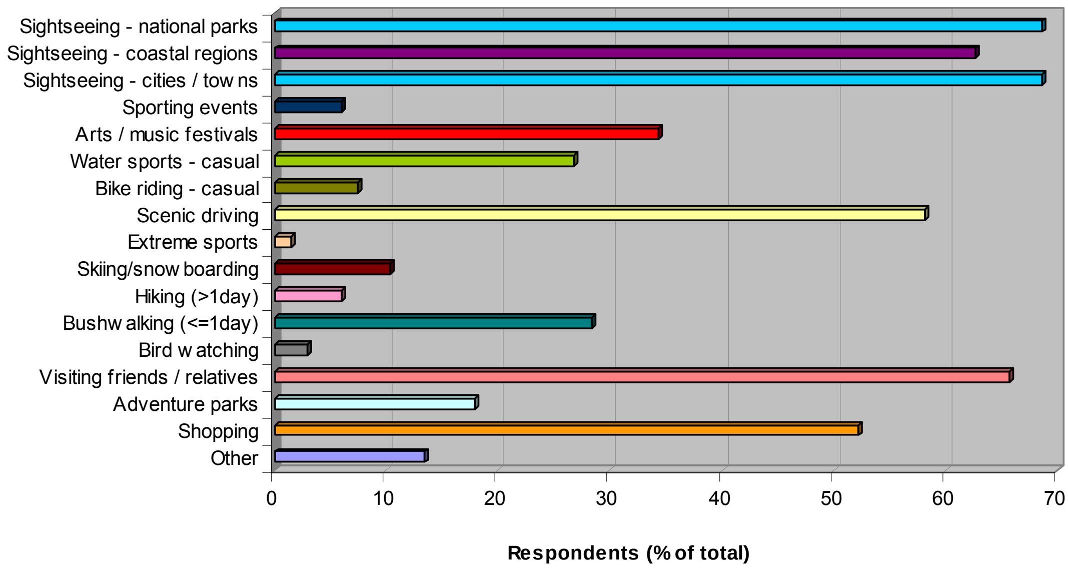

Figure 5.15 Main holiday activities.

5.4.4 Psychological characteristics

More subjective measures enable the determination of attitudes, opinions, preferences and motivations, in this case with respect to the possibilities for information access during DHR travel. To this end, respondents were asked questions under two categories – the first pertaining to the types of location-related information they would like to have available and their preferred methods for accessing it; and the second regarding their opinions of a hypothetical holiday information service.

As mentioned previously, navigation is a major part of travel and as such participants were asked to select from a predefined list which form(s) of navigation information they would potentially like to have available during their holidays. Whilst all types of information were represented in the target user populations' preferences – see Figure 5.16 – the most popular (desired by over 90% of respondents) was directions involving the most scenic route. Also highly popular were locations of prominent landmarks along a route, route directions involving stopping points and route directions involving either the fastest or shortest route (all desired by over 67% of respondents). Notably, the desire for knowing traffic conditions along a route figured highly (over 50%) – this theme having previously emerged as an issue people encountered when travelling on holidays (refer to Table 5.4). Additional suggestions by respondents included: "I would also like to be able to see the distance exactly in kilometres" and "Information on events that could cause an increase in traffic along a certain route", whilst one respondent noted that "it all depends on what kind of holiday you are going on".[4]

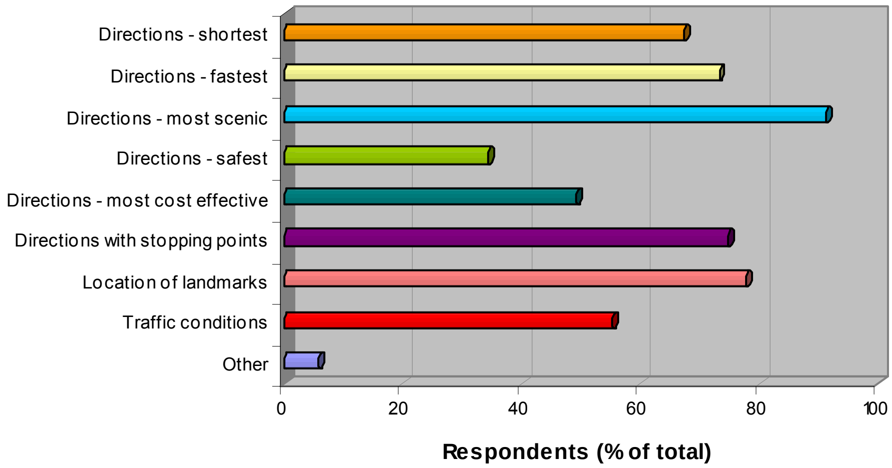

Figure 5.16 Desired navigation information.

It has already been established that, apart from navigation information, there are numerous other types of location-related information utilised whilst on holiday. In order to obtain a complete picture of users' location information needs and preferences, respondents were asked to specify other types of information they would like to have available during their travels. Again a pre-determined response set was supplied with respondents' encouraged to make additional suggestions. As can be seen in Figure 5.17, most of the pre-defined information types were expected to be useful to respondents for their DHR travel. Of most importance were the location of tourist attractions, banks and ATMs, food outlets and petrol stations. Of lesser importance were the location of nearby family and friends, virtual tours and advertisements for discounts on accommodation/other. In terms of the location of nearby services and amenities (desired by 60% of respondents), examples given by the users themselves (including the domain-

[4] Respondents were additionally asked to provide preferences for particular methods of accessing navigation-related information in terms of access before a trip, during their holiday travels or both. The results of this question were discarded, however, due to problems with the question design (which was found to be largely ineffectual) as well as the emphasis on route guidance representations, which were later deemed to be outside the scope of the research (Section 7.3.2).

experts) included public toilets, supermarkets, chemists, medical facilities, police/fire stations, public transport, visitor information centres and auto-mechanics. Additional location-related information that respondents desired included: traffic reports for local areas, opening times for nearby services, shops and attractions and dog-friendly parks.

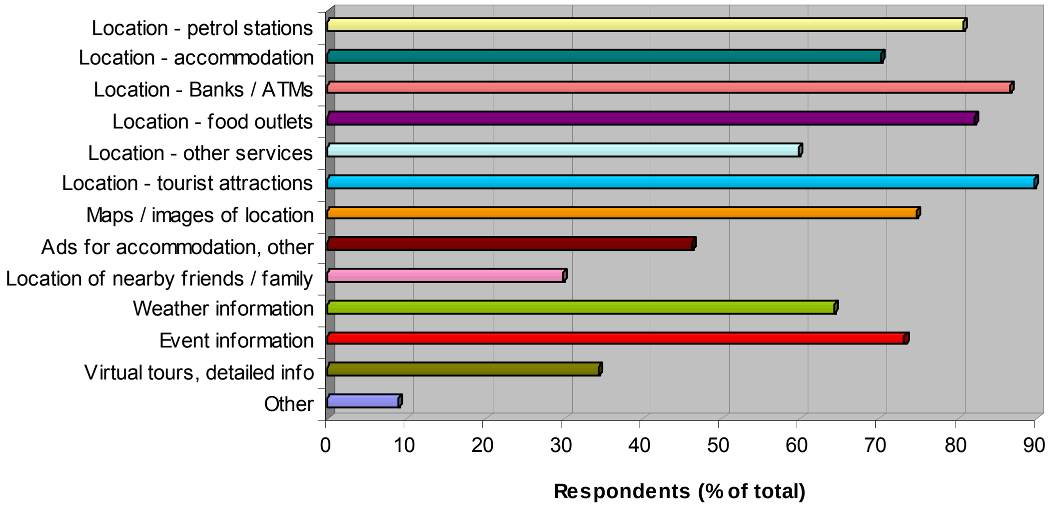

Figure 5.17 Other desired location-related information.

Expanding on the respondents' apparent desire for location (and other) information relating to services, Figure 5.18 shows the perceived level of usefulness the respondents placed on a selection of POIs. The rating categories ranged from "very useful" to "not useful at all", with an option for those who were "indifferent" to information on the POI types. The POIs for which location-related information was considered most useful included: banks and ATMs, service stations and garages, restaurants and cafes. Those generally considered not useful at all included: florists and real estate agents. Overall there were wide-ranging preferences, which was also the case for the domain-experts. The domain-experts, however, placed a proportionally greater expected level of usefulness on information relating to hotels and motels.

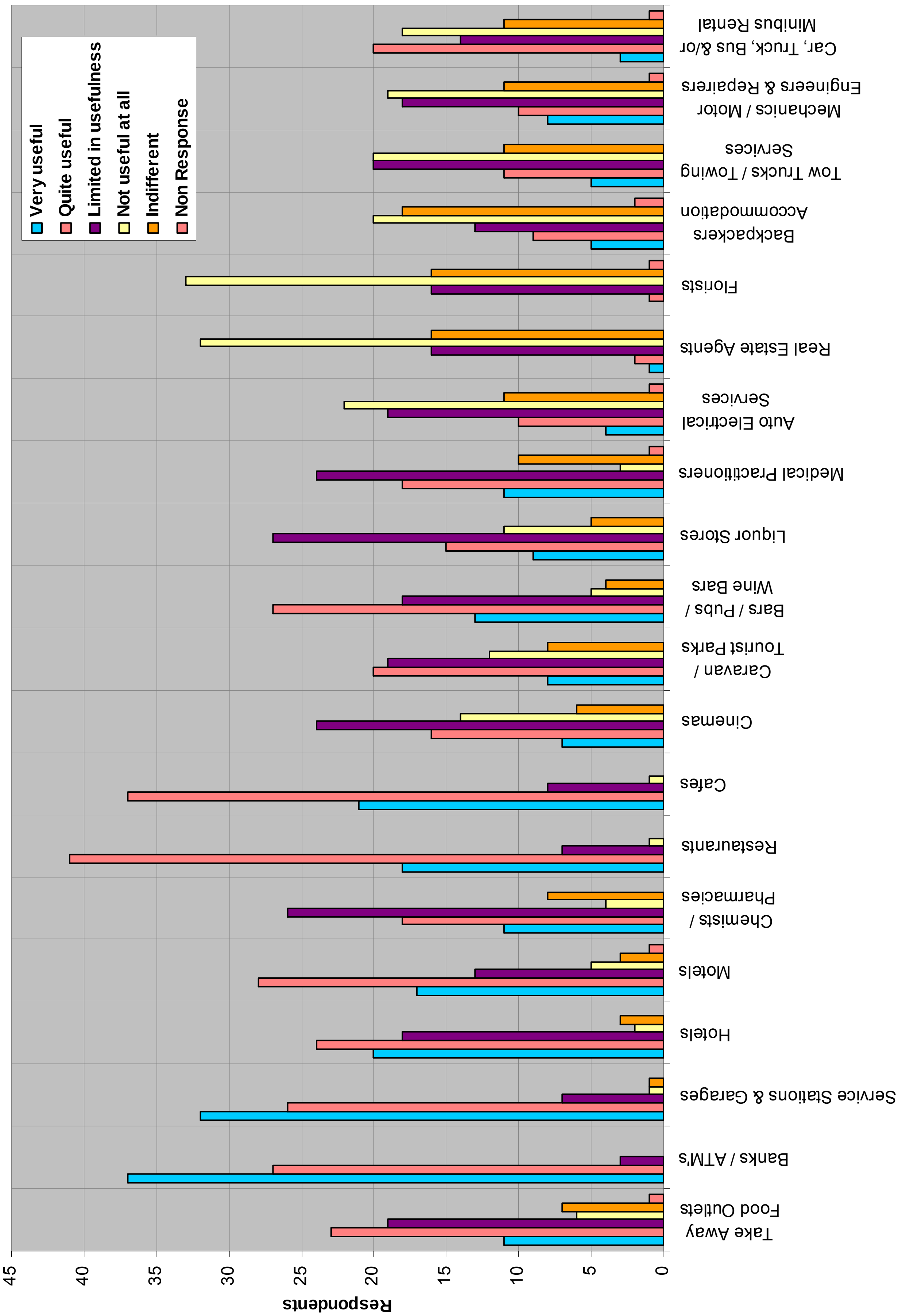

Figure 5.18 Usefulness of selected Places of Interest.

The final set of subjective measures were gathered in relation to a hypothetical service called 'Holiday Assistant' – an application suite running on a mobile/SmartPhone or handheld computer that used a multimedia display (with sounds and graphics) to provide users with instant up-to-date, location-based information while travelling on holidays. With only this description in hand, respondents were asked their opinion on how likely it would be that they would use such a service. The majority were generally receptive to the idea of the 'Holiday Assistant', with 24% of respondents stating that they would definitely use such as service and 40% claiming they would probably use it. Conversely, 9% believed they would be unlikely to use the 'Holiday Assistant' and 3% would not want to use it at all. Just under a quarter of respondents were unsure, requiring more information. In comparison, of the domain-experts 35% would definitely use the service and 29% would probably use it, whilst 24% were unlikely to use the service and 12% were unsure (none of the experts rejected the service entirely).

In terms of the actual use of a 'Holiday Assistant', most respondents expected it to be of most value while travelling to their destination *and* at their destination (for planning and when 'out and about'). Proportionally fewer believed that it would be useful prior to departing on their travels (Figure 5.19a). The domain-experts (Figure 5.19b) were less enthusiastic about using a 'Holiday Assistant' before departing and enroute to their destination, however they displayed considerable interest in its use at their destination, particularly when 'out and about'.

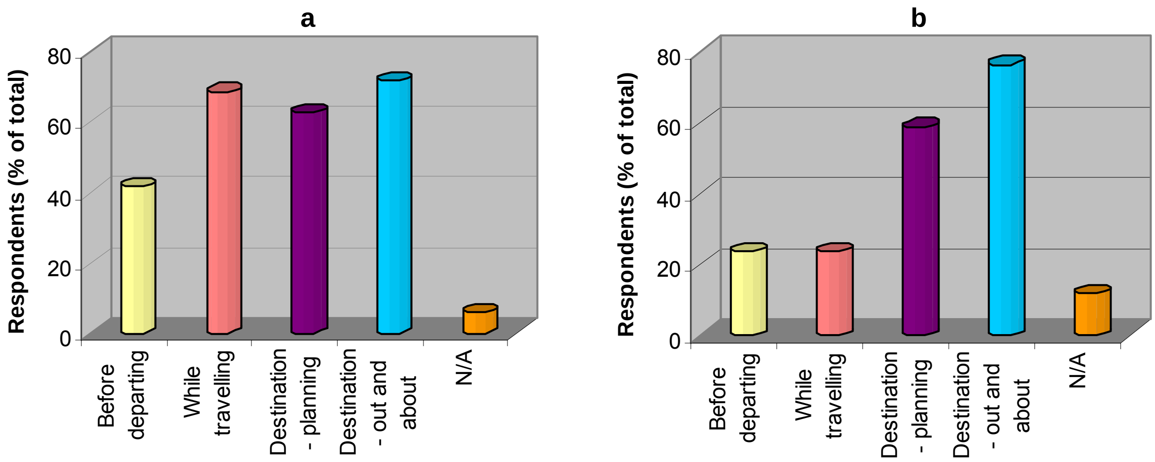

Figure 5.19 Expected use of a 'Holiday Assistant' by (a) target user population and (b) domain-experts.

When asked to provide reasons for why they would or wouldn't use a 'Holiday Assistant' service, there was again a surprisingly large rate of response, considering the open-ended nature of the question. Altogether, 49 of the 67 target user population responded, with all 17 of the domain-experts answering this question. A number of major themes were distilled from the comments provided, which are described in Table 5.5 and their occurrence illustrated in Figure 5.20. Due to the phrasing of the question, each of the 19 resulting sub-themes were categorised as either reasons for using a 'Holiday Assistant', reasons for not using a 'Holiday Assistant' or attributes upon which the use of a 'Holiday Assistant' would depend. A number of the sub-themes were additionally grouped under broader theme headings to display their linkages (see Table 5.5).

Table 5.5 Reasons for use/non-use of a "Holiday Assistant" service.

Theme	Sub-theme	Example(s)
REASONS FOR USE		
Usefulness/ convenience		"It would be handy and a time saver to be able to look these things up from anywhere" "Easy access to tourist info without the need to visit info centres to plan events when at destination"
Efficiency		"It would cut down on the time needed to be spent researching before and during your holiday" "This could save a trip to the tourist information centre where we would normally get this info"
Portability (size)		"It is easier to carry than a stack of maps and brochures like we currently do" "...smaller than a guidebook"
Holiday enhancement		"Remove frustration at spending time having to search around when away from home" "...don't miss out on things"
Potential for other uses		"I could see the use beyond holiday travel ... the availability to turn on/off items of interest is/would be very useful"
Information	Integration	"Would provide a range of information in the one package"
	Currency	"Sometimes the information centres just don't have the information you need or it is out of date"
REASONS FOR NON-USE		
Prefer traditional information (and access methods)		"I prefer talking to real people and asking them what's good" "Map (hardcopy) would be 100 times more useful and practical"
Additional 'luggage'		"Something extra to lug about" "It would be another 'gadget' to carry around"
Prefer to avoid	Technology	"Spend most of my holidays trying to get away from technology"
	Planning	"Takes away from adventure and the chance encounters of a trip"
USE-DEPENDENCIES		
Cost (service, devices)		"Depends on the cost of use. Cost would likely dictate how often I used it" "Probably [wouldn't use] if it cost what I'd deem too much money"
Network coverage/ reliability		"I would not use it if ... it was unreliable" "Coverage would be an issue for some areas"
Location (size, familiarity)		"Its use would also depend upon the size of the area being visited"
Usability	Device-related	"The screen on the mobile is too small to convey much meaningful information, using it is too fiddly"
	User-friendliness	"I would like to know ... how user-friendly it would be ... before saying yes"
Information	Relevance	"Depends on ... how relevant the information it provides is"
	Reliability/ accuracy	"If cost was reasonable, and quality of information was accurate, it would be well used" "Would also be wary of data reliability and currency"
	Currency	"Depends on ... the relevance and currentness [sic] of information"

"target user population" "domain-experts"

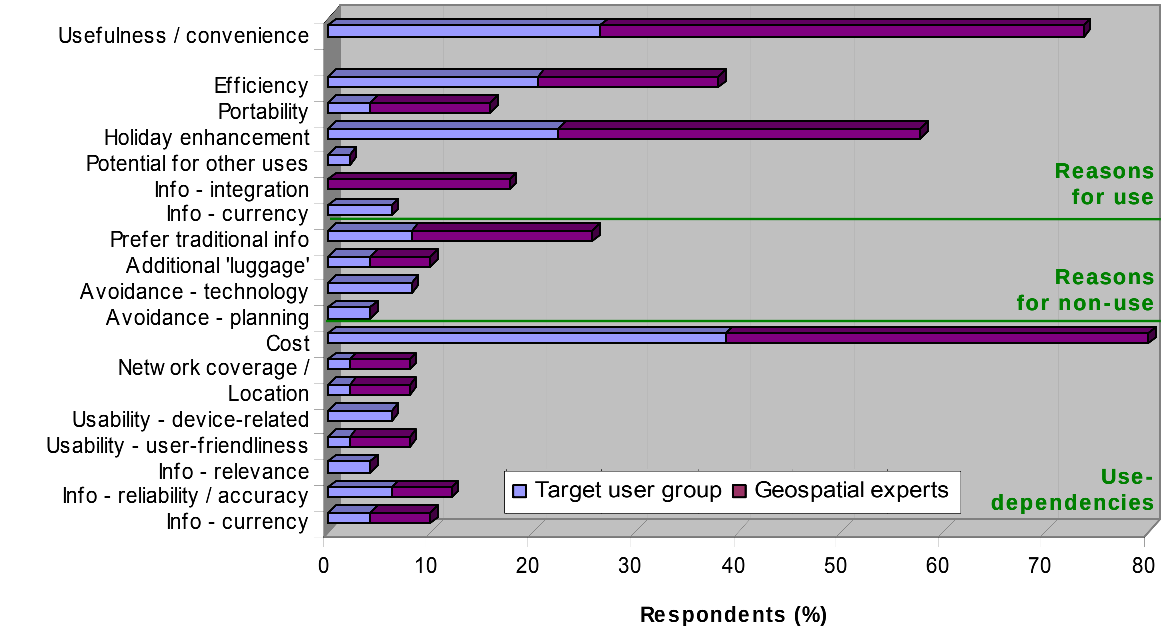

Figure 5.20 Occurrence of reasons for use / non-use of a "Holiday Assistant" service (by theme).

By far, the most common reason cited for use of a 'Holiday Assistant', by both user groups, was the perceived *usefulness/convenience* of the service (13 members of the target user population and eight domain-experts). Closely related to this theme, and subsequently also popular reasons for use were the expectations of improved *efficiency* and *holiday enhancement*. Additional themes encouraging use included the high *portability* of the service, its apparent *integration of comprehensive information* sources, the expected high *currency* of the information contained and the potential of the service for *uses other than travel*. The most common reason for non-use of a 'Holiday Assistant' was the *preference for traditional information /access*, put forth by four members of the target user population and three domain-experts. Other themes discouraging use were the fact that the 'Holiday Assistant' would be *another piece of luggage* to be taken on holiday, a *preference to get away from technology* while away from home and a *reluctance to plan travels and/or stick to a schedule*. In terms of use-dependencies, *cost* was the major factor (and the most common theme overall). Here, 19 members of the target user population and seven domain-experts were concerned about the cost of the service (particularly with respect to the information it provided) and/or the cost of the device(s) required to access it. In addition to this, respondents were concerned about issues of *network coverage and service reliability*, the *usability* of the service and the device(s) involved, the *information* contained within the service – its *relevance*, *reliability/accuracy* and *currency* – and the ultimate need for the service, based on the *size of the destination* and the user's *familiarity* with it.

5.5 Analysis and Discussion

With a description of the target user population now in hand, it is appropriate to analyse the findings in-depth in order to develop the final user profile. In doing so, each aspect of the population must be considered in terms of its relevance to the profiling activity, the implications it poses to the cartographic UI design models and, finally, any requirements for further investigation to be fulfilled prior to the design activities. Rather than summarising separate user profiles for each significant category of users, the decision was made to formulate the final user profile as a 'range' of characteristics. This was based on a need to consider the users as *individuals* – holiday-makers operate via a set of personal goals and as such they cannot be classified into groups without some loss in the understanding of their individual needs. Note, more specific user profiles (or archetypes) were developed in the form of 'personas' as part of the user task analysis activities (see Section 6.5.3).

5.5.1 Questionnaire success

Prior to discussing the trends arising from the questionnaire data, it is necessary to assess the questionnaire itself as a tool for user profiling. In this respect, the relative benefits and limitations of online data collection are discussed, followed by consideration of the resulting data's accuracy and rigour.

5.5.1.1 Online distribution

The majority of the user profiling data was collected via the Web using an online submission form, with the remainder gathered through hard-copy questionnaires. While each is a valid technique for data collection, the use of the online tool warrants further discussion. In line with the findings of other studies (e.g. Harper *et al.* 1997), a number of benefits and limitations were associated with employing this technique for the research. Beginning with the benefits: the use of an online tool meant lower costs for questionnaire distribution in terms of print and return mail expenses, as well as reductions in the effort required for the distribution, and turn-around times for responses (including follow-up contact). Associated with this was the potential for greater participation, with the ability to reach numerous respondents simultaneously, regardless of their physical location, and the transference of the data entry task to the respondent (i.e. no need for data recording or transcription). The online submission form also meant that there was little effort required for the data collection – with all responses emailed directly to the researchers – and data aggregation and processing (e.g. error checking) – since the data was already digitally encoded and could be imported directly into the data analysis software (Microsoft Excel).

Another benefit that was realised early on came from the need to pre-determine the response coding and levels of measurement during the questionnaire's design, in order to facilitate building the online form – a task that would have been substantially more complex had it been left until the data aggregation stage. Additionally, constraints were able to be placed on appropriate response fields to ensure the correct input type (e.g. numeric vs. textual) and/or maximum input length. Finally, the questionnaire medium led to each respondent automatically satisfying the desirable characteristic of being technologically capable (as per Section 5.2.3). In terms of benefits to the respondents themselves, supplying the questionnaire online meant that participation was entirely voluntary (i.e. there was no pressure to complete it, as can be the case when an interviewer is present). Respondents were also able to progress at their own pace, moving back and forth between questionnaire 'pages' at will (without losing any of their responses) and could choose to exit at any time, thus automatically discontinuing their participation in the project.

In terms of limitations these were substantially fewer in number. The main disadvantage of using an online questionnaire (specific to this study) was the reliance on an external party to program and publish the questionnaire form. Whilst entirely understandable, there were significant time delays in this process due to the low priority Sensis developers attached to the project, with respect to their own commercial tasks. A second limitation was the need for manual checking of duplicate participant entries (through comparison of names, contact details and question responses) since there was no procedure in place to prevent respondents from submitting the questionnaire more than once. This may have been prevented had resources permitted the incorporation of individual logins and associated response logging, however this was not considered a critical issue for the small number of responses expected and indeed could have led to difficulties in obtaining ethical approval. A final limitation was the non-random nature of participant selection, whereby respondents were essentially 'self-selected' to take part in the research (and hence form part of the target user population). This was again not seen as a major issue since the qualitative methodology of the research (Chapter 4) and the subsequent sampling techniques employed (Section 5.2.4) were selected with the knowledge that the results would and could not be generalised to the larger population (i.e. this was not an aim of the research).

In light of the benefits outweighing the limitations, the use of an online questionnaire to collect the user profiling data was considered an overall success, not least due to the unexpectedly high response rate of 35% from the target user population and the rich detail of the data generated.

5.5.1.2 Accuracy and rigour

As established in Section 4.5, the study's focus on qualitative methods of data analysis warranted a qualitative approach to ensuring credibility (i.e. accuracy and rigour). As such, no effort was made (nor was it intended) to assure the statistical reliability and validity of the questionnaire as a measurement instrument. For this phase of the research the accuracy and rigour of the data were maximised in a number of ways, using the recommendations of researchers in the field of qualitative research (Kirakowski 2000; Aldridge & Levine 2001; de Vaus 1995; Creswell 2003).

In terms of rigour, this was ensured through careful selection and design of the user profiling data collection instrument, as well as systematic analysis of the results by a single researcher, which ensured that the themes developed for the target user population were consistent across the data. With a focus on accuracy, a great deal of care was taken during the development of the questionnaire, including careful question construction and wording to ensure clarity and avoid issues such as 'response bias' (Section 5.4.2.1). This was the primary purpose of the pilot testing and questionnaire revision detailed in Section 5.3.2.2. Additionally, while the questionnaire's dominance by closed questions had the potential to severely limit and bias the responses through the presentation of pre-determined response categories, the addition of an open-ended 'other' category, where possible, reduced the severity of this, as did the inclusion of fully open-ended questions at key stages of the questionnaire. Finally, during the processing of responses, careful coding, checking and cleaning of the data was undertaken including:

- omission of 'junk' responses;
- categorisation and handling of missing data – e.g. missed questions, non-response/refusal to answer, response not required, no opinion; and
- testing for errors – e.g. valid range/bound checks and erroneous code entries (minimised during construction of the online form); filter/routing checks for disagreements between contingent responses; and logical/consistency checks between unlinked, but related questions.

Notably, even with this careful preparation, the data processing uncovered problems within the questions which had to be considered during the analysis. For example, one question had the potential to elicit socially desirable responses (Section 5.4.2.1), while a number of others combined separate technologies (e.g. handheld computers and SmartPhones) into single questions, making analysis of the responses difficult. Additionally, the questionnaire was largely based around participants' recall of past travel events, which had the potential to provide unreliable information (particularly where time measurement or frequency of occurrence were involved), thus it was important to be mindful of these responses during the analysis.

Revisiting the accuracy checks defined by Creswell (2003) and summarised in Section 4.5, three of these were employed for the analysis – rich, thick description; clarification of researcher bias; and presentation of negative/discrepant information. An additional check – triangulation – was completed as part of the next phase of the research, user task analysis, whereby a different method of investigation further informed and completed the description of the target user population.

5.5.2 Observed trends

Whilst Section 5.4 presented the high-level patterns that emerged in the data, this discussion delves further into the themes and trends observed. Where the results differ substantially, the data for the domain-experts is discussed separately (however the small number of these respondents makes their data less informative); otherwise the analysis primarily concerns the target user population (sourced from the Sensis evaluator database). The discussion divides the user profile into 'user characteristics', 'context of use' and 'user preferences' – each of which come into play during use and learning of a final product (Hackos & Redish 1998) – with the complete user profile summarised in Table 5.6. This is prefaced by a brief discussion of the bias brought to this phase of the study.

5.5.2.1 Researcher bias

As with any long-term research project, the researcher understandably brought along a certain degree of bias that comes with immersing oneself in a specific topic. In this respect there was held an initial belief that a DHR travel mLBS was something that people were interested in and thus would want to use – hence the aim of the research being to optimise the component cartographic representations. This no doubt influenced the nature of the questions comprising the questionnaire which, while all efforts were made to keep them as generic and comprehensive as possible, were for the most part constructed with existing travel mLBS (and related research) in mind. Therefore they likely did not capture the entire range of user needs and characteristics. It is for this reason that a number of areas for further investigation are highlighted throughout this section (and summarised in Table 5.6), the intention being to fill as many gaps as possible during the user task analysis phase.

In terms of the assumed user interest, the data (fortunately) supported this view and thus justified the continuation of the research. In particular, the high response rate from the target user population demonstrated that there was indeed a great deal of interest in the study, while responses to a key question provided further encouragement – when asked how likely they would be to use a DHR travel mLBS, 64% of respondents declared that they would *probably* or *definitely* use it.

Table 5.6 The final user profile, related implications for the cartographic UI design models and requirements for further investigation.

Characteristics (Range)	Design Model Implications	Further Investigations Required
User Characteristics		
Male or female	Different approaches / abilities with navigation, geospatial tasks	Gender of travel companion(s)
Aged 25+		
Australian residents		
None to limited vision problems	Issues with fine detail and/or small screens; Colour blindness	
Context of Use		
Moderate to frequent domestic travellers	Familiarity with the service will increase with each holiday and should be accommodated	
Visitors of unfamiliar destinations	Support for lack of knowledge about destination(s)	
Holiday range from short to long-term durations	Different geospatial information needs depending on duration of holiday	Geospatial information needs for different travel durations
Travel by car or air to destinations	Support different modes of travel	
Demonstrate movement around destination	Navigation and geospatial tasks to be supported	
Undertake widely varying activities	Consistent support for geospatial tasks	
Regularly rely on map-based products	Carefully consider the purpose and use of maps	
Actively seek tourism information	Incorporate the most common types and sources of information	
Experience a variety of wayfinding and decision-making problems	Consider common difficulties and attempt to overcome, where possible	
High familiarity with desktop/laptop computer environments	Assume general proficiency with computer-based interaction tools and multimedia	
High familiarity with mobile phones for voice and non-voice uses	Assume general proficiency with mobile phone-type interaction tools and multimedia; Account for potential unfamiliarity with SmartPhones	Preferences regarding technological platform for mLBS
Not formally trained and experienced with geospatial information	Support different levels of geospatial information knowledge	
Comfortable with familiar, general-purpose map representations	Consider the incorporation of (aspects of) familiar representations to satisfy currently accepted / preferred techniques	
Less comfortable with other navigational maps	Avoidance of undesirable map characteristics	Map characteristics causing difficulties
Variability in need to reorient maps	Support individual preferences for map orientation	
None to some difficulty determining directions	Support individual preferences / needs for directional awareness	
None to few difficulties remembering previous routes	Account for individual navigational needs	

Table 5.6 (cont.) The final user profile, related implications for the cartographic UI design models and requirements for further investigation.

Characteristics (Range)	Design Model Implications	Further Investigations Required
Context of Use (cont.)		
Rarely become lost	Consider minimal user positioning support, upon request	
Can provide and follow landmark-based routes and follow directions/distances	Support individual preferences for route formats, ensuring adequate landmark information	Instances of users being lost
User Preferences		
Holiday experience variously considered to include or not include travel to/from/between destinations	Provide support for the different holiday behaviours	
Require detailed local information at destinations	Ensure sufficient local detail to cater for user needs	
Would use a DHR travel mLBS	The research motivation is vindicated	
Mainly interested in a DHR travel mLBS for 'on-trip' situations, with some 'pre-trip' requirements	Provide sufficient 'on-trip' support	
Varying reasons for use, non-use or dependent use of a DHR travel mLBS	• Ensure convenience and efficiency in order to enhance the holiday experience and justify the service's use • Integrate disparate information for a seamless user experience • Ensure the currency and accuracy and quality of the information provided, communicating this to the user • Utilise the benefits of traditional information access methods • Focus on the provision of decision-support • Maximise information relevance for the individual user • Provide information at a range of detail levels, to cater for varying holiday and destination types	

5.5.2.2 User characteristics

Demographically, the majority of the target user population were male, between 25 and 40 years of age and residing in Victoria. It is misleading to generalise to this level, however, as it masks important factors requiring consideration. Treating each attribute in turn, it would be foolish to have tailored the design to male users since there were also a significant number of females within the target user population. Moreover, commonsense dictated that people do not always travel on their own, but rather with friends and/or family, who would likely include members of both sexes. To verify this assumption, the user task analysis endeavoured to gather more companion-based data.

Remaining mindful that individuals vary widely in their spatial competence (Gilmartin & Patton 1984), it was initially deemed important for widely accepted differences in gender approaches to, and abilities with, navigation and other spatial tasks to be considered during the design phase of the research. In particular, studies have shown men to have distinct advantages over women with the abilities of spatial relations and orientation (important for map reading and route planning), targeting[5], spatial visualisation/mental manipulation[6] (related to the generation of "cognitive maps"), disembedding[7] and spatial perception[8] (Kimura 1999; Gilmartin & Patton 1984; Kawai *et al.* 2003). Conversely, women have been seen to excel at spatial location memory, perhaps explaining their comparatively higher recall of landmark and street name details following route-learning trials. All of these factors may in turn provide a basis for findings that "women tend more often to use more specific objects [landmarks]" to give directions and find their way (Kimura 1999, p.64), while "men tend to use distance or cardinal directions" when navigating (p.47). Further discussion of gender-based spatial issues is provided below, with respect to users' experience with geospatial information.

In terms of age spread, the sampling of respondents based on predetermined age groups explained the pattern observed. Most interesting, though, was the fact that a small number of respondents fell above the initially specified age range (25-40, refer to Table 5.2) prompting a realisation that the general issues being studied were not restricted by an upper age limit for the travellers. As such, older users were not excluded from the final target population[9]. Similarly, the home-state of the users (all Australian residents, as expected) was explained by the sampling technique, with the collection of this data being simply to aid in the sampling of users for the user task analysis rather than to inform the design. Thus there could be no analysis or conclusions reached for this variable other than to acknowledge that the small number of interstate users did not demonstrate any marked differences, in terms of travel habits, from their Victorian counterparts.

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5 The ability to hit a target or intercept a projectile (Kimura 1999).

6 The ability to imagine what would happen when parts of an object are folded or put together (Kimura 1999).

7 The ability to find a figure hidden within a more complex one, requiring much of the pattern to be ignored (Kimura 1999).

8 The ability to determine the real-world horizontal and vertical, often in the presence of distracting cues (Kimura 1999).

9 Anecdotal evidence suggests that excluding the 15 to 25 age group may lead to the omission of important feedback for the research, since this is considered the largest potential market for mobile applications. In order to control the scope of the research such investigations cannot be included in this study, however it remains a valuable area for further investigation.

The only physical attribute gathered for the users concerned their vision and viewing of computer screens. Arguably, this was a very narrow approach to determining issues of information design and accessibility, as it did not cover the broad range of human disabilities not associated with sight. It was determined early on, however, that issues of accessibility for people with physical disabilities would not be a focus of the cartographic UI design models as this would expand the study's scope to an unattainable size. Instead the research was aimed at optimising the accessibility of cartographic information for users 'in general', concentrating on cognitive rather than physical usefulness. That said, a small number of users did cite problems with their vision which would undoubtedly impact on their use of mLBS incorporating visual media. Whilst many of those affected could wear glasses to correct their vision problems, the need to ensure high information clarity for the small screen sizes involved in the research was acknowledged, potentially requiring a reduction in overall reliance on users' *visual* sense. An additional issue of note is colour blindness (not evident in the data, but present within the larger population), which sees those affected confusing reds or purples with greens, pinks with blue-greens or yellows with blues, with other deficiencies possible (Martin *et al.* 2000). This had implications for the design with the need to carefully consider the use of affected colours and colour combinations.

5.5.2.3 Context of use

The context within which the cartographic UI design models apply is perhaps the most important part of the user profile. Supporting the initial characterisation of regular travellers (Table 5.2), each member of the target user population was considered an 'expert' to some degree in terms of DHR travel, since all had been on at least one holiday within the last two years ('moderate' travellers), with a large number having taken between four and six holidays during this time ('frequent' travellers). This in itself had implications for the design in terms of users 'learning' the travel mLBS – regular travellers/users would rapidly increase their familiarity with the service, becoming 'experts' with differing information access requirements to newer users. Such differences had to be catered for in order to avoid frustrating users of different levels. In terms of the distances travelled by the users during their holidays, while initially thought to be important, this attribute turned out to be inconsequential to the design since there were no great differences between the numbers travelling interstate or intrastate. More revealing were the level of familiarity that users had with their destinations and the duration of their stay.

Dealing first with familiarity, most of the users had travelled to destinations they had never visited before and thus it followed that they had no first-hand experience with those destinations. These users varied widely in the *proportion* of their travel that was to new destinations, however it was found that three-quarters of the target user population and over one-half of the domain-experts had travelled to new destinations more than 25% of the time. These users were of particular interest for the next phase of the study as they were likely to be information-rich – a requirement of the criterion sampling adopted for the user task analysis interviews (Section 5.2.4.1). Whilst the high number of users travelling to unfamiliar destinations encouraged and validated the aims and expectations of the research (Table 5.2), the fact that many of the users also travelled regularly (or in some cases solely) to familiar destinations had additional implications. As discussed in Section 2.5.1, high usability is not the only factor that contributes to the usefulness and success of a product; there is also high utility, which must be ensured for all user types. A DHR travel mLBS should therefore also accommodate the geospatial needs of users travelling to familiar locations. Unfortunately, however, the boundaries of the research made it necessary to continue to limit the cartographic UI design models' scope to the support of unfamiliar travel.

Information on the duration of the users' holidays was also important, with similar proportions spending one to four days or one to two weeks at their destination(s), and a small number staying between two weeks and one month. These results highlighted differences in holiday durations, which could be categorised as 'short-term' (one to four days), 'medium-term' (one to two weeks) or 'long-term' (two weeks to one month or longer). One may assume that a user's geospatial information goals, tasks, needs and preferences will differ according to (and perhaps dictate) the holiday duration, being most pronounced between the extremes of short- and long-term travel (e.g. more careful route planning given a shorter timeframe). Unfortunately, insufficient data was collected by the questionnaire to clearly identify any such relationships, since individual holidays were not distinguished within the responses. To rectify this situation and endeavour to emphasize patterns and variations related to holiday duration, the focus of the user task analysis was on specific, individual travel events.

An early assumption that users would obtain the most navigational benefit from a DHR travel mLBS when travelling *overland* to reach their destination (Table 5.2), was encouraged by the large proportion of users who travelled by automobile (over three-quarters). This presented only half the picture, however, with navigation (and many other geospatial goals – Table 5.3) also being important when *at* a destination, the data showing the target user populations' dominant modes in this respect to be automobile, walking and public transport. Hence it would have been narrow-minded to exclude from the target user population those respondents who did not travel overland on holiday, particularly since the data showed that the majority of these travellers took most of their holidays to unfamiliar destinations and were thus information-rich. The design implications relating to transportation modes thus related to ensuring sufficient support for each stage and manner of travel.

Informing further on the movement of users at their destinations and associated geospatial tasks – refer to Table 5.3 – was information concerning holiday activities. By far, the most popular activity was sightseeing which requires knowledge of sites of interest (identification and event tasks) along with travel to, and often between, such sites (localisation, proximity and wayfinding tasks). Scenic driving, while potentially more open-ended, also relies on geospatial knowledge and tasks such as wayfinding, localisation, proximity and themes (e.g. a winery tour). Other popular activities, such as visiting friends and relatives, shopping, skiing/snowboarding, bushwalking, art/music festivals and causal water sports again have geospatial components; requiring sufficient information to, at the very least, investigate where the activities are located. The principal consideration to be gained from this was the need to provide geospatial support for a wide variety of activities and task in a consistent manner.

To obtain an idea of the current sources of geospatial information used during the pre- and on-trip stages of the users' holidays, data was collected regarding commonly used location-related information, navigation aids/techniques and other decision-support information. Understandably the responses to these questions were highly contingent on the users' recall of events, as well as being biased by the predetermined response set presented in each case (although an 'other' option was always provided). Hence the data could not be considered highly reliable, although it was sufficient for the purpose of obtaining an indication of users' potential geospatial information needs and practices, which were addressed in the cartographic UI design models.

The aids commonly employed by users before and during their travels to provide navigation information were street directories, state road maps, tourist maps and street, traffic or tourist signs – with Internet maps and directions also important to the target user population, but noticeably less so for the domain-experts. This demonstrated a heavy reliance on (and perhaps a preference for) mapping products, which was highlighted for consideration during the design phase. Moreover, the high use of signage indicated a need for matching map-based data (e.g. street names) with information and landmarks within the environment (e.g. street signs) in order to assess the current situation and make adjustments accordingly (e.g. when following a route). Navigation aids employed by a mid-range of users provided further insight into less tangible information-gathering techniques during travel. These included memory and intuition, sighting landmarks and obtaining directions from local inhabitants.

The location-related information that appeared to be of most importance to users, both before and during their holidays, were directions of various forms (written, spoken, map-based), the location of accommodation (generally chosen and booked prior to departing), the location of specific tourist attractions, the location of services/amenities and local weather reports. Other information types and sources commonly used to help make holiday-related decisions included Tourist Information Centres, tourist brochures and guidebooks, websites or online directories and the recommendations of friends. Knowledge from local inhabitants was also important, but more so for the target user population. Interestingly, this group cited greater use of decision support information in general when compared to the domain-experts – this could be a recall-related issue or may be a valid difference between the two user groups. Nonetheless, it was evident that all users actively sought tourism information to assist with their holiday decision-making, with the more common information types and sources (as a minimum) recommended for integration into the design.

A key factor in the context of use for the cartographic UI design models was information relating to the problems users had experienced with wayfinding and decision-making during their DHR travel. Such issues, particularly where common, had great potential for informing the inclusion and design of information within the mLBS. Supporting the idea of a comprehensive service that is available anywhere, anytime, the most common complaint concerned limited access to relevant and timely information. Linked to this, users also took issue with the accuracy and completeness of the information that was available, as well as its currency (i.e. how up-to-date it was). As identified above, many users relied on information in the environment, in the form of street signs, while travelling. This practice appeared to be a source of frustration for many users, however, with a large number citing inadequacies in street signage across Australia. Other noted problems which were considered for the design models concerned difficulties with navigating to locations, self-orientation at a new location, locating specific streets and landmarks, finding and locating services, the quality of and access to services, and limitations on time. Further information was sought relating to these and other travel-related issues during the user task analysis, in the context of specific travel events.

The final dimension of the use context concerned users' experience and related knowledge with respect to the technology platform for the DHR travel mLBS, as well as the geospatial information underlying the cartographic UI design models. To first deal with technology, because the final platform had not been selected at the time of the questionnaire's preparation, information on technological experience was gathered quite broadly, under the assumption that experience with common and mLBS-related computing and communication technologies would contribute to, and thus inform on, the users' general technological prowess.

With this in mind, almost every respondent was a frequent user of a desktop/laptop computer, with an emphasis on their use for Internet access, Email, word processing and spreadsheets. Mobile and SmartPhones were almost as popular with most participants being current owners and/or users of such devices for a variety of non-voice purposes, most notably SMS, alarm/event notification, games and phonebook tasks. The use of handheld computers was comparatively more limited. Unfortunately, the questions yielding this information were not worded clearly enough to gather distinct information on SmartPhones (the eventual development platform), since these were combined with mobile phones in some questions and handheld computers in others. Thus it is possible that the results discussed here related more to the other technologies, rather than to SmartPhones. While reducing the usefulness of the data at a precise level, this data collection issue was not considered critical to the user profiling as the interest was more general – i.e. an overall view of users' technological experience was sought, rather than a specific view. In particular, there were implications for the design in the generally widespread use of all types of computers and phones for interactive, multimedia tasks (e.g. internet, games) which boded well for an interactive multimedia-based mLBS application. Additional information was sought during the user task analysis phase relating to preferred technologies for mLBS, which provided support for the selected technology platform.

Two questions were asked to ascertain the user's overall experience with the types of geospatial information used during holiday travel. First, formal training and/or qualifications in this discipline were sought, uncovering an expected divide between the geospatial qualifications of the target user population (effectively having none) and the domain-experts (all qualified and/or working within the geospatial field). Despite their lack of detailed experience with geospatial information, a large proportion of the target user population had used Internet-based maps, supporting the aforementioned penchant for map-based geospatial information. From the data it was surmised that the majority of users had no formal experience with and knowledge of geospatial information, however they were likely exposed to such on a daily basis and during their travels, often without realising it. The remaining users, however, had an intimate knowledge of geospatial information and thus potentially did not require as much explanation of certain concepts as did the non-expert users. Hence, in line with individual differences in geospatial knowledge known to exist across the human population (Section 2.5.3), and the aforementioned differences between males and females, the range of users' domain expertise within the target user population required the design to cater for alternative approaches to, and abilities with, navigation and other spatial tasks.

A second question diverged from formal geospatial knowledge and experience, concentrating on the users' perception of their personal skills with map reading and navigation. Whilst a highly subjective question, susceptible to socially desirable responses, this was also an important measure in that it enabled users to rate their own abilities and thus "define themselves" in terms of their experiences with geospatial information (Hackos & Redish 1998, p.35). The following analysis thus looks beyond the target user population's high self-rating of map reading and navigation abilities, to examine in more detail each statement to which the users responded 'always', 'often', 'sometimes' or 'never'. Additionally, since spatial abilities are known to differ between the genders, some discussion of this topic is included.

- **I can read Melway and/or UBD maps with ease.**

All users, in general, found it simple to read the popular Melway and/or UBD street directories, which cover Australian capital cities, regional districts and rural towns. This most likely reflected a high familiarity with their component general-purpose maps, resulting from daily/weekly use of such products. Notably, no significant differences were found between males and females in their claimed competency with directory maps, despite an initial expectation for males to be more proficient due to their 'superior' spatial orientation and relational abilities (Kimura 1999). This may be a result of the high number of specific objects/landmarks included in these maps (favouring female navigation), combined with detailed geometric information (favouring males), or it may be an anomaly of the sample. Nonetheless, it is preferable to take Gilmartin's (1984) advice and remain sceptical of predicting the spatial abilities of individuals within the target user population on the basis of gender – indeed, recent studies indicate that there is variability **across** females in terms of spatial abilities, based on prenatal testosterone exposure (Kempel *et al.* 2005). What was important to be gained from these findings was the aforementioned reliance on map products by all users, which has the potential to make design decisions both simpler (i.e. directory-style maps known to be acceptable to users) and more challenging (i.e. compounded by major differences in the visualisation media).

- **I have difficulty reading navigational maps other than Melway and UBD (e.g. state road maps, hiking trail maps).**

The target user population appeared to have slightly more difficulty reading 'non-directory style' navigational maps (the domain-experts were largely more confident in this respect). The reason for these difficulties may be issues with the maps themselves, in terms of their clarity and usability, however it seems more likely that lack of familiarity was the cause (i.e. they may only use such maps when travelling, rather than on a daily basis as with street directories). This may also explain the data for the domain-experts who likely have more frequent exposure to a wider variety of map types. When looking at the gender differences in the target users' responses to this statement, the expected pattern (as per above) was more evident: 10% more males than females claimed to 'never' have difficulty reading navigational maps, whilst 16% more females than males admitted to 'sometimes' having difficulties. This indicates a gender difference that may be dependent on map type; however it was impossible to acknowledge this with any degree of certainty since the actual navigational maps used, including their characteristics, were unknown. The overall implication of these observations was again the need to carefully consider the design of any maps employed in the models, so that they were useful to all user types, abilities and preferences.

- **I tend to turn maps around so that they 'face' the direction I am travelling.**

Roughly a third of the target user population commonly felt the need to reorient maps to correspond with their current heading. It was assumed that the motivation for this was to assist them in reading and using the maps more effectively. Comparable numbers of users did this either only occasionally or else not at all. Thus, rather than highlighting a dominant map orientation behaviour across the population, it appeared that there were a range of individual differences which had to be catered for in the cartographic UI design models. Looking to specific gender differences, substantially more women in the population reoriented maps regularly, and a greater proportion of males than females claimed 'never' to turn their maps around. This supported research findings that "females used more behavioural aids (head tilt, hand rotation, and the like) than males while performing spatial tasks" (Gilmartin & Patton 1984, p.607). Considering this trend, it should have been possible to build map orientation preferences into the design models based on the user's gender, however this would have been dangerous since not all women in the user population exhibited the map-turning tendency. It was more reasonable to discount the effect of gender and instead concentrate on the range of individual differences, potentially building such customisation in as a general feature (e.g. users could choose to have the map always orient in the direction they are facing).

- **I usually know, or can easily work out, where North is.**

The target user population was largely confident in their knowledge of, or ability to determine, compass directions when at a location. A substantial number, however, admitted to only sometimes being able to do so, supporting the already evident individual differences in geospatial skills and abilities within the population. More interesting was the pattern that emerged when looking at the gender differences related to this statement. Whilst a greater proportion of males than females had high confidence in their directional abilities, an even larger divide was seen in the less confident 'sometimes' response with the proportion of females almost doubling males.

What did this mean for the cartographic UI design models? Revisiting the statement itself, it was clear that the responses were not informative on their own – i.e. there was no information regarding the effect that knowing or not knowing compass directions had on the users' geospatial activities. It was considered more useful to look at the results in conjunction with those for the previous statement. Although the qualitative purpose and design of the questionnaire, and its subsequently non-statistical results, inhibited any quantitative analysis being done, one specific trend was recognisable between this and the map reorientation statement. Roughly 40% of respondents believed that they were 'always' or 'often' aware of North at a location **and** almost never felt the need to turn maps in their direction of travel. This 'high' correlation suggested there may be a link between an awareness of compass directions and the tendency to reorient maps, however further investigation would be required to establish this with any certainty. Another area for further research (but beyond the scope of this study) was the accuracy with which users estimate their own ability to perceive 'North'. Based on anecdotal evidence, some people tend to approximate North using streets and landmarks, often leading to an incorrect estimate of the direction. For the purposes of this analysis, however, it was sufficient to simply acknowledge the individual navigation differences displayed by the users.

- **I find it easy to follow/provide a route using (a) written or spoken directions and distances (e.g. "turn left at Murray St, then it's about 300m on your right"); and (b) landmarks (e.g. "turn right at the old post office, then it's up a bit further on your left").**

Due to the similarities in their subject matter, these four statements were combined for this section of the discussion. In general, the vast majority of the target user population found it 'always' or 'often' easy to both *follow* and *provide* landmark-based routes. An equivalent result was obtained for *following* direction-/distance-based routes. Whilst still a majority, substantially fewer users found it as easy to *provide* direction-/distance-based routes. This was an interesting deviation, which may have been a product of the respondents being more used to navigating via landmarks (supported by their high use of street directories, tourist maps and road signs) and thus more comfortable providing directions in a similar manner. Some further investigation into preferred route direction formats was warranted. Also of note was the absence of any significant gender differences between landmark- and direction-/distance-based routes. As introduced earlier, women are generally believed to have more difficulty than men in following and providing direction-/distance-based navigational information, with their strength instead being in following and providing landmark-based routes (Kawai *et al.* 2003). Since this appeared not to be the case in the target user population, it was again preferable to ignore the absence of gender differences and simply focus on the differences between individuals.

Looking now to the relationships between the four statements, the following matrix compares the data in a different way:

Following a route • 70% claimed the same degree of ease for following both landmark- and direction-/distance-based routes • Three responses differed substantially, each favouring following landmark-based routes	**Direction- / distance-based route** • 52% claimed the same degree of ease for following and providing direction-/distance-based routes; the remainder tending toward greater ease with following such a route • Two responses differed substantially, each favouring following such routes
Providing a route • 73% claimed the same degree of ease for providing both landmark- and direction-/distance-based routes; the remainder tending toward greater ease with the former • Three responses differed substantially, each favouring providing landmark-based routes	**Landmark-based route** • 56% claimed the same degree of ease for following and providing landmark-based routes; the remainder tending toward greater ease with following such a route • Four responses differed substantially, each favouring following such routes

It appeared from this organisation of the data that the target user population did not have a strong capacity for a particular format either when following or providing a route (although there was a slight tendency toward landmark-based routes). In terms of the users' capacity for either following or providing each of the two different route formats, in both cases almost half the respondents found it easier to follow the route than provide it. Whilst a relatively complicated analysis, the matrix served to highlight the variations within the target user population with respect to route formats and the ease/difficulty with which they were each followed or provided. The most pertinent conclusion for the cartographic UI design models was the tentative generalisation that landmarks should feature highly within any navigational maps/instructions in the system.

- **I find it difficult to retrace my steps after visiting a new destination.**

Very few respondents recalled common difficulties retracing a route after visiting an unfamiliar location. In fact almost half the target user population 'never' had such problems, with an equal number only 'sometimes' encountering this. There were no notable gender differences. The main implication for the design models here was that the users likely only required navigational information when visiting a location for the first time, with their memory of the trip being adequate on return visits. Despite this, the presence of users who did commonly experience difficulties retracing their steps, whilst small in number, raised a need to provide at least minimal support even for familiar trips.

- **I commonly get lost, especially in unfamiliar locations.**

The overwhelming response to this statement was a firm 'never', with only a small number of users admitting to 'sometimes' getting lost. Again, there were no notable gender differences. Hence it appeared that the target users had few issues in general with losing their way, even in unfamiliar locations, and thus did not require positioning support in addition to their current processes. At first this seemed surprising, however on further consideration the possibility was recognised that such events do occur for each user but they are so few and far between that they did not consider them to be of note. To test this hypothesis, additional information was collected during the user task analysis regarding specific instances where users had been lost while on holidays. At the same time their reactions and actions to rectify the situation(s) were sought in order to ascertain their geospatial information needs.

5.5.2.4 User preferences

The types and sources of information the users currently employed were discussed earlier as part of the discussion on Context of Use. Here, the analysis concerns the *desires* of the target user population in terms of the types of geospatial information and access to such that they would find useful while travelling. Dealing first with navigational information, there was a strong preference for routes that increased the enjoyment of enroute travel, with users favouring scenic routes and knowledge of the location of prominent landmarks, features and other attractions along their way. Possibly related to this, there were also high levels of interest in routes involving personally selected 'stopping' points (note, this was less attractive to the domain-experts). The next preference appeared to favour arriving at a destination in the most efficient manner, namely via the 'shortest' or 'fastest' route. These results suggested two different holiday behaviours to potentially be considered by the cartographic UI design models: (1) where the travel to/from/between the destination(s) is as much a part of the holiday as is the visit itself; and (2) where the holiday is focused solely on the destination(s). As an aside, traffic conditions along a route also figured highly for the target user population, but did not appear to be associated with either of the aforementioned holiday behaviours.

Looking now to other forms of geospatial information desired by the users during their holidays, locational information figured most highly, particularly that for tourist attractions, ATMS/banks, food outlets and petrol stations (these results were also supported by the levels of usefulness that users assigned to a list of common POIs). Other items deemed important were local maps/images, weather and events. In each case, the users were interested in geospatial information specific to their current location (and in some cases the current time), which would satisfy their immediate, individual needs. This had major design implications in terms of the level of detail, accuracy and timeliness of the service.

The penultimate set of user preferences requiring discussion concerned the subjective opinions that users provided about the proposed 'Holiday Assistant' service. This analysis previously established the users' high interest in using such a service. When asked at what stage of their holiday they might use the service, however most of the target users responded that they would use it throughout the entire trip, placing less importance on its use prior to departure. The domain-experts displayed slightly different preferences, favouring the service's use only at a destination (i.e. not enroute). The target users' response was as expected – the information within the service may be accessed via a number of alternative, and perhaps superior, methods before leaving home, however such access would be more difficult while 'on the road'. Despite being more unexpected, the domain-experts' response may be a product of their more formal geospatial knowledge and experience giving them greater confidence in navigating to their destination. The implications of this involved emphasising 'on-trip' support within the service, while providing some 'pre-trip' functionality.

Finally, one of the most informative sets of user responses for input into the cartographic UI design models was produced by asking users why they would/wouldn't use a 'Holiday Assistant' service. Although there were a number of common themes in the responses – e.g. use because of the perceived convenience and efficiency it would provide; non-use because of a preference for traditional methods of information access; use-dependence based on the cost of the service – it would be foolish to discount those that occurred less frequently. For example, the relevance of the information provided by the service was a use-dependency highlighted by only four users (out of the 66 responses to this question); however this theme had emerged several times throughout responses to previous questions. Each theme was therefore treated on its own merit and thus considered as an implication for the design models.

5.6 Chapter Summary

This chapter has described the process by which the target user population for the research was formally defined. The box below summarises the major techniques and outcomes that contributed toward achieving the goals for this phase of the research: (1) definition of the user profile, consisting of the full range of 'user', 'use context' and 'user preference' characteristics; (2) determination of the implications these characteristics pose to the cartographic UI design models; and (3) identification of further investigations required prior to the commencement of the design activities. Overall, the user profiling was considered a success. Despite the data collection displaying some minor weaknesses, the entire process of developing, distributing and analysing the results of the qualitative questionnaire was an extremely valuable experience, which achieved the aims and expanded the researchers' skill set in preparation for the remainder of the study. Moreover, the user profiling outcomes provided important input into the subsequent phases of the research, including a foundation for the specification of users' requirements, which forms the focus of the next chapter.

- To simplify the specification of the target user population for the research, a specific mLBS application area was selected, comprising 'domestic holiday-related (DHR) travel'.
- The target users were initially described thus:
  - Characteristics – Australian domestic travellers, between the ages of 25 and 40, who travel regularly on holidays to distant, often unfamiliar locations using overland modes of transport; these users would typically be technologically-capable and embrace time-saving opportunities.
  - High-level goals – orientation, overview, navigation, exploration, planning, self-education and information discovery.
  - High-level tasks – localisation, proximity, wayfinding, events, identification and themes.
- Appropriate users were sourced to represent the defined target user population, comprising a combination of geospatial domain-experts and Sensis' product evaluators (non-experts).
- Two non-probability sampling techniques – criterion and opportunistic – were identified for the research, with the aim of gaining a deeper understanding of users who were likely to be information rich. Each was applied to the user profiling phase.
- A 'qualitative survey' was selected to gather user profiling data regarding the attributes, behaviours and preferences of the users, with a focus on their use of geospatial information during DHR travel. To this end, a research-specific instrument was developed and pilot tested before being distributed to potential users in both hardcopy and online format.
- Various data were gathered and results presented, relating to the users':
  - Physical characteristics (relevant demographics),
  - Knowledge and experience (geospatial information; technology; travel),
  - Goals and tasks (travel), and
  - Psychological characteristics (travel/geospatial preferences and opinions).
- The results were analysed and discussed, producing a user profile range:
  - **User characteristics** – males and females; aged 25 and over; Australian residents; have limited to no vision problems.

- **Context of use** – moderate to frequent domestic travellers; visit familiar and unfamiliar destinations; take short to long-term holidays; travel by car or air; move around at a destination; undertake varying activities; rely heavily on map products (most comfortable with *familiar* representations); actively seek out tourist information before and during travels; often rely on intangible information; experience various wayfinding problems, but rarely become lost; highly familiar with desktop computing and mobile phone usage; either formally trained or not experienced at all with geospatial information; often to never reorient maps; have some to no difficulty remembering routes; have fewer difficulties providing and following landmark-based routes than directions/distances.
- **User preferences** – open to using a DHR travel mLBS, but mainly *during* a trip; consider the travel to/from/between destinations to be either part of, or incidental to, the holiday experience; have variable opinions on navigational information; require detailed local information; have strong reasons for use, non-use or dependent use of the proposed system.

- Additional outputs included various design implications posed by the profile characteristics and requirements for further investigation.

6 Phase II: User Task Analysis

6.1 Introduction

In the previous chapter, the first User-Centred Design activity for the research was completed. The result – a complete user profile – began the process of *understanding and specifying the context of use* for the target users of a DHR travel mLBS, by defining their geospatial knowledge, skills, experience, education, training, attributes, habits, preferences and capabilities. Moving forward, the outstanding factors of relevance to the research comprised the users' geospatial goals, tasks and information requirements, as well as the environment of use for the proposed mLBS, the definition of which forms the focus of this chapter. To define these characteristics, a variation on the UE technique 'task analysis' was adopted, in the form of a 'goal-driven user task analysis'. Conventional user task analysis is the process of describing and evaluating the fine-grained and precisely defined tasks and actions currently performed (or required) in order for users to accomplish specific goals (Bolchini & Mylopoulos 2003; Mayhew 1999). Considering the ill-defined and open-ended nature of users' goals in tourism environments, however, a 'goal-driven' rather than a traditional task-oriented approach to the analysis was deemed most appropriate for the research. Prominent in the field of Requirements Engineering, goal-driven analysis techniques aim to determine user needs for the purpose of providing decision-making support, rather than defining a step-by-step process for users to follow in pursuit of a goal (van Lamsweerde 2001; Albers 1998). Moreover they enable the support of high-level user goals, the exploration of design alternatives and the definition of comprehensive design requirements (Bolchini & Mylopoulos 2003).

This chapter is structured according to the goal-driven user task analysis for the research, beginning with the selection of an appropriate data collection technique (Section 6.3.1), followed by a description of the data collection process (Section 6.3.2) and the selection of a goal-driven modelling technique (Section 6.4). The remainder of the chapter (Section 6.5) comprises the results of the analysis process, including: models of the users' goals, tasks and requirements; sets of representative personas and scenarios; and a description of the environment of use.

6.2 Definitions

Traditional user task analysis aims to produce a deep understanding of users' current goals and associated tasks, the personal, social and cultural characteristics they bring to their tasks, the impact of any previous knowledge and experience on their thoughts and actions, the influence of the physical environment, and the qualities that users' value most, in order to create designs that help users achieve their goals (Hackos & Redish 1998). This definition is equally applicable to goal-driven user task analysis, the adoption and nature of which are further elaborated in Section 6.4.1. Before moving on to the application of goal-driven user task analysis to the research, it is useful to define two important terms used throughout this chapter, and the remainder of the thesis (from Hackos & Redish 1998; Bolchini & Mylopoulos 2003; van Lamsweerde 2001):

- **Goal** – refers to the overall purpose or objective of an endeavour; i.e. "a state of affairs that the user wishes to achieve" (Bolchini & Mylopoulos 2003, p.167); can be formulated at varying levels of abstraction. Note the distinction between *soft goals* – "whose satisfaction cannot be established in a clear-cut sense" – and *hard goals* – "whose satisfaction can be established through verification techniques" (van Lamsweerde 2001, p.251).

  Example: *A traveller wishes to find suitable accommodation.*

- **Task** – refers to a unit of actual 'work' (i.e. a course of action) that the user performs towards achieving a goal (often in conjunction with other tasks); can be broken down into smaller units such as sub-tasks and actions.

  Example: *The traveller looks up an online accommodation directory, identifying and comparing potential lodgings, their characteristics and accessibility.*

6.3 Data Collection

6.3.1 User task analysis techniques

To augment the questionnaire data gathered during the user profiling phase, a number of traditional user task analysis data collection techniques were available, which were also appropriate for the ensuing goal-driven data analysis. As with most of the research decisions thus far, the choice of technique required a balance between the level of detail required, the resources available and what was in fact possible. Three primary data collection techniques were investigated: contextual inquiry; interviewing without observation, and focus groups. Below is a summary of the component methods available and relevant to the research, along with their benefits, limitations and an assessment of their suitability. This is followed by a more detailed discussion of the selected technique – Critical Incident interviews – an approach to interviewing without observation.

6.3.1.1 Contextual Inquiry

Contextual Inquiry is considered ideal for collecting user task analysis data during pre-design activities as it involves observing and interviewing users while they undertake *real* tasks in the *real* world (Raven & Flanders 1996). The relationship created is essentially one of 'master' – the user, who teaches while doing – and 'apprentice' – the designer, who learns by observing/questioning

(Beyer & Holzblatt 1995). This technique was largely derived from ethnography, which developed within anthropology as a qualitative social research strategy for gaining insight into the life experiences of different cultural groups (Blomberg 1995). Its adaptation and simplification for Contextual Inquiry resulted from calls within the HCI and systems design communities for design that incorporates a deeper understanding of the unique culture of a given user group, their environment of activity and their current tasks (Blomberg 1995; Mayhew 1999). Table 6.1 compares a number of common Contextual Inquiry techniques.

Table 6.1 Contextual Inquiry techniques (adapted from Hackos & Redish 1998; Kirwan & Ainsworth 1992).

Name	Description	Benefits	Limitations
Verbal protocols	Observing and talking with the user about their tasks as they undertake them in their natural environment; the user is often encouraged to provide a verbal commentary of their actions, decisions and reasoning ('think aloud' technique).	• Provide an 'in context' view of the user's inferences, intuitions and mental models/ processes. • No reliance on recall.	• The act of verbalisation may interfere with the behaviours being investigated. • Users may have difficulty verbalising their thoughts.
Talking immediately after the task	Observing and listening, without talking, while the user undertakes tasks in their natural environment; discussion with the user takes place immediately after the tasks are completed.	• Useful when it is not appropriate to undertake obtrusive observations (e.g. where safety, timing and/or concentration are key).	• Relies on the user's recall abilities (subject to distortion and memory loss) no matter how immediate the discussion is.
Role playing and staged scenarios	The creation of situations within a near-natural environment, where observation and talking with the user can be undertaken during tasks.	• Useful when the researcher must be unobtrusive and/or where the task occurs infrequently (i.e. is not readily observable). • Scenario reuse between different users.	• Degrades the reality of the task situation (the data is considered less credible than that gathered under 'real' conditions).
Cued recall	The use of video or audiotape to prompt a user's recall of tasks they have previously undertaken within their natural environment.	• Useful when a user is not available for discussion immediately after an observation session and/or when an observer cannot be present during the tasks.	• Relies on the user's recall abilities – data may potentially be lost or misinterpreted.

The observational basis of Contextual Inquiry offered data collection within natural environments that could not be obtained through any other method. Moreover, the techniques had the potential to provide maximum task familiarity as well as objective information for comparison with other data. Conversely, Contextual Inquiry had the potential to produce data which was incomplete and inconsistent (due to the inherent lack of precision and control in natural settings), and that lead to considerable time and effort during the inductive analysis process (Kirwan & Ainsworth 1992). The decision was ultimately made to discount this set of techniques, largely due to an additional limitation: “there is a strong tendency for people to react – whether favourably or unfavourably – to being observed and recorded, in a way that they would not if merely being ‘measured’ in an apparently more impersonal way” (Kirwan & Ainsworth 1992, p.54). Coupled with the obvious practical difficulties of observing users in holiday settings, the expected intrusion on the users’ privacy resulting from observations of their DHR travel activities was predicted as extreme. Therefore this technique was abandoned in pursuit of a less intrusive approach.

6.3.1.2 Interviewing without observation

Interviewing is an extremely common method for eliciting information from users either in the presence (Section 6.3.1.1) or absence of observation (i.e. where observations are inappropriate or not possible). User task analysis interview techniques are largely qualitative, comprising “active interactions” toward “negotiated, contextually based results” (Fontana & Frey 2000, p.646) – namely information about users, their tasks and their environment. There are three general categories of interviews: (1) *unstructured* or ‘informal conversational’, whereby open-ended questions emerge spontaneously from the immediate context (commonly employed during user observation); (2) *interview guide*, where a set of themes are outlined in advance and the same lines of inquiry are explored with each user (a common technique in focus groups); and (3) *structured* or ‘standardised open-ended’, where each user is asked the same sequence of pre-determined questions enabling more systematic data collection (Patton 2002; Fontana & Frey 2000; Kirwan & Ainsworth 1992). The structured interview is the most common format for the range of interview techniques compared in Table 6.2.

Table 6.2 Interviewing without observation techniques (adapted from Hackos & Redish 1998; Kirwan & Ainsworth 1992).

Name	Description	Benefits	Limitations
Process analysis	The user ‘walks through’ the task or process of interest; the interviewer probes for further information about each task – e.g. timing, triggers, major steps, information requirements, information produced.	• Enables an in-depth focus on tasks.	• Most suited to business processes and group work situations.
Ethnographic interview	Semi-structured interviews with users to understand their general task context, task vocabulary and issues, prior to (and in preparation for) direct observations.	• Makes the interviewer more knowledgeable about the user’s tasks and thus able to ask informed questions during later observation.	• Reliant on ensuing observations.

Table 6.2 (cont.) Interviewing without observation techniques (adapted from Hackos & Redish 1998; Kirwan & Ainsworth 1992).

Name	Description	Benefits	Limitations
Artefact[1] walkthrough	Collecting and discussing artefacts (i.e. materials) typically employed by users during tasks.	• Provides an understanding of how tasks are currently undertaken. • Provides a focus for simplifying and/or finding innovative ways to assist users with tasks. • Can stimulate useful discussion. • Reuse of artefacts between users.	• Can potentially draw focus to the more routine aspects of each task.
Critical Incident technique	Collecting stories of real situations and behaviours via user recall of specific critical incidents; the interviewer probes for additional information regarding each incident using pre-planned questions.	• Rapid and detailed data collection. • Enables concentration on tasks and behaviours, rather than generalisations and opinions. • Recounted situations can form the basis of scenarios.	• Relies on the user's recall abilities.

The collective benefits of these techniques indicated early on that some form of interviewing would be optimal for collecting user task analysis data during the study. In general, interviews were considered the most economic approach, in terms of the resources required to collect the data. They were also a familiar approach for both user and interviewer and were relatively flexible, with unexpected or interesting information able to be readily explored as it arose. Furthermore, structured interviews provided for consistency in the data collected, which aids in comparison (Kirwan & Ainsworth 1992). The main disadvantage of interviewing techniques was their lack of direct observation and the subsequent reliance on recall of events. In this way, important tasks and behaviours not recounted by the user would be lost. Furthermore, the analysis of interview data was expected to be time consuming (generally based on video- or audiotape analysis) and the data susceptible to bias – for example, the user may provide information they believe is expected, rather than the reality (Kirwan & Ainsworth 1992). For the reasons given in Table 6.2, the Critical Incident technique was considered by far the most suitable interviewing technique in the absence of observation and as such was selected for the user task analysis data collection. This method is discussed in more detail in Section 6.3.2.

6.3.1.3 Focus groups

Traditionally a market research technique, focus groups comprise meetings of usually eight to twelve users which are moderated by a facilitator. During sessions, the facilitator elicits the users' attitudes, opinions, preferences, reactions, requirements, problems, etc., while following a

[1] An alternative spelling of this term – 'artifact' – is more common in the USA.

prepared script of the issues/questions to be addressed (Hackos & Redish 1998). In user task analysis, a task-based focus group concentrates on how users perform their tasks, what they have done previously and what they may do in certain situations. With skilled facilitation, the interaction between users in a focus group can yield a wide variety of information (i.e. users provide prompts for one another). There is a danger, however, for group dynamics to produce adverse effects, limiting the variety of responses given. An example of this is where one or two personalities dominate the discussion, influencing its direction and the ultimate conclusions of the group. Finally focus groups are, like interviews, conducted in 'non-natural' environments with no direct observation (i.e. reliant on the users' recall abilities). Furthermore, unlike the Critical Incident technique, focus groups can be limited in the amount of information gathered relating to users' behaviours since there cannot be detailed attention given to individuals. For these reasons, this technique was considered unsuitable for the user task analysis data collection phase.

6.3.2 Research method: Critical Incidents

As discussed earlier, the Critical Incident technique is a type of interview without observation. It was first described as a task requirements data collection technique by Flanagan (1954) who cited its origins within the Aviation Psychology Program of the US Army Air Forces in World War II. The technique, in general terms, is a set of procedures for gathering observations of human behaviour during defined situations. Flanagan (1954) defines the two key aspects of the technique:

> *"By an incident is meant any observable human activity that is sufficiently complete in itself to permit inferences to be made about the person performing the act. To be critical, an incident must occur in a situation where the purpose or intent of the act seems fairly clear to the observer and where its consequences are sufficiently definite to leave little doubt concerning its effects."* (p.327)

The key to the use of the Critical Incident technique as a method of collecting data for a user task analysis is in its flexibility, and thus its ability for adaptation to specific studies. The underlying premise is that "critical incidents will be inherently memorable" (Kirwan & Ainsworth 1992, p.47) and so user recall should, theoretically, be maximised by the application of this technique (as an alternative to direct observation).

Rather than taking a traditional approach to applying the Critical Incident technique – i.e. focusing on rare events and their level of severity – the research approached the user task analysis from the perspective that a critical incident equated to a specific holiday taken by a user. By focusing on a specific DHR travel event, each user could be probed for detailed information regarding specific goals and tasks (both common and infrequent) undertaken during that time.

6.3.2.1 Qualitative interview development

With the data collection technique in hand, a specific user task analysis interview 'instrument' was required for gathering the data. According to Patton (2002) the purpose of qualitative interviews is to find out about things that cannot be directly observed: feelings, thoughts, intentions, past behaviours, etc. The interviewer in particular is challenged to facilitate the interviewee (i.e. the user) in taking the interviewer "into his or her world" (p.341). There are six types of questions that can be employed in an interview situation on any given topic (Patton 2002) in order to elicit specific kinds of information:

- **Experience and behaviour** – what the user does or has done (behaviours, experiences, actions, activities);
- **Opinion and values** – what the user thinks about some issue or experience, i.e. their cognitive and interpretive processes (goals, intentions, desires, expectations);
- **Feeling** – the user's responses to their experiences and thoughts (emotions);
- **Knowledge** – what the user knows (facts);
- **Sensory** – what the user has seen, heard, touched, tasted and smelled (stimuli experienced); and
- **Background/demographic** – how the user categorises themself (characteristics).

These distinctions were considered during the interview planning, particularly to focus the data collection priorities and to sequence questions. Also taken into account were Patton's (2002) criteria for question wording which recommended that questions should be: (a) open-ended – there should be no imposition of pre-determined responses (i.e. the user is able to answer in their own words); (b) non-dichotomous – discouraging simple yes/no responses which limit user expression; (c) neutral – the user must feel comfortable that their responses will not provoke favour or disfavour from the interviewer, who should be especially careful not to lead the user into providing 'desirable' or 'appropriate' responses; (d) singular – no more than one idea should be contained within a single question; and (e) clear – employing the 'language' of the user.

In terms of question content, the underlying principle for the user task analysis was thus: "the more we know about [the users], the better we can design for them" (Hackos & Redish 1998, p.25). With a focus on DHR travel goals and tasks incorporating the use of geospatial information, the main points of investigation were: what users do before, during and after their travels; what their goals are throughout their holidays; what tasks they undertake to meet these goals; and what problems they encounter while undertaking those tasks. A high, yet all-encompassing level of granularity was planned for the data collection. In particular it was deemed important to understand how users moved between each of the levels shown in Figure 6.1 – i.e. how their goals and decisions influenced their tasks and requirements.

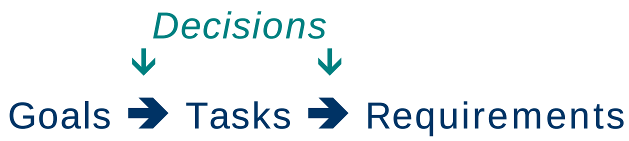


Figure 6.1 Levels of granularity for the user task analysis data collection.

Accordingly, a draft of interview questions was produced, incorporating six distinct sections focused on eliciting various geospatial tasks undertaken during users' recent DHR travel:

- **A – Introduction**
  Two questions designed to direct the user's thoughts toward upcoming travels and a particular, recent holiday to an unfamiliar destination – which formed the majority of the interview's focus. Intended to gather experience and behaviour; and background/ demographic data

- **B – Pre-trip**
  Three questions about the user's geospatially-related preparations in advance of the focal holiday, including their initial destination criteria and any location-related research/planning (including identification and event tasks) they may have undertaken. Intended to gather experience and behaviour; opinion and values; feeling; and sensory data.

- **C – On-trip**
  Nine questions about the user's geospatially-related experiences during the focal holiday, including: how they arrived at their destination; their goals and aims when there; wayfinding, orientation, proximity and localisation tasks; any problems they encountered; methods of decision-making; human interactions; information source preferences and their comfort levels with the destination at the conclusion of the trip. Intended to gather experience and behaviour; opinion and values; feeling; and sensory data.

- **D – Post-trip**
  Two questions regarding the user's after-trip impressions, including whom they shared their travel experiences with on their return and how their experiences might contribute to their future travels. Intended to gather experience and behaviour; and opinion and values data.

- **E – Familiar Destinations**
  One question asking the user to highlight any differences between the aspects discussed in relation to the focal holiday and the last holiday they took to a more familiar location. Intended to gather experience and behaviour; opinion and values; feeling; and sensory data.

- **F – Future Information Sources**
  Five questions designed to elicit the user's opinions of, and preferences for, future geospatial information sources whilst on holidays. Intended to gather opinion and values; and feeling data.

The interview was designed to include additional materials in the form of artefacts (see Table 6.2) to assist in users' recall of geospatial information sources that they may have used during their DHR travel. These materials took the form of two Microsoft PowerPoint presentations incorporating imagery and text (see Appendix B, Section B.5). The first presentation was scheduled at the beginning of the 'Pre-trip' section, and contained artefacts similar to those the user may have encountered while planning their trip. The second presentation was scheduled at the beginning of the 'On-trip' section, and contained artefacts similar to those the user may have encountered during their trip. Being mindful of the potential for the artefacts to 'lead' user responses, all images and text were limited in terms of how long they were exposed to the user.

6.3.2.2 Pilot testing and schedule revision

As with the user profiling questionnaire, it was considered important to pilot test the interview, so as to ensure that it was understandable to users and operated effectively. An additional reason for the testing was to provide the interviewer with practice posing the questions in a 'real' interview situation and the assistant with experience operating the equipment used for videotaping each session. The Online Evaluation Resource Library (National Science Foundation 2005) recommends that the participants used in pilot testing should not be involved in the formal interviews. They go on to identify that there are no definitive rules for conducting interview pilots, suggesting the following process as "reasonable" for average-size studies:

(a) **Edit** – Review by several individuals; revise interview.

(b) **Early Pilot** – Conduct of the interview (separately) with two individuals possessing similarities to the target respondents, who are asked to respond as if in a real interview situation but also to comment on question clarity, sequencing and overall experience; revise interview.

(c) **Full Pilot** – Conduct of the interview with a group of three or four individuals possessing similarities to the target respondents, who are asked to respond as if in a real interview situation but save all feedback until the end; interviewer concentrates on timing; revise interview.

As discussed in relation to the user profiling questionnaire (Section 5.3.2.2), it is considered acceptable to undertake only small-scale pilot testing in a situation such as this, where resources are limited. Provided that there is at least some intensive testing, valuable information for improving the interview will arise. For this phase of the research, only the first two steps were undertaken. The 'Edit' phase comprised several revisions of the initial interview draft following feedback from the research supervisors. Two individuals from the domain-expert group (i.e. representative of members of the target user population), were then utilised for the 'Early Pilot' phase. The feedback obtained from this phase was considered sufficient for identifying all major problems with question clarity, sequencing and timing, as well as enabling the technology involved (i.e. the video recorder and a laptop computer for displaying the artefact presentations) to be thoroughly tested. Therefore the omission of a 'Full Pilot' was not considered a major oversight for the research.

6.3.2.3 Interview sampling and conduct

A number of arrangements were required prior to conducting the interviews, most notably obtaining access to a suitable interview space and scheduling participants. Since the initial contact with the user group came through Sensis, it was preferable to conduct the interviews at a Sensis work site, which was also considered a professional environment where participants would feel comfortable. This proved to be no problem with a meeting room made available at Sensis' Melbourne office.

Purposeful criterion sampling was again employed (see Section 5.2.4.1), with a set of criteria initially determined to isolate information-rich participants who would ideally provide a deeper understanding of geospatially-related DHR travel goals and tasks. These criteria were based on the target users' responses to the user profiling questionnaire:

- Willing to participate further in the research;
- Victorian – more likely to attend face-to-face interviews held in Melbourne;
- Over the age of 25;
- More than 25% of holidays taken within the last two years were to new destinations – unfamiliar travel behaviours were considered to be more informative than those during familiar travel; and

- Provided detailed comments for any/all of the open-ended questions (e.g. reason for expected use/non-use of a holiday mLBS, problems encountered during travel, additional comments, etc.) – thus considered willing to share experiences and opinions.

According to Patton (2002), "there are no rules for sample size in qualitative inquiry" (p.244). Citing a necessary trade-off between breadth (studying a narrow range of experiences for many people) and depth (studying a broad range of experiences for just a few people), he sees the decision toward one or the other as dependent on the study's purpose, the usefulness of the information gathered, the perceived credibility and the available resources. When studying users as part of a user task analysis, Hackos and Redish (1998) recommend small sample sizes – in the realm of six to eight individuals from each user group – claiming that those patterns most important to the design phase will emerge very quickly, with only minor variations to be found from additional users. This perspective was based on the authors' practical experience, as well as published research into sample sizes for usability testing recommending five-user studies (Nielsen 2000; Virzi 1992; Nielsen & Landauer 1993). Other researchers are more sceptical, however, rebuking the statistical formula used to arrive at these figures (Spool & Schroeder 2001; Woolrych & Cockton 2001). Considering each of these views and the size of the target user population for the study (67 individuals), a sample size of eight was selected. This constituted almost 12% of the total population and 18% of the users remaining once the above criteria were applied. Such a sample size was deemed acceptable on the basis that: (a) sufficient individuals would remain for participation during the remaining phases of the research; (b) the selection of information-rich participants and a highly detailed analysis of the data would maximise its validity, meaningfulness and the insights generated (Patton 2002); (c) the available resources (e.g. time, personnel, facilities) would be optimal for a study of this scale; and (d) the qualitative purpose of the research did not warrant generalisation to a larger population, thus statistical rigour was irrelevant.

In selecting the users for the sample, a mixture of the following characteristics was sought:

- Gender
- Age group
- Holiday frequency (last 2 years)
- Holiday distance
- Holiday length
- Propensity for use of a holiday mLBS
- Mode of transportation to/at destination

Random numbers were assigned to each user with individuals then contacted in sequence. Users were skipped where they were too similar (in terms of the above characteristics) to an individual already included in the sample. This continued until nine users had been scheduled, allowing for one "no-show" (i.e. non-attendance). At the time of contact (conducted by telephone), users were provided with background information before being asked to participate in the interview sessions. These conversations followed a script, a copy of which is included in Appendix B, Section B.1. As users were recruited, a schedule was updated, incorporating the interview time, contact details and user characteristics. A representation of the final schedule is shown in Table 6.3. At the conclusion of this process, all nine participants were sent an email to confirm their interview date and time, provide instructions for their arrival at the interview and supply them with the Plain Language Statement (PLS) and Consent Form in advance of the interview (refer to Appendix B, Sections B.2, B.3 and B.4).

Table 6.3 The final interview schedule.

Characteristics	Day 1	Day 2	Day 3	Day 4
Session 1				
gender	Female	Male	Male	Female
age	31-40	31-40	41-50	25-30
holiday frequency	1-3	6-12	1-3	1-3
holiday distance	Inter/Intrastate	Inter/Intrastate	Inter/Intrastate	Intrastate
holiday length	1-4 days	1-2 weeks	1-2 weeks	1-4 days
mLBS opinion	Unlikely	Unsure	Probably	Definitely
travel mode	Car	Plane	Plane	Car
Session 2				
gender			Male	
age			31-40	
holiday frequency			1-3	
holiday distance			Interstate	
holiday length			1-2 weeks	
mLBS opinion			Unsure	
travel mode			ferry/car	
Session 3				
gender	Male	Female	Male	Female
age	25-30	25-30	25-30	31-40
holiday frequency	4-6	1-3	4-6	1-3
holiday distance	Inter/Intrastate	Interstate	Intrastate	Inter/Intrastate
holiday length	1-4 days	2 weeks – 1 month	1-4 days	1-2 weeks
mLBS opinion	Probably	Probably	Definitely	Unsure
travel mode	Car	Plane/Taxi	Plane	Plane

During each interview there were three people in attendance: the interviewer, the interviewee (i.e. participant) and an assistant responsible for videotaping the interview. At the beginning of each session, the participant was asked to read and sign both the PLS and Consent Form, in acknowledgement of having been informed of the research, the interview's purpose and other pertinent details (e.g. privacy). Following this, they were given a cash gratuity for their time and effort, and asked to sign another form which stated that they had received the gratuity and were willing to be videotaped during the interview.

When each interview began, every effort was made by the interviewer to build a rapport with the participant (while maintaining control), in order to indicate that the information they were providing was important and thus encourage them to increase the richness and depth of their responses. To this effect, a number of procedures were followed (recommended by Patton 2002; Aldridge & Levine 2001; Fontana & Frey 2000; Hackos & Redish 1998):

- **Probes** – follow-up questions used to elicit more detailed information and/or to encourage participants to elaborate on their opinions or accounts of experiences; note, a number of specific probes were included in the interview script (see Appendix B, Section B.5).
- **Illustrative examples** – provided to clarify questions and thus facilitate deeper responses.
- **Presupposition** – wording questions so as to convey an assumption that the participant has something to say.
- **Prefatory statements** – introducing a question or set of questions about to be posed in order to focus the participant's attention/awareness while giving them time to organise their thoughts.
- **Interested and active listening** – rewarding the user's participation without evaluating responses; includes support and recognition responses (verbal/non-verbal reinforcement and feedback).

At the conclusion of each interview the user was thanked and asked if they were willing to perform 'checking' of their own data. This entailed review and amendment of a summary of the interview content, based on notes taken by the interviewer and the assistant during the session. All participants proved willing to do this.

Appendix B contains the final list of interview questions and the two artefact-based presentations (Section B.5).

6.4 Modelling Techniques

Prior to reviewing and analysing the interview data, it was necessary to establish the data modelling technique to be employed so that the analysis could be planned and proceed in such a way as to capture the appropriate themes and trends. In this section the available options are discussed, including further justification of the need for a goal-driven approach to the analysis.

6.4.1 Task-driven modelling

The underlying purpose of this user task analysis was to determine user-centred requirements as input for the design of cartographic representation models for a DHR travel mLBS. According to Bolchini and Mylopoulos (2003) "the heterogeneous family of task-based techniques represents the dominant paradigm for the analysis of user requirements" whereby "tasks are analyzed and decomposed providing an input for the design activity" (p.166). There are numerous data analysis and modelling techniques available within traditional task analysis, including the following (Hackos & Redish 1998; Kirwan & Ainsworth 1992):

- **Workflow diagrams** – the capture and analysis of collaborative, sequential tasks (i.e. those that move through a number of users and steps in pursuit of an overall goal); highlights who is responsible for each step in the process.
- **Task lists and sequences** (*process analysis*) – high-level lists of what an individual user has to be able to accomplish with a product, later broken down into lower-level tasks, ordered by the most common sequence in which they are performed; tasks are phrased in the users' own language; product flexibility is considered where tasks are completed in different sequences.
- **Task hierarchies** (*hierarchical task analysis*) – hierarchical representations of the interrelationships among tasks; produces a hierarchy of the various tasks, sub-tasks and actions along with statements of the conditions required to undertake them; those high-level tasks most closely associated with goals are shown at the top, with low-level sub-tasks shown at the base of the hierarchy; can be developed in as little or as much detail as necessary.
- **Procedural analysis** (*detailed task descriptions*) – divides each task into the step-by-step actions and decisions the user currently goes through in order to complete it (inherent in task hierarchies); feedback, artefacts and tools used during the task process may also be specified.
- **Task flowcharts** (*operational sequence diagrams*) – detailed displays of alternative paths (steps and decisions) and interrelationships (temporal, spatial and conceptual) in pursuit of a single task; shows the options available to users and their conditional decisions; can be effective in highlighting unnecessary complexity in the way that tasks are currently performed.
- **Task scenarios** – stories about the users, their environments, their tasks and how they perform them; may range in detail from brief – facts only, no task detail – to complete – the entire task/task sequence from beginning to end.

While some of these methods initially appeared promising for the analysis (e.g. task lists/ sequences and task hierarchies), there were limitations associated with a task-driven approach which encouraged the shift toward goal-driven analysis. The main set of limitations related to the nature of the target users' goals and tasks. As discussed previously (Section **5.2.2.2**), the DHR travel application area is largely characterised by ill-defined, open-ended (soft) goals (e.g. finding out what is worth visiting at a location) that are realised in dynamic, unstructured environments by means of vague 'problem solving' or 'decision-making'-type tasks (Bolchini & Mylopoulos 2003). This goal-driven user perspective is in direct opposition to the task-driven outlook that characterises users in highly structured environments (e.g. performing a job consisting of routine actions) where their goal is to complete each well-recognised task in the most efficient manner

(Albers 1998). According to Albers (1998), "the ill-structured approaches [to problem solving] used in real-world situations do not lend themselves to the conventional task analysis approaches … when the task is not well-defined or well-structured, the attempts to describe step-by-step actions breakdown because no single route to a solution exists" (p.234). Indeed, a user's choice of tasks in pursuit of any one goal is highly dependent on the relative values that they place on external factors, such as time, cost, their own skills, their confidence in particular situations, and so on (Hackos & Redish 1998). Overall, to support users' problem solving and decision-making tasks, the system must "provide a relevant view of the current situation" (Albers 1998, p.236) through the identification of their goals and sub-goals, thereby catering to the variety of expectations, interests, practical needs and goal definitions that the users possess (Bolchini & Mylopoulos 2003). Realistically this can only be managed through a goal-driven approach to the definition of user requirements.

An additional limitation of task analysis techniques concerned the focus of task-based modelling on fine-grained and precisely defined user needs which had the potential to result in premature design commitments borne from task-based assumptions (Bolchini & Mylopoulos 2003). Furthermore, relying solely on the decomposition of tasks for defining user requirements would negate the "exploration of high-level design alternatives" (Bolchini & Mylopoulos 2003, p.170). With its aim of exploring and evaluating alternative cartographic representations, this study could not afford to become fixated on any 'anticipated' solutions, which might not satisfy the target users' goals. Thus, this was further justification for adopting a goal-driven approach.

6.4.2 Goal-driven modelling

Goal-based techniques have long been used in the field of Requirements Engineering (RE) for identifying and analysing high-level user and stakeholder goals, which are then refined to produce system requirements as input into subsequent design activities (Bolchini & Mylopoulos 2003). Building on the previous discussion regarding the limitations of task-based techniques, van Lamsweerde (2001) provides a number of reasons for the importance of making goals a focus of analysis activities:

- goals provide specific criteria for the complete specification and validation of requirements;
- irrelevant requirements can be avoided through validation against specified goals;
- goals provide a traceable rationale and structure for explaining requirements to stakeholders;
- goals allow alternative requirements to be validated and designs to be explored;
- multiple and/or conflicting requirements can be managed through goal definitions;

- stable information (i.e. high-level goals) is kept separate from more volatile information (i.e. tasks, requirements); and
- goals drive the identification of supporting requirements.

These factors held equally true for defining user requirements in pursuit of optimal cartographic UI design models and as such a goal-driven approach was adopted for analysing the user task analysis interview data.

Whilst there are numerous ways to conduct a goal-driven analysis, the basic aims are the same, being to uncover: (a) the information directly related to achieving a goal; (b) the sub-goals that must be realised in order to meet the goal; (c) information that can be used to test the validity and reliability of the goal-related information; (d) information which may restrict possible goal solutions; (e) variation in information requiring the setting of other goal(s); and (f) related information that may influence decision-making (Albers 1998). The first step in the general analysis process involves goal identification, which is not always simple, with goals having a broader scope and coarser granularity than tasks (van Lamsweerde 2001; Bolchini & Mylopoulos 2003). Once an initial set of user goals is obtained, however, associated requirements and additional goals can be defined and elaborated by a process of refinement and abstraction. Finally, the goals and requirements can be verified and validated with respect to one another, often in conjunction with scenarios generated from the data (van Lamsweerde 2001). The list below describes some of the more prominent goal-driven analysis techniques available to the research.

- **KAOS** (**K**nowledge **A**cquisition in aut**O**mated **S**pecification) – a set of strategies within RE for acquiring and elaborating functional and non-functional software requirements (in terms of goals, constraints, assumptions, objects, events, actions, actors[2], etc.), beginning with system-level and organisational goals from which lower-lever task- or action-oriented descriptions are progressively refined (Dardenne *et al.* 1993). A detailed requirements set is produced, incorporating the assignment of responsibilities to alternative actors and enabling conflict detection and resolution (Bolchini *et al.* 2003; van Lamsweerde 2001). A major aspect of the approach, goal 'operationalization', is accomplished through the introduction of AND/OR links that "relate goals to the operations which ensure them through corresponding required pre-, post- and trigger conditions" (van Lamsweerde 2001, p.252).
- **i* framework** – a set of operators for describing the intentional structure of the organisational environment within which an information system operates (Yu 1993).

[2] The term 'actor' (used here exclusively) is often substituted in the literature by the word 'agent' – an influence of the field of Artificial Intelligence.

Undertaken through modelling dependencies among actors, the framework is based on the premise that "organizational [actors] depend on each other for goals to be achieved, tasks to be performed, and resources to be furnished (Yu 1993, p.34). The affected actors (generally users and major stakeholders), their goals, various dependencies, intentions and related rationales are identified in order to model high-level goals, early system requirements and non-functional requirements (Bolchini & Mylopoulos 2003; Bolchini et al. 2003).

- **AWARE** (**A**nalysis of **W**eb **A**pplication **RE**quirements) – an extension of the i* modelling framework, this enables the definition of hypermedia requirements for input into the conceptual design of Web applications, based on additional analysis of actors' goals (Bolchini *et al.* 2003). The high-level goals of both users and stakeholders are identified and broken down into sub-goals through AND/OR decompositions, which are then refined into tasks and, ultimately, functional and non-functional requirements representing indications for the designer. The entire process is supported by the development of salient scenarios – "envisioning the user experience in context" (Bolchini & Mylopoulos 2003, p.171). A 'hypermedia requirement taxonomy' is then used to classify each requirement by the design dimension that it will impact (e.g. Content, Structure of Content, Access Paths to Content, Navigation, Presentation, User Operation, System Operation and Interaction). An additional benefit of this technique is the identification of conflicts between requirements, which helps the designer to reflect on possible design strategies for accommodating alternatives.
- **Goal/information diagrams** – a graphical method of capturing users' goals and information needs when solving ill-structured problems. This is intended to support the spectrum of situation-relevant information whilst specifying task-inherent, task-supportive, task-enhancing and task-peripheral knowledge (Albers 1998). Diagrams are generally produced during group discussions with users, for individual scenarios developed previously from the data. The process is one of continual definition and refinement, incorporating the following steps: (1) define "the goals a user wants to achieve or the problems that must be addressed"; (2) define and hierarchically arrange "any sub-goals that must be achieved in accomplishing the main goal"; (3) define "the information required to achieve each terminal sub-goal"; (4) define "the [cause-effect] inter-relationship between differing goals, goals and information needs, and information needs"; and (5) define the users' ratings of "relative importance [between] the information needs" (Albers 1998, pp.241-2).

6.4.2.1 Technique selection

As stated previously, the main purpose of this analysis was to determine user-centred requirements as input for the design of cartographic UI models. A second, underlying aim was to accomplish this in a simple, straightforward manner with the results easily transformed/fed into the design models. Considering this, it was immediately evident that the RE-centred approaches of KAOS and the i* framework were overly complex for the study. Specifically, these highly formal modelling techniques were too concerned with organisational systems and relationships between different actors. Indeed, the research's focus was primarily on *individual* users, with no attention intended or given to other stakeholders. Of those remaining, the AWARE technique held the most promise for the study, having been developed with hypermedia systems in mind, while goal/information diagrams were found to be very similar (down to their support by scenarios), differing mainly in their user involvement. The ultimate approach selected for the goal-driven analysis was therefore a combination of the AWARE and goal/information diagram techniques, generally following the steps outlined in the latter (excluding user group discussions), with the final models being more typical of the former (excluding stakeholder goals). The general process is shown in Figure 6.2 and described below.

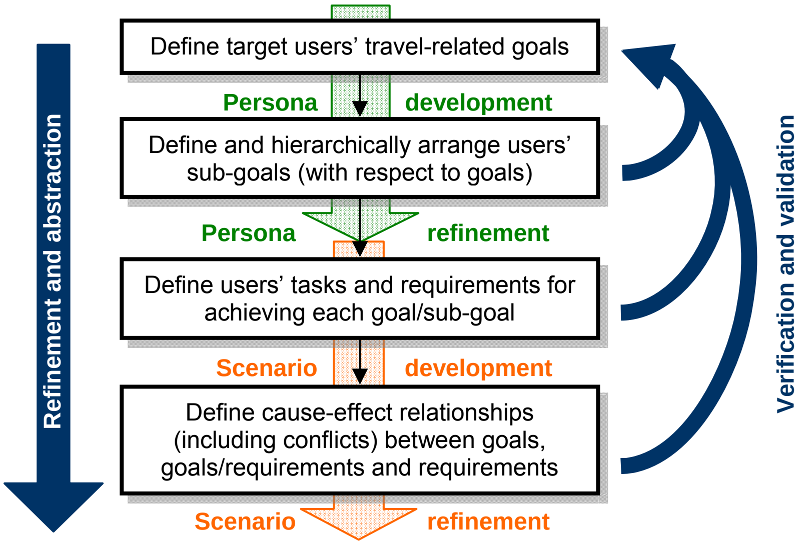


Figure 6.2 The user task modelling process for the research.

- Development of initial, salient user personas for the support of subsequent steps.
- Definition of target users' goals (or 'problems' to be solved). Validation with and refinement of personas.
- Definition and hierarchical arrangement of sub-goals (with respect to goals) via AND/OR graphs (see explanation below). Validation with and refinement of personas.
- Development of initial, salient user scenarios for the support of subsequent steps.
- Definition of high-level tasks in conjunction with information requirements for achieving each sub-goal (and therefore goal). Validation with and refinement of scenarios.
- Definition of cause-effect relationships (including any conflicts) between goals, goals/ requirements and requirements; addition to AND/OR graphs. Validation with and refinement of scenarios.

The inclusion of AND/OR graphs in the analysis provided a structure for decomposing goals into tasks and requirements, as well as a graphical representation of the results of the modelling process. It is a technique employed by many analysis approaches (e.g. KAOS, i*, AWARE). Van Lamsweerde (2001) describes AND/OR graphs in terms of goal refinement links between the various entities:

- *links between goals* – designate situations where goals positively or negatively support one another, with conflict links introduced between two goals when the satisfaction of one can prevent the satisfaction of the other;
- *AND-refinement links* – relate a goal to a set of sub-goals, where the satisfaction of all sub-goals is required to satisfy the parent goal;
- *OR-refinement links* – relate a goal to an alternative set of refinements (where the satisfaction of one refinement is sufficient to satisfy the parent goal), with such relationships enabling the exploration of alternatives for achieving a goal (Bolchini & Mylopoulos 2003);
- *goal satisficing* – used to deal with soft goals whereby the parent goal can be said to be achieved within acceptable limits (but not absolutely) by the soft goal's satisfaction.

More detailed information regarding the analysis process is provided within the results.

6.4.2.2 User personas and scenarios

Before moving on, it is necessary to define two important elements of the user task modeling process described in the previous section. Known as 'personas' and 'scenarios', these are tools that, particularly when used together, can be an effective aid to UCD activities.

Originating in the field of marketing and with a basis in psychology, personas were first applied to design practice by Cooper (in 1999), who described them as "*hypothetical archetypes* of actual users" (Cooper 2004a, p.124). They are essentially 'fictional' or 'pretend' people, developed from user data, who are representative of user types within the target population, but who should not be confused with real people. According to Cooper (2004a), the key to a persona's effectiveness as a design tool is in its precision and specificity, each of which contributes to its believability; for example personas commonly have a name, age, gender, ethnicity, personality, family, friends, occupation, skills, motivations, socioeconomic status and even a likeness. More importantly, each persona is defined by its unique set of goals (Cooper 2004b), making them especially relevant to the goal-driven user task analysis at hand. According to Cooper (2004a), personas form the basis for all subsequent goal-driven design, by revealing the scope and nature of the design problem.

Personas can be used for a variety of purposes, most notably as a foundation for building scenarios and collecting data, while helping to focus activities (e.g. design exploration, user testing, etc.) sequentially on different user types. If used correctly, personas can augment the UCD process by amplifying the effectiveness of the other methods in use (Pruitt & Grudin 2003). Specifically, they can enhance: engagement with, and thus focus on users; recognition of users' socio-political issues; and identification of population complexity toward the portrayal of representative users (Grudin & Pruitt 2002). More generally, the act of persona creation makes transparent any assumptions made about the target population, and the decision-making criteria used. This is especially important since personas (typically presented through narrative and storytelling) are perhaps most valuable as a medium for communication: "It's easy to explain and justify design decisions when they're based on Persona goals" (Kim Goodwin quoted in Pruitt & Grudin 2003, p.3; Grudin & Pruitt 2002). Cooper (2004a) further affirms the value of personas over real users who, he states, have "quirks and behavioral anomalies that interfere with the design process … [and which are] not extensible across a population" (p.129). Grudin & Pruitt (2002) warn, however, that "persona use needs to be complemented with a strong, ongoing effort to obtain as much quantitative and qualitative information about users [upon which they are based] as possible, to improve the selection, enrichment, and evolution of sets of personas" (p.147).

A set of personas should not aim to encompass every conceivable user in a target population. In fact, it is generally accepted that a more successful design will result from designing for just one 'user', than designing *vaguely* for everyone (or for the designer themself) (Cooper 2004a; Pruitt & Grudin 2003). A project will typically produce three to seven unique personas for a target population, often including anti-personas (i.e. those specifically **not** being designed for). Of these, at least one (and no more than three) will normally be a *primary persona* – "the individual who is the main focus of the design" and who must be satisfied by their own separate and unique interface (Cooper 2004a, p.137). The primary persona effectively represents the most difficult group to design for and is therefore the driving force.

Distinct from personas, scenarios are descriptions of usage episodes, each having a setting, actors with goals or objectives, and a sequence of actions and events (Go & Carroll 2004). Put more simply, they encompass "the things users characteristically want to do and need to do, as well as the momentous events of user interaction" (Carroll & Rosson 1992b). Desirable features of scenarios include: (1) their concreteness, fixing an interpretation and offering a specific solution; (2) their emphasis on reflection and inquiry as design activities; (3) their support of abstraction and categorisation; (4) their promotion of work-/task-orientation; and (5) their flexibility, being deliberately open-ended and thus easily revised or elaborated (Carroll 2000; Go & Carroll 2004). Manifested in a variety of ways (e.g. textual narratives, storyboards, video mock-ups), there are infinite scenarios possible for any one design project, with the aim being to produce a set that provides good coverage (Carroll & Rosson 1992b). With their similar aims (e.g. the organisation, justification and communication of design ideas, based on user data), it is argued that scenarios developed in the absence of personas will generally be less effective. Grudin & Pruitt (2002), for example, cite that scenarios are often difficult to reconstruct and are not engaging, with the added drawback that there are few guidelines as to how actors should be defined or used appropriately. A solution to these problems can be found in constructing scenarios around existing personas and their goals (Grudin & Pruitt 2002; Pruitt & Grudin 2003). Personas are then 'played through' the scenarios to test the validity of designs and associated assumptions – analogous to a method actor (the *designer*) inhabiting a character (the *persona*), knowing what s/he knows, feeling what s/he feels, thinking how s/he thinks, and so on – with scenarios providing specific contexts and detail needed to support the process (Cooper 2004b).

6.5 Analysis and Results

The purpose of the user task analysis was to establish a deeper understanding of the target user group through the definition of their geospatial goals and tasks, as well as their environment of use. The outcomes, presented below, were directly input into the cartographic UI design models in order to adequately support the target users' needs. Detailed below is the process of analysis followed to obtain the required results, while items relating to the user profile and environment of use are also addressed.

6.5.1 Interview narratives and initial personas

The first product of the analysis was a set of documents containing narrative summaries of each user interview, which were produced immediately following the sessions using a combination of memory and the notes taken throughout. On their completion each narrative was emailed to the appropriate participant who was asked to check the document and confirm whether or not it correctly reflected the contents of their interview. They were also encouraged to make amendments in order to rectify any errors or misinterpretations, as well as to add additional information where they felt it was relevant. This form of 'member checking' was intended to assist in maximising the accuracy of the research results (refer to Section 4.5). The final narrative summaries are presented in Appendix B, Section B.6.

To make the raw interview data more accessible, transcripts were made of each interview from the video recordings. Using the transcripts and the aforementioned narratives, short summaries were then created for each participant describing their current domestic travel habits, and incorporating the type of information required for the development of personas (as per Section 6.4.2.2):

Participant 1

- Female; 31-40 years old; travels twice a year, with her partner.
- Half of her travel is to unfamiliar destinations.
- Prefers not to pre-plan activities and events; travels for relaxation.
- Books only the ‘major’ accommodation.
- Activities include sightseeing (coastal, cities/towns), arts/music festivals, scenic driving, visiting friends/relatives, wineries, art galleries, local arts & crafts.
- Experimental whilst travelling; e.g. takes new routes to avoid boredom with familiar routes.
- Plans up to 2 days in advance once ‘on the road’.
- Has difficulty finding suitable food outlets (vegetarian).
- Prefers to have little interaction with others.

Participant 2

- Male; 25-30 years old; travels six times a year, with his wife, baby and their dog.
- Weekend trips (short drives).
- A longer one every couple of years.
- Prefers new destinations, on the coast, with local sightseeing.
- Activities include sightseeing (NPs, coastal, cities/towns), scenic driving, casual water sports (swimming), (bush) walking, visiting friends/relatives.
- Does online pre-planning for accommodation, activities, restaurants and the weather.
- Likes to retain some flexibility.
- Focused on the destination (not the journey there) because he is often time-limited.
- Visits tourism centres along the way to collect information and speak with locals.

Participant 3

- Male; 31-40 years old; travels four to five times a year, with his girlfriend and/or family.
- 60% of his travel is to unfamiliar destinations.
- Likes to book the first 2 nights accommodation only.
- Pre-plans the route to his destination and the location of food outlets (vegan).
- Researches activities and plans a rough framework, checking proximities, operating times, etc.
- Activities include sightseeing (NPs, coastal), bushwalking, visiting friends/relatives.
- Prefers new places where he can relax, but with many activities available.
- Prefers destinations/accommodation that are accessible and inexpensive (e.g. hostels).
- Uses guidebooks and the Internet for pre-planning.
- Will make unplanned stop offs to see/do things of interest.

Participant 4

- Female; 25-30 years old; travels once or twice a year, with her young family.
- 90% of her travel is to unfamiliar destinations.
- Travel is generally for the enjoyment of her daughter.
- Conducts detailed (online) pre-planning to find out about her destination, route.
- Looks online for last-minute discounted accommodation.
- Chooses activities her daughter will enjoy.
- Activities include sightseeing (cities/towns), theme parks, beach, shopping.

Participant 5

- Male; 41-50 years old; travels two to three times a year.
- Half of his travel is to unfamiliar destinations.
- Activities include sightseeing (NPs, coastal, cities/towns), scenic driving, bushwalking, visiting friends/relatives, shopping.
- Work-related travel includes leisure time.
- Conducts online pre-planning for activities, events, weather.
- Likes to have location maps in advance for proximities and wayfinding.
- Seeks local information at destination.
- Family holidays involve less pre-planning.
- Prefers seaside locations catering for preferred activities (swimming, etc.).
- The travel to the destination is not part of the holiday.
- The destination is dictated by accommodation availability/cost (camping).

Participant 6

- Male; 31-40 years old; travels on his own, six times a year.
- 100% of his travel is to unfamiliar destinations.
- Holidays consist of bushwalks.
- Prefers new, wilderness locations, for an ‘escape’.
- Will purchase a map prior to travel.
- Checks the weather in advance (online).
- Carefully pre-plans route.
- Uses a guidebook for locating accommodation and food.
- Activities include: sightseeing (NPs), casual water sports, hiking.

Participant 7

- Male; 25-30 years old; travels twice a year.
- One third of his travel is to unfamiliar destinations.
- Travels for work, but fits in leisure time where possible.
- Takes his wife along when he can.
- Looks at maps in advance to build a mental map.
- Pre-plans accommodation and researches activities/attractions (online), time permitting.
- Activities include sightseeing (NPs, coastal, cities/towns), skiing/snowboarding, bushwalking, visiting friends/relatives, shopping.
- Likes to be more spontaneous when not time-constrained (i.e. on longer trips).
- Collects brochures, maps and local knowledge whilst travelling.

Participant 8

- Female; 25-30 year old; travels once a year, with her husband.
- Half of her travel is to unfamiliar destinations.
- Travels to relax and get away from the ‘everyday’.
- Prefers to travel somewhere that is close to home (i.e. short drive) and low cost.
- Does more research for a longer trip (also depends on the holiday purpose).
- Looks at street directory immediately before travel for an overview of the route.
- Activities include sightseeing (NPs, cities/towns), scenic driving, shopping.

Following this the participant summaries were carefully compared, analysed and grouped into a number of generic user types, which would form the basis of personas to be refined and used throughout the modelling process. The initial persona descriptions are presented below.

Persona 1 ~ *participants 4 and 5*

Persona 1 is 35 years old and travels two or three times a year with her husband and two young children. These family holidays are focused on the kids, therefore she tends to choose a destination based on there being several activities that they will enjoy doing. Understandably, she is concerned about saving money and generally seeks out low-cost or discounted accommodation. Where feasible, she prefers to drive to her holiday destinations, but for longer trips she will fly for convenience. Her trips away average one to two weeks, their duration constrained by work and school commitments. Persona 1 likes to do a medium amount of advance planning, especially in terms of finding out about her destination and how to get there.

Persona 2 ~ *participants 2 and 3*

Persona 2 is a 26 year old student who travels with his girlfriend up to five times a year. He drives to intrastate destinations, but prefers to fly over longer distances for convenience. Whilst seeking a relaxing break, he is quite active when travelling, trying to fit in as many new activities and experiences as possible. His time away is generally limited by work/study constraints, so Persona 2 commonly does a high level of pre-trip research and pre-planning, using the Internet and guidebooks, to maximise the trip. His girlfriend is a vegetarian, and they have had trouble finding suitable food options in the past, so he is careful to include this as part of his research. Favouring budget accommodation, Persona 2 will generally book at least their first few nights' accommodation, preferring to be less structured once he is comfortable in a location.

Persona 3 ~ *participants 1 and 8*

Persona 3 is 50 years old and travels once or twice a year with her partner, for the sole purpose of relaxation. She likes to escape from the everyday pressures of life, especially technology, so that they can simply enjoy each other's company. Her travel often involves specific obligations (e.g. visiting family), but she always makes room for personal holiday time. With this in mind, the travel to and from the destination is itself a part of her holiday experience. Persona 3 will pre-book her accommodation, but only where necessary, such as at locations where she has to be at fixed times. Otherwise she likes to be more experimental and "free-form" in terms of where she stays and what she does. She tends not to do research or plan in advance of travel, and undertakes largely passive activities, choosing to do them if/when they become apparent along the way.

Persona 4 ~ *participants 5, 6 and 7*

Persona 4 is 41 years old and flies about four times a year to distant locations as part of his work. He usually has some 'downtime' during these trips and tries to fit in leisure time where possible. Persona 4 does as much pre-trip research (online) as his time permits, focusing on accommodation, activities, attractions, events and weather forecasts. He especially likes to look at maps of his location in advance so that he can create his own 'mental map'. Because he works during the day, Persona 4's activities are largely restricted by what can be done at night; however he occasionally has a weekend free to do daytime activities. Whilst at his destination, he collects brochures, maps and local knowledge to help him make decisions about what to do.

6.5.2 Defining the goals and their relationships

6.5.2.1 Goal definition

With the initial personas defined, it was possible to begin the goal-driven modelling process. As shown in Figure 6.2, the first stage was to define the target users' travel-related *goals*. In order to accomplish this an in-depth analysis was made of each interview transcript and the associated participant narrative, with particular consideration given to the following (derived from Cooper 2004b; Hackos & Redish 1998):

1. What is the user trying to achieve?
2. Why are they doing this (look for underlying goals)?
3. Goals may be action-oriented OR broad, less clearly defined, unstructured and wide-reaching.
4. A goal is an end condition and is generally stable over time (compared with a task, which is an intermediate process needed to achieve a goal).
5. Goals are related to a user's values.

From this, 12 goal-related themes were identified – represented in Figure 6.3 by red rectangles. Hierarchical affinity diagrams were then used to iteratively relate the themes to one another and assist in their abstraction and refinement into actual goals. The goal list resulting from the first iteration is represented in Figure 6.3 by yellow rectangles, while the final set of goals (after several additional iterations) is represented in green. Of this final set, each goal – except for the self-explanatory 'Go on holiday' – was described and illustrated using examples from the data:

- **Satisfy obligations** – Holiday travel is prompted by commitments or responsibilities.
  E.g. *"going for a conference and then taking the time to come back home … trying to fit it in with other obligations"*
- **Determine route –** Establishing the means of getting to a location (destination or other).
  E.g. *"typically if we had time we'd always do the coastal, scenic view"*

- **Obtain overview of location(s)** – Finding out information about a destination or other location, either in advance, or by experiencing it first-hand.

  E.g. *"once I knew where we were going … [I looked at] a couple of QLD tourism websites to get a feel for where the hotel was, how far away it was from … the shopping … the main part of Surfer's Paradise … theme parks"*
- **Relax –** Holiday travel is prompted by a desire to get away from 'the everyday'.

  E.g. *"it really is about relaxation with things of minor interest, nothing over-stimulating"*
- **Select destination(s) –** Holiday travel involves a minimum of one destination; in this case, the destination is unfamiliar.

  E.g. *"somewhere … that I hadn't been before and different … a wilderness area"*
- **Find suitable accommodation –** Overnight travel requires accommodation which is generally selected to match specific criteria.

  E.g. *"we chose that accommodation because it had a nice view of the water"*
- **Find things to do / of interest –** Identifying and pursuing activities to undertake during leisure time.

  E.g. *"typically we drop into Victorian Information Centres along the way … that would give us an idea of what else is around the area"*
- **Fulfil desires –** Holiday travel is prompted by a wish to go somewhere and/or experience something specific (e.g. a festival, an activity type).

  E.g. *"we wanted to go to Cape Tribulation … [and] to Mossman National Park"*
- **Minimise monetary costs –** An overall goal (or criterion) which influences many of the decisions made towards other goals.

  E.g. *"we wanted something that we could drive to. We figured that would be the least expensive way"*
- **Maximise time available for travel –** An overall goal which influences many of the decisions made towards other goals.

  E.g. *"the only real reason we would [have an itinerary] … [is to] make the most of our time constraints"*

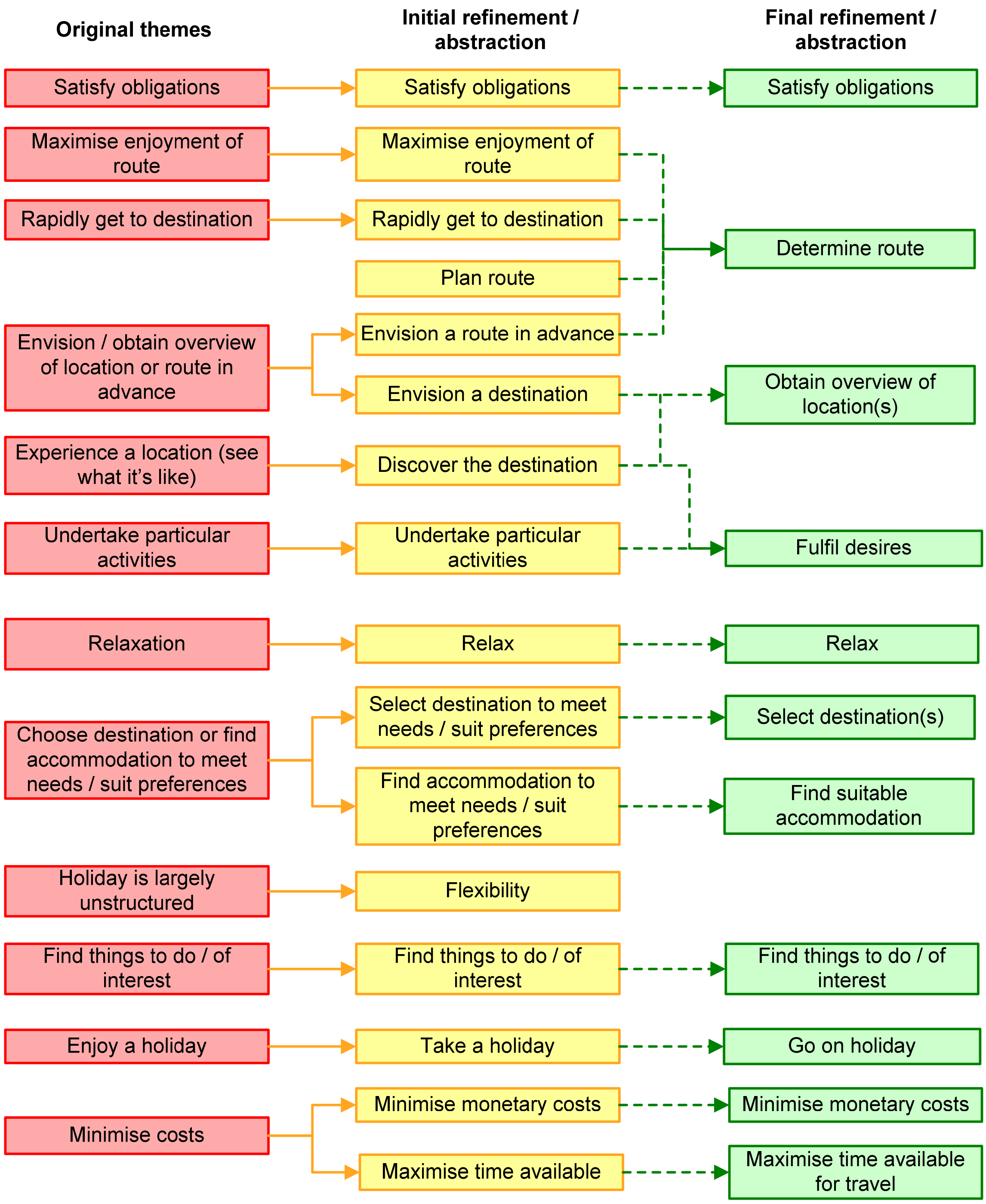


Figure 6.3 Definition and refinement of target users' travel-related goals.

The process of identifying and defining the users' goals was revealing in several respects. First, the use of hierarchical arrangement to abstract the goals suggested that not only had high-level goals been identified, but there were also a large number of sub-goals defined. Second, the list of goals/sub-goals had been drawn from the entire user set with some goals relating to all users (e.g. 'Select destination(s)'), while others related only to a subset (e.g. 'Satisfy obligations'). This enabled the initial personas to be verified and updated using the common goals of their underlying participants (the final personas, incorporating this information are presented in Section 6.5.3). Finally, the definition of each goal/sub-goal emphasised three distinct types of goals (not entirely unexpected, as per the aforementioned considerations): (1) broad, motivational goals, which generally embodied a user's impetus for going on holiday; (2) wide-reaching, value-based goals, founded on a user's personal criteria; and (3) low-level, action-based goals, which were more task-oriented and helped to satisfy other goals. It must be noted that, whilst (3) were necessarily sub-goals of (1) and (2), there was more depth to the division between goals and sub-goals, as discussed in the next section.

At this point it was pertinent to revisit the identified list of *a priori* geospatial goals within mobile tourism environments (refer to Table 5.3), to see whether these were evident within the data. Following a detailed examination of the two goal lists, it was found that a complex relationship existed here and that the *a priori* goals were overly generic in comparison to those obtained from the data. Therefore it was deemed sufficient to remain aware of the linkages (Table 6.4) while basing the modelling process on the data-driven goals.

Table 6.4 Relationship of the *a priori* geospatial goals to selected data-driven goals for DHR travellers.

***A priori* geospatial goals**

Data-driven goals	Orientation	Overview	Navigation	Exploration	Planning	Self-education	Info discovery
Minimise monetary costs					✓		
Maximise time avail. for travel					✓		
Select destination(s)					✓		
Obtain overview of location(s)	✓	✓		✓	✓	✓	✓
Find suitable accommodation					✓		
Determine route			✓		✓		
Find things to do / of interest				✓	✓		✓

6.5.2.2 Hierarchical arrangement

A sub-goal is a refinement of a parent, or underlying goal. According to van Lamsweerde (2001), all sub-goals in a refinement set must be satisfied in order to fulfil the associated parent goal (equating to an AND relationship between the sub-goals). Whilst a valid claim, this research did not follow the same logic, preferring to view sub-goals as individual entities with AND (all must be satisfied), OR (only one must be satisfied) or AND/OR (one or more may be satisfied) relationships possible, in order to satisfy a parent goal. This viewpoint was reached during the second stage of the goal modelling process: define and hierarchically arrange users' *sub-goals* with respect to *goals*.

As mentioned in the previous section, the users' sub-goals were extracted from the data during the process of goal definition. Moreover, the affinity diagrams which assisted this process embodied the first iteration of a hierarchical arrangement of the users' goals and sub-goals. Several iterations of this initial hierarchy, in conjunction with verification and validation using the personas, produced numerous refinements to the representation of relationships between the goals and sub-goals. This process also helped to clarify which were the primary goals and which were the secondary goals, tertiary goals, and so on. The final hierarchy is shown in Figure 6.4, represented as an AND/OR graph with the parent goals at the top and the lowest-level sub-goals at the bottom.

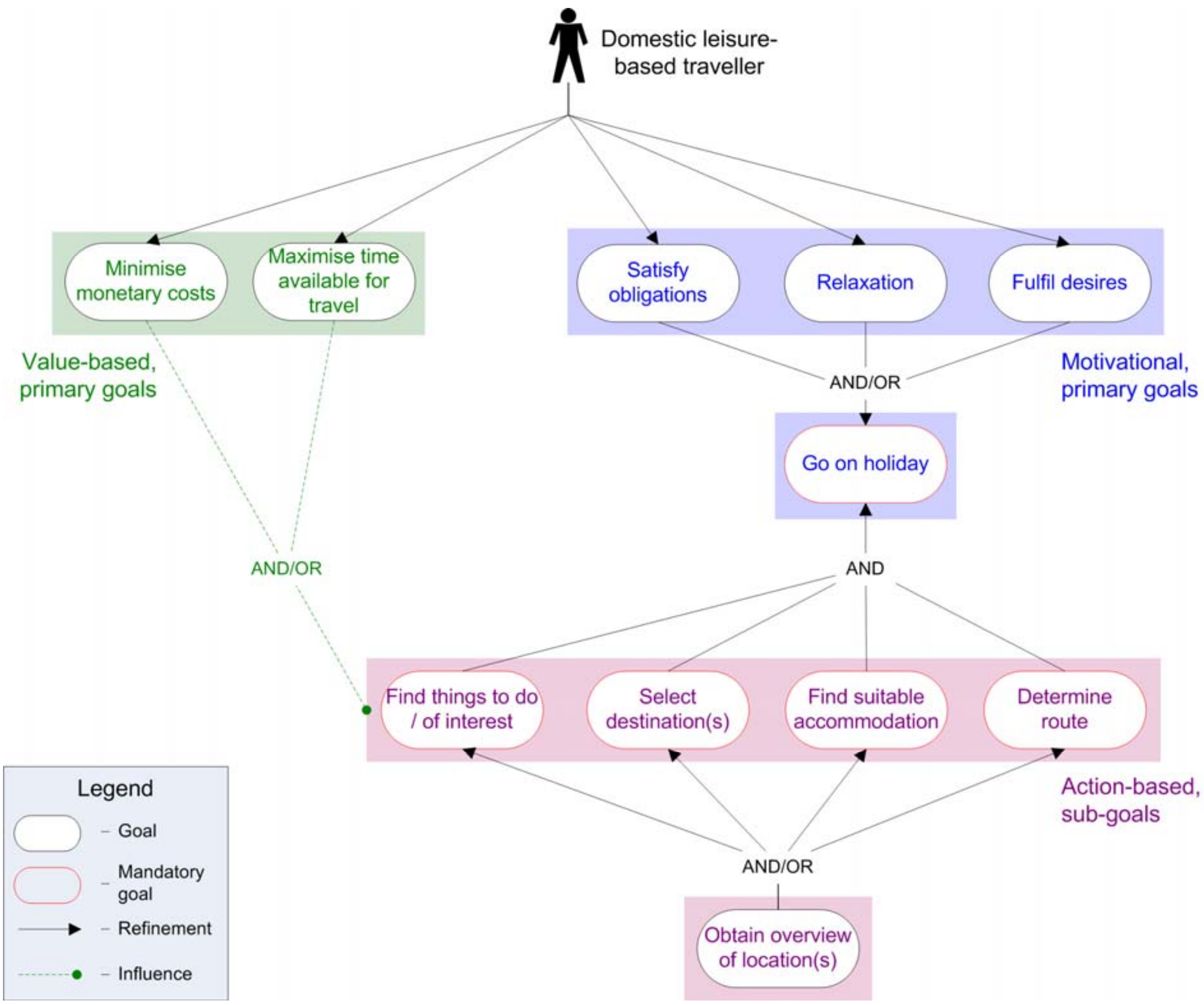


Figure 6.4 AND/OR graph showing the hierarchical arrangement of users' goals and sub-goals.

There are a number of elements within the above graph worthy of reiteration / elaboration:

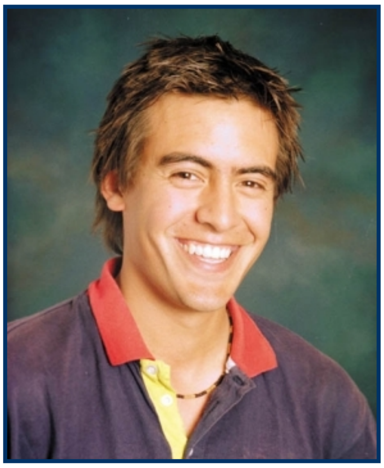
- **Primary goals versus sub-goals** – by definition, sub-goals are the refinements of primary goals with the graph labelled to reflect this hierarchy; this distinction was not considered highly important, however, with the generic term 'goals' adopted for the remainder of the research.

- **Motivational, value-based and action-based goals** – three distinct goal types were identified in the data with the broader, motivational and value-based goals comprising the upper levels of the graph, while the more specific, action-oriented goals constituted the lower levels.
- **Mandatory goals** – five of the goals were found to be common to all users, whereby their satisfaction is considered 'mandatory' for fulfilling the associated parent goal(s).
- **AND/OR links** – discussed above in relation to sub-goals, it was found that many of the goals exhibited an AND/OR relationship with one another (i.e. one or more may be fulfilled at the same time in order to satisfy the associated parent goal) and thus were considered optional.

6.5.3 Final personas

Before moving onto the next stage of the modelling, it was necessary to produce a final refinement of the existing personas, updating their goal-related characteristics with new information resulting from the hierarchical arrangement process. At this time the personas were also supplemented with more specific, personal characteristics (including fictional names and likenesses), thus increasing their credibility as target users.

Lisa is a 35-year-old part-time schoolteacher who travels with her husband and two young boys, two to three times a year. These family holidays are focused on the children having fun and experiencing new things, therefore she tends to choose a destination based on there being several activities that they will enjoy (e.g. swimming, theme parks, etc.), while she and her husband can relax. The trips generally last one to two weeks, their duration constrained by work and school commitments. Occasionally, Lisa will organise a holiday together with the families of her children's friends. Aware of the often high costs of travelling with children, Lisa is conscious of saving money where possible, and for this reason she usually seeks out accommodation that is low-cost (e.g. camping) or discounted (e.g. last minute Internet deals). Where feasible, she also prefers the family to drive to their holiday destinations (as this is generally cheaper), but for longer trips they will fly, for convenience. Lisa is a very organised person and aims to avoid feeling stressed when on holiday. To improve her confidence, she tends to do a reasonable amount of advance planning, especially in terms of finding out about her destination and accommodation, and how to get there. She especially likes using the Internet for this purpose. While competent with a desktop computer, Lisa owns an old-model mobile phone and has never been exposed to the advanced mobile functionalities offered by SmartPhones or handheld computers. Despite this she feels that she would probably find something like the 'Holiday Assistant' useful.



Daniel is a 26-year-old, full-time university student who travels up to five times a year to different parts of Australia, usually with his girlfriend Kate. He likes to drive to destinations within his home state of Victoria, but prefers flying over longer distances (i.e. interstate). Daniel and Kate are quite enthusiastic and active when travelling, trying to fit in as many new locations, activities and experiences as possible. Their time away is generally limited by work/study constraints (ranging between two and ten days), so Daniel generally does a high level of pre-trip research and some pre-planning. For this he uses guidebooks and the Internet, and places particular emphasis on activities (e.g. water sports, bushwalking, sightseeing, etc.), so as to make the most of their experience. Kate is vegetarian, and they have had trouble finding suitable food options in the past, so he is careful to include this as part of his research. In addition, Daniel counts the travel to/from/between destinations as part of his holiday experience, so he will plan his routes and/or methods of travel so that they provide interest, while maximising time. Having a limited income, Daniel favours budget lodgings (e.g. backpacker hostels), and will generally book at least their first few nights' accommodation in advance, preferring to have less structure once he is comfortable in a location. Throughout a holiday, he consults his guidebook and seeks out tourist information centres (particularly to obtain maps since his sense of direction is quite poor). In doing these things, as well as speaking to local operators, he makes sure that he isn't missing out on anything in a given region. He has found his mobile phone an invaluable resource for contacting local operators (e.g. for accommodation) during his travels. Daniel is unsure whether he would make use of a service such as the 'Holiday Assistant' – particularly if it cost substantially more than the information sources he currently uses.

Linda is 50 years old and works full-time as an office manager. She travels once or twice a year with her partner Geoff, sharing with him the motivation of escaping from the everyday pressures of life – in particular technology – so that they can enjoy each other's company in more relaxed settings. Although her travel often involves specific obligations (e.g. visiting family) and is quite often limited in its duration, Linda always makes room for personal holiday time. With this in mind, the travel to and from her destinations is itself a part of her holiday (e.g. she will often take a longer, new route rather than travel a familiar path). Linda will pre-book her accommodation, but only where necessary, such as at locations where she has to be at fixed times. Otherwise she likes to be more experimental and "free-form" in terms of where she stays and what she does. Enjoying a relatively disposable income, Linda will stay anywhere from motels to five-star resorts, depending on her criteria at the time. She tends not to do research or plan in advance of travel (lacking the time and desire to do so), and undertakes largely passive activities while on holidays (e.g. scenic driving, visiting art galleries, shopping, etc.), choosing to do them if/when they become apparent along the way. Linda has a good sense of direction and general spatial awareness and, quite successfully, relies on her memory and intuition to find her way around whilst travelling (if she does need assistance, she prefers to look at a map rather than follow written or spoken instructions as she is a very 'visual' person). She has found that her eyesight has been deteriorating over time, however, to the point where she must now wear glasses to view fine detail (e.g. on computer screens). These factors, combined with her resistance to using technology away from work and her preference for relaxing, unplanned holidays, has led to her view that she would be unlikely to use the 'Holiday Assistant' service, unless she could be assured that it would not be intrusive.

Kevin is a 41-year-old computer systems technician who flies regularly (about four or five times a year) to distant locations as part of his work. He usually has some 'downtime' during these trips and tries to fit in leisure time where possible. Being genuinely interested in getting to know his destination, Kevin does as much pre-trip research (online) as his time permits, focusing on accommodation (paid for by his work), activities (such as sightseeing, scuba diving, skiing, etc.), attractions, events and weather forecasts. He especially likes to look at maps of his destination in advance so that he can create his own 'mental map' of the region, and will generally carry a (highly detailed) local map around with him once there. When he arrives at his destination, he collects additional tourist information, mostly to validate the research he's already done. Because he works during the day, Kevin's activities are largely restricted by what can be done at night; however he occasionally has a weekend free to do daytime activities and will sometimes use his frequent flyer points to fly his family over to join him. While at his destination, he collects brochures and maps to help him make decisions about what to do and where to go. Being a naturally friendly and outgoing person, he gathers extra knowledge about his location by talking to local residents and operators. Kevin loves technology and can be considered an early-adopter of new devices and applications. For example, he always has his SmartPhone with him and has even installed a digital compass application on it to assist him during his travels. With this in mind, he believes that he would definitely make use of a service such as the 'Holiday Assistant'.

✧ ✧ ✧ ✧

The above set of four unique personas was considered the 'cast of characters' for the ongoing research[3], and as such it was upon their goals and needs that the design process was focused. Before this, however, the personas were used as input into the remainder of the task modelling, in order to develop a complete picture of the target users for the research.

6.5.4 Initial scenarios

In preparation for the definition of the users' tasks and requirements, a number of initial scenarios of use were developed. Originally identified in Section 6.4.2.2, the following are some of the considerations taken into account when writing the scenarios:

- a scenario is a description of a usage episode, having a setting, one or more actors with a shared goal, and a sequence of actions and events towards achieving that goal (Carroll 2000; Go & Carroll 2004);
- scenarios encompass the things users characteristically want to do (daily use), need to do (necessary-use), and momentous events of user interaction (edge-case) (Carroll & Rosson 1992a; Cooper 2004b);
- scenarios should be written from the user's perspective and be based on user data, in particular personas and their goals (Grudin & Pruitt 2002);

[3] Despite Cooper's (2004b) claim there should be at least one primary persona within the 'cast', as well as anti-personas (refer to Section 6.4.2.2), these were not considered relevant to the research: while Cooper describes the design of complete product interfaces which satisfy the primary persona above all others and do not cater to anti-personas, this study was instead concerned with designing useful cartographic UI components, under the assumption that each persona would at some time have a need for accessing geospatial information through the mLBS application.

- a set of scenarios should provide good coverage of the infinite possibilities of use (Carroll & Rosson 1992a);
- scenarios need to be complete in breadth more than depth (Cooper 2004b) and should be iteratively developed to increase precision (Go & Carroll 2004); and
- initial scenarios should be quite rough, specifying users' tasks without committing to the details of 'how' (Carroll 2000).

The following scenarios were developed as an initial set which assisted with the remainder of the user modelling process, while they themselves were elaborated and refined into a final, comprehensive collection. At this stage the scenarios were intended to encompass all of the identified user goals (in various combinations), without specifying tasks or requirements. They were written from the perspective of the identified personas.

1. Lisa and her family have been staying at a friend's timeshare for a week and have decided to take a day trip tomorrow to do a few things in the surrounding area. Having the kids' enjoyment as her number one priority, she chooses activities that they will find fun.
   Goals: Fulfil desires; Find things to do / of interest.
2. Daniel and his girlfriend have decided that they've seen enough of this city and want to travel up into the hills. They are trying to stick to a holiday budget and need to keep their accommodation and transportation costs down in order to do so.
   Goals: Fulfil desires; Minimise monetary costs; Determine route; Find suitable accommodation.
3. Linda and her partner are heading home from visiting family interstate and would like to spend a few days travelling back via a different road. They prefer not to book ahead since they don't want to stick to a schedule, but they want to make sure there will be accommodation options available along the way.
   Goals: Satisfy obligations; Find suitable accommodation.
4. Kevin has been sent interstate by his work for a couple of weeks to a location he's never been before. He's thinking of taking his family along on his next visit there and making it into a holiday for them, so he maximises his non-work time to experience and get to know the area.
   Goals: Satisfy obligations; Obtain overview of location(s); Maximise time available for travel.
5. Lisa and her family have been away camping and are about to drive home. The route they followed to get here was quite 'round-about', originally chosen to allow them to stop and visit new places, but she'd rather take a more direct (and faster) route home.
   Goals: Determine route.

6. Daniel and his girlfriend have arrived at their holiday destination with three days ahead with nothing planned. They have lots of activities in mind but are not sure how they will go about fitting them all in.

   Goals: Fulfil desires; Maximise time available for travel; Find things to do / of interest.

7. At the end of a five-day conference, Linda feels like taking a few extra days before returning home, to go somewhere she can just relax and not feel any pressure to be active. She looks for a destination more remote, but not too far from where she's been staying, as well as accommodation with day-spa facilities.

   Goals: Relaxation; Select destination(s); Find suitable accommodation.

8. Kevin will be here for the next week, meeting with several clients at different locations. He will therefore need to move around a lot and would like to get an idea of the general layout of the city, including where the businesses are located and how to get around, before his first appointment.

   Goals: Satisfy obligations; Obtain overview of location(s); Determine route.

9. Lisa and her family have been on the road for two hours and should have arrived at their accommodation by now. They are not sure whether they've missed the turn-off or if they're even on the right road – the area they're in is very remote, there are no visible signs and no one is around to ask for directions.

   Goals: Obtain overview of location(s).

10. Daniel and his girlfriend have rented a car and are about to embark on the next stage of their holiday – a 300km journey north. To make the trip more enjoyable, they'd like to follow a route that has things to do and places to visit along the way.

    Goals: Fulfil desires; Determine route; Find things to do / of interest.

11. The region where Kevin is working and staying in is known for its gourmet produce. He wants to go somewhere for dinner tonight that offers local food and wine, but is not too expensive as he has a limited daily allowance.

    Goals: Satisfy obligations; Minimise monetary costs; Find things to do / of interest.

6.5.5 Defining the tasks and their requirements

6.5.5.1 Categorisation and hierarchical arrangement

The next stage of the modelling process (Figure 6.2) was to identify the high-level tasks that users' undertook to achieve the defined goals, along with their associated information requirements (i.e. specific knowledge or awareness of facts that a user may need in order to accomplish the tasks) – each to be supported by the cartographic UI design models. This was carried out through further in-depth analysis of the interview transcripts and participant narratives (along with some revisiting of the user profile), with the data initially categorised in the following manner:

Goal (e.g. obtain an overview of a location)

↳**High-level task** (e.g. determine what's in the immediate area)

↳**Information requirement(s)** (e.g. current location and orientation; indicators – signage, landmarks, etc.)

It was realised early on during this process, that the only goals to which high-level tasks and information requirements were directly relevant were the 'action-based (sub-)goals'. Indeed, those goals identified as 'value-based, primary goals' (*minimise monetary costs* and *maximise time available for travel*) were found to comprise users' personal criteria and were thus more constraints than goals, variously applicable to the different tasks. Similarly, the 'motivational primary goals' (*satisfy obligations*, *relax*, *fulfil desires* and *go on holiday*) were again associated with the users' own criteria during decision-making tasks, albeit in a broader sense.

Within the categorised data, many information requirements were found to be common to different tasks and, in some cases, different goals. This prompted the analysis to move directly onto the next stage of the modelling process – the definition of cause-effect relationships between goals ↔ goals, goals ↔ requirements and requirements ↔ requirements. The approach taken for this was to add each task and requirement to the existing AND/OR graph in Figure 6.4, creating appropriate links (supported by the data) between entities. The size of the AND/OR graph soon became unmanageable, however, and was split to form five additional graphs – one devoted to each action-based goal.

Throughout the entire process, the tasks and requirements were further refined and validated (see Section 6.5.5.2 for final definitions), including the distinction of information requirements with a geospatial basis from those with no direct geospatial basis. The primary reason for this was that the latter were considered beyond the scope of the research and therefore not relevant to the design activities. The AND/OR graphs show the distinction between the two types of information requirements, determined through the application of the following criteria in identifying **geospatial** information requirements (based on the definition of geospatial information provided in Section 2.2.1):

(a) the information concerns one or more entities which are distributed over geographic space (i.e. in two, three or more dimensions) and/or time – e.g. locations and proximities; or

(b) the information is directly associated with other information requirements satisfying criterion 1 – e.g. local knowledge.

Note that where an information requirement was found to comprise both geospatial and non-geospatial aspects (e.g. *restrictions*), it was classed as a geospatial information requirement with the intention of incorporating only the relevant aspects into the design. Amongst its description of tasks and information requirements, the following section provides clarification regarding the classification of information requirements as geospatial.

Before moving on, it should be noted that no conflicts were identified between any of the entities in the AND/OR graphs (i.e. none of the goals/tasks negated the operation of other goals/tasks), which was most likely a combination of the high level of the analysis and the open-ended nature of the users' goals and tasks. Furthermore, there were no links shown between different information requirements in the graphs, despite their existence. The main reason for this was to improve the clarity of the graphs, since the association of multiple requirements to any one task (shown as influencing factors) can be taken to inherently assume a relationship between those requirements.

6.5.5.2 Task and requirement descriptions

The AND/OR graphs developed as a major part of the user task analysis modelling depicted numerous high-level tasks and information requirements. Presented from Figure 6.5 to Figure 6.9, inclusive, it was deemed useful to explain here the flow within the graphs in order to promote a better understanding of these. Essentially, each AND/OR graph comprised a distinct top-down flow, reflecting the refinement of goals (top) into high-level tasks (middle) and information requirements (bottom). Using Figure 6.5 as an example, the **goal** *select destination(s)* was refined, at the first level, into the **task** *identify & compare destinations*, which was in turn refined into the two **sub-tasks**: *find out local-level detail about the location* and *determine the accessibility of each destination*. The latter was then refined into two further **sub-tasks**: *identify & compare lodgings* and *identify & compare routes*. Along the way certain tasks were also associated with potential information requirements, for example: *determine the accessibility of each destination* may be influenced by the destination's *location and proximity*, the *costs involved* and any *restrictions* (such as the time available), as well as the user's *personal criteria*, which itself was potentially influenced by the constraints *minimise monetary costs* and *maximise time available for travel*. Note that where multiple tasks were identified for the satisfaction of a single goal, these were considered neither mutually exclusive nor mandatory, and the same was true for multiple information requirements or criteria influencing a single task.

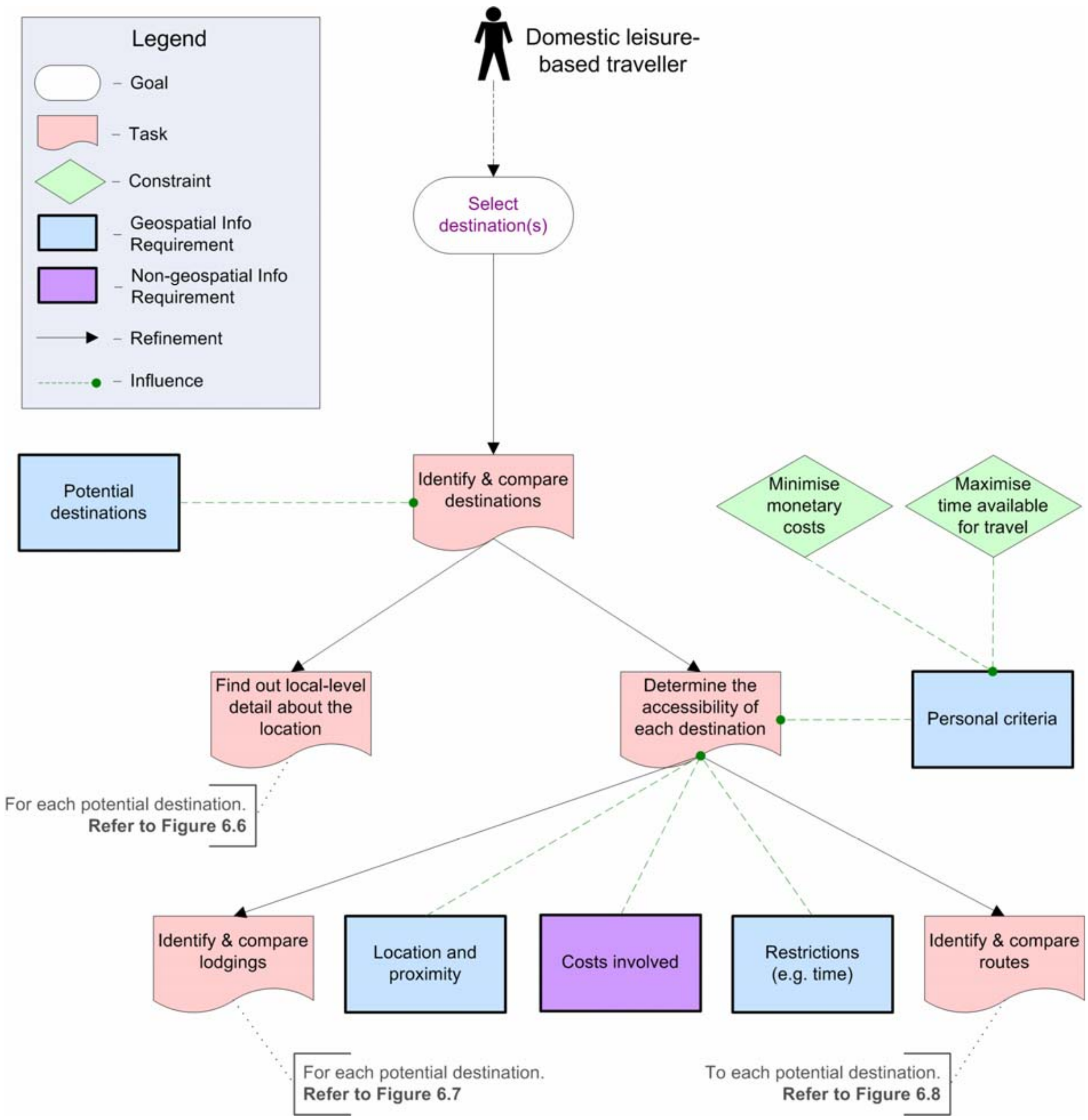


Figure 6.5 AND/OR graph for *Select destination(s)* showing the relationships between current goals, tasks and information requirements. Using scenario 7 (Section 6.5.4) as an example, there are a number of *potential destinations* from which Linda can choose a small subset of locations about which to *find out local-level detail* – in this respect places that offer her an environment where she can specifically relax. In order to satisfy her criteria for a location that is remote yet not too far away, and accommodation with day-spa facilities, she may seek information about the *location and proximity* of each potential destination with respect to where she is now, and may also *identify & compare lodgings* in each area.

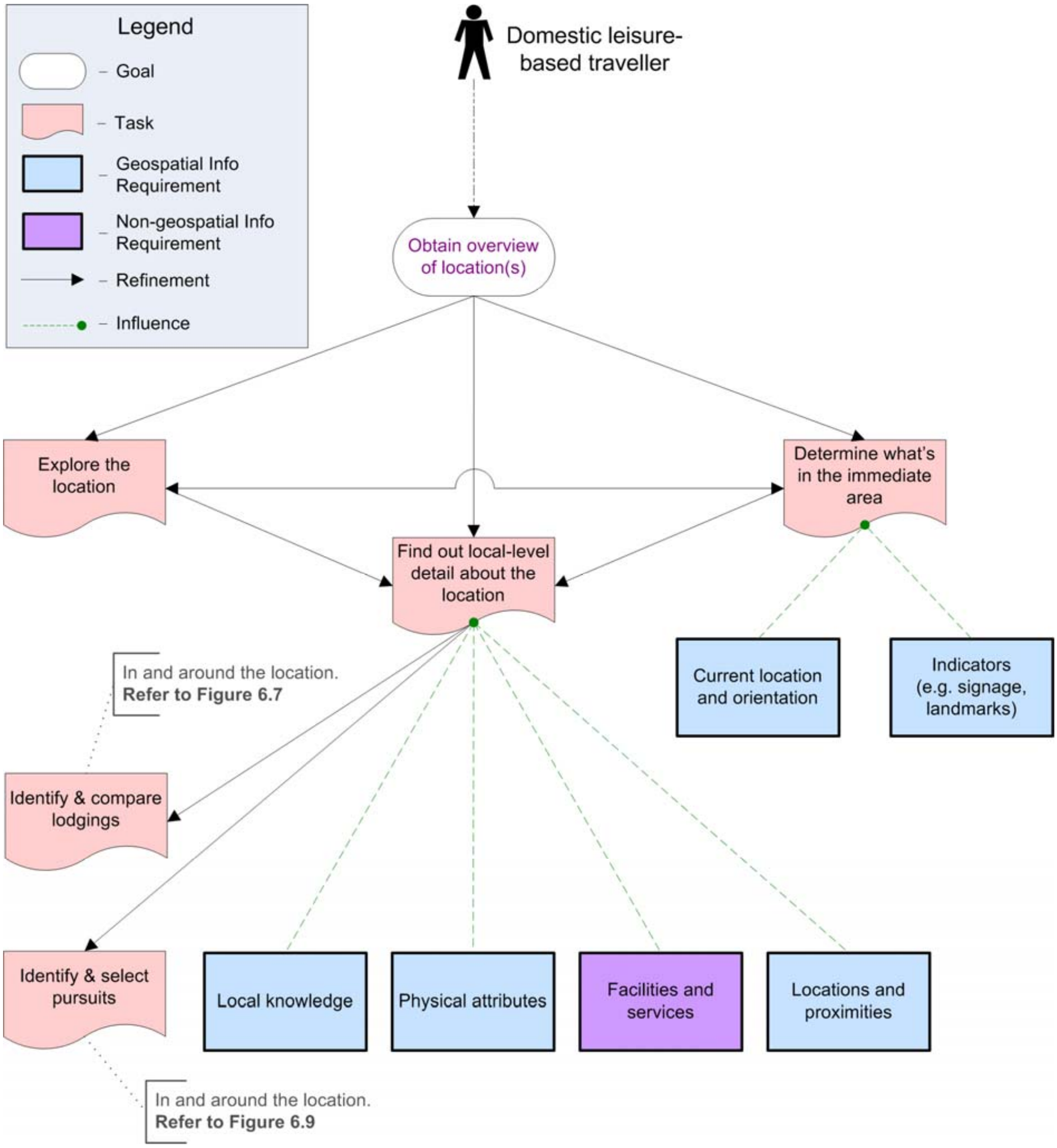


Figure 6.6 AND/OR graph for *Obtain overview of location(s)* showing the relationships between current goals, tasks and information requirements. Using scenario 8 (Section 6.5.4) as an example, in order to obtain a good overview of the city, Kevin may decide to seek information from his hotel's information desk about its layout and *facilities*, including relevant *locations and proximities* to his hotel and appointments, as well as general recommendations from the staff regarding the most efficient means of transport to get around. He may also choose to do some reconnaissance on his own, taking some time to walk around the city.

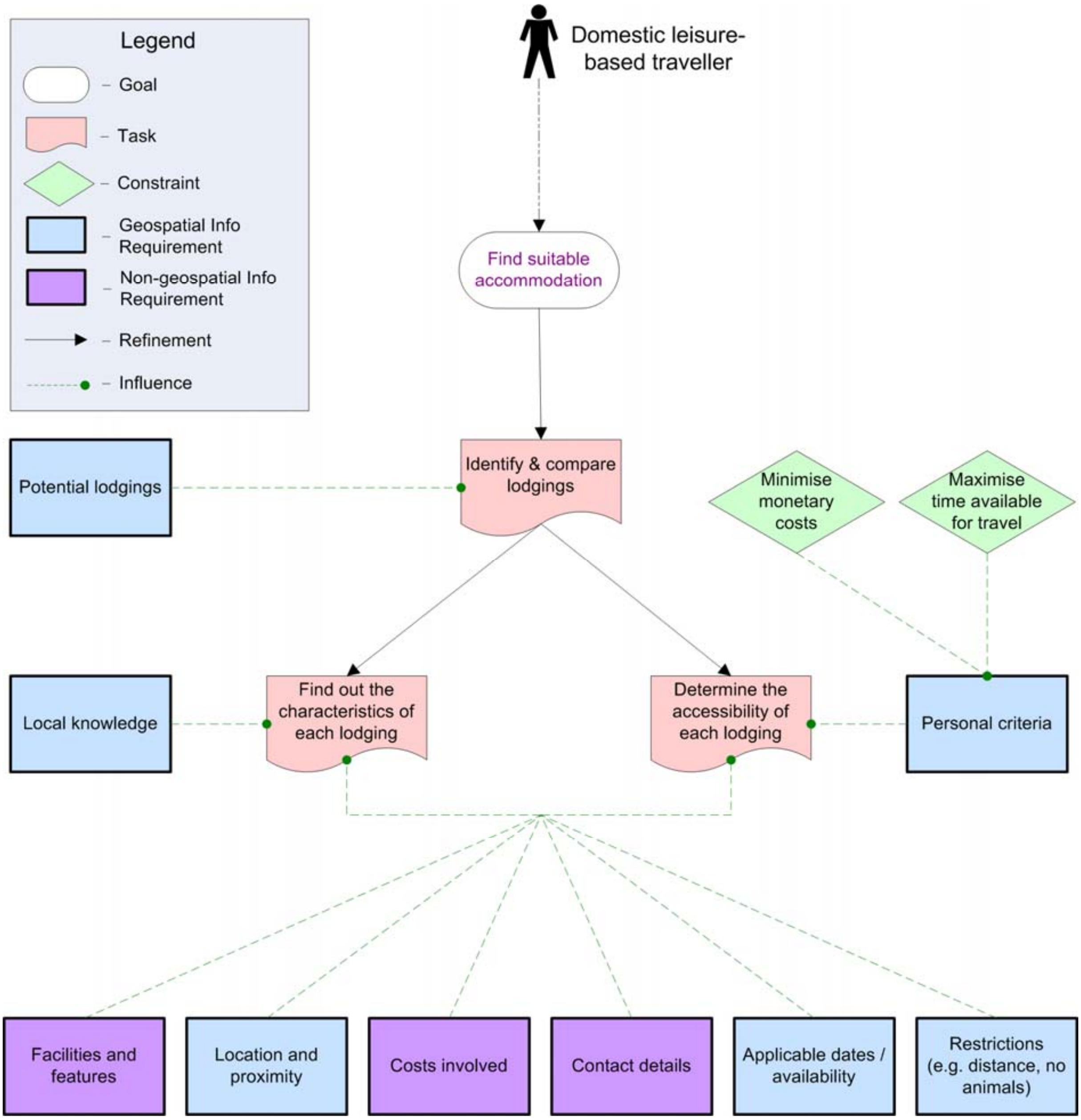


Figure 6.7 AND/OR graph for *Find suitable accommodation* showing the relationships between current goals, tasks and information requirements. Using scenario 3 (Section 6.5.4) as an example, Linda and her partner already know their route so all they need to do is identify *potential lodgings* along the way. They may also choose to find out about a selection of the lodgings' *facilities and features*, to ensure that they will be comfortable, but what they are mainly concerned with is that there are rooms generally available, so they may call around to check this in advance (without making any bookings).

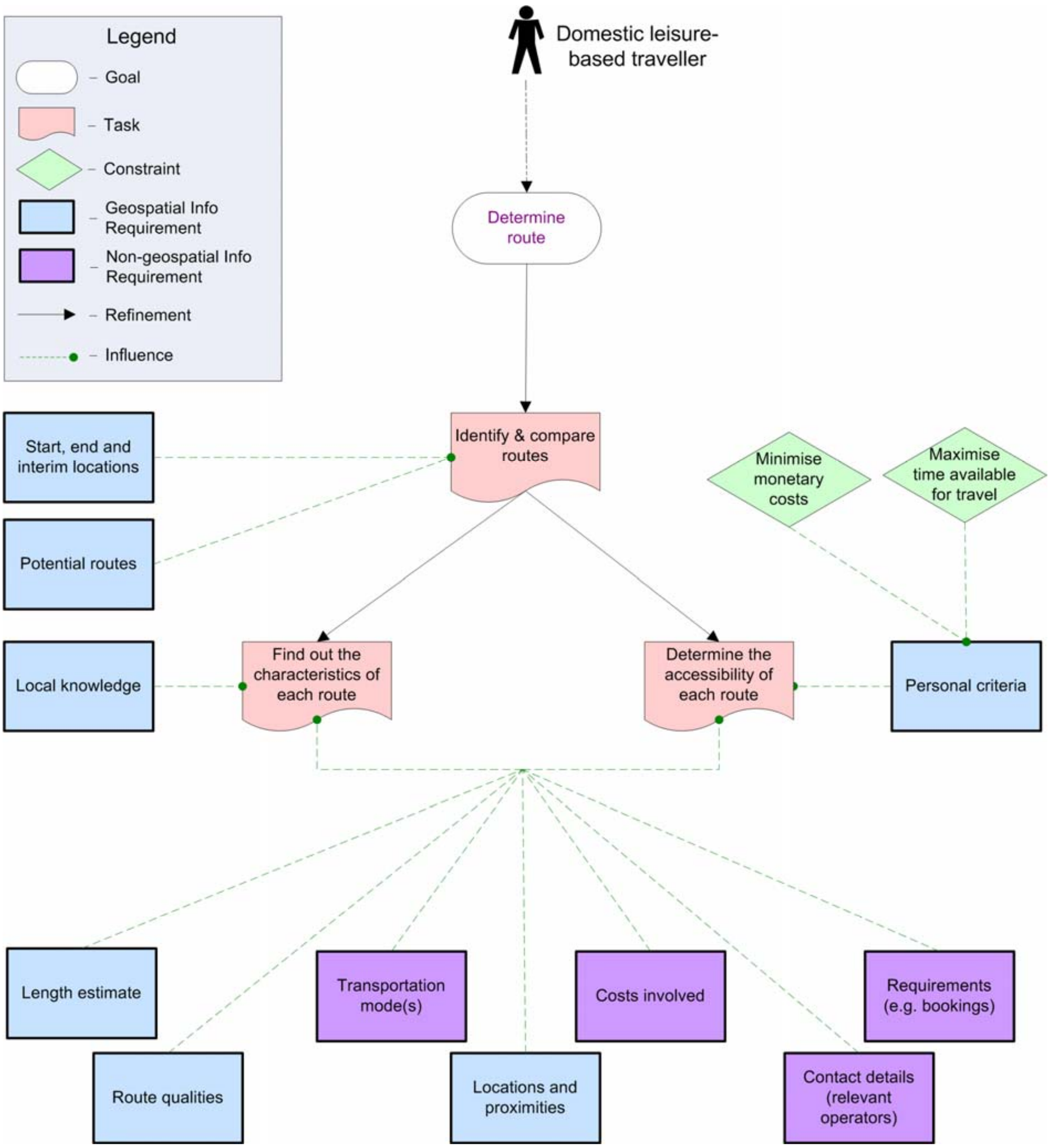


Figure 6.8 AND/OR graph for *Determine route* showing the relationships between current goals, tasks and information requirements. Using scenario 2 (Section 6.5.4) as an example, Daniel and his girlfriend have a number of *potential routes* available to them between their *start and end locations* so he will likely *identify & compare* each to meet his 'low cost' *personal criteria* – i.e. in terms of the *costs involved*, the *transportation mode* and the *length* of the trip. To find out some of this information he may need to obtain the *contact details* for relevant operators.

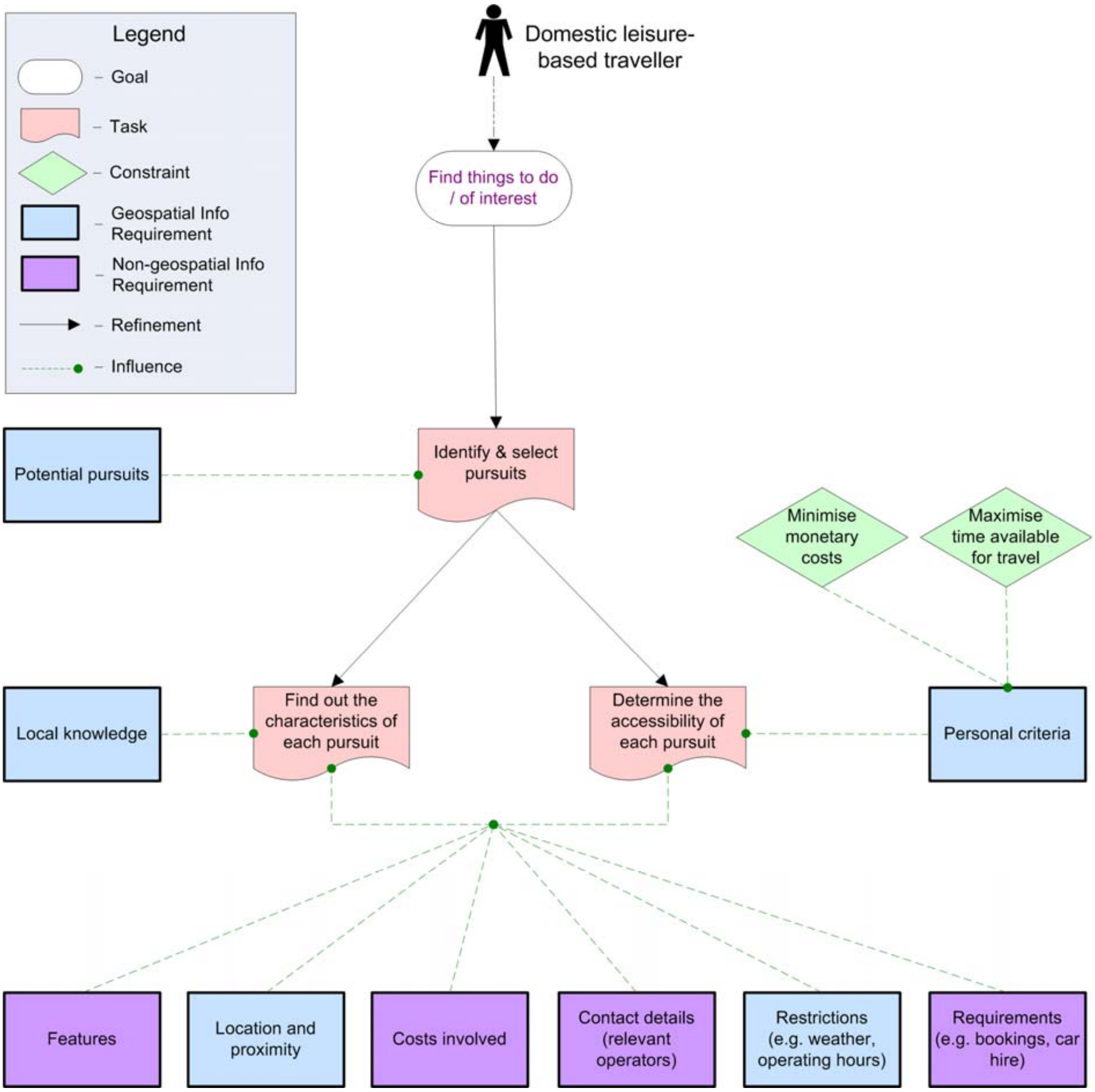


Figure 6.9 AND/OR graph for *Find things to do / of interest* showing the relationships between current goals, tasks and information requirements. Using scenario 1 (Section 6.5.4) as an example, Lisa may identify all of the *potential pursuits* that she thinks her kids will enjoy, finding out more detailed information about their *features*, *requirements*, *restrictions*, etc. by contacting relevant operators and even talking to the owner of the nearby general store.

In developing the AND/OR graphs, numerous high-level tasks and interrelated information requirements were identified. Each is described briefly below with respect to the goal/task with which it was primarily associated.

- Select destination(s):
  - *Identify & compare destinations* – users may not only have to decide between potential destinations where they will spend the majority of their holiday, they may also seek interim (i.e. enroute), side (i.e. once there) and/or other additional destinations.
    - → Potential destinations – knowledge of locations that the user may potentially visit.

      Geospatial components (GC): each destination is positioned in geographic space.
  - *Determine the accessibility of each destination* – a destination's perceived accessibility (i.e. ease of access, suitability) depends on numerous factors, assessed according to the user's personal criteria.
    - → Personal criteria – the range of personal preferences and constraints that will affect the user's final choice of destination (e.g. on the coast).

      GC: may relate to geospatial entities (e.g. locations and proximities, restrictions).
    - → Location and proximity – the physical location of the destination and its distance to objects of interest (e.g. the user's home, the coast, an event, activities).

      GC: locations and distances are inherently geospatial measures.
    - → Costs involved[4] – all monetary costs that will contribute to the total cost of the holiday (e.g. flights, petrol, accommodation, activities).
    - → Restrictions – anything that will place limits on the holiday (e.g. dates/times required for travel, seasonal events, booking requirements).

      GC: temporal limitations may impact on the timing of the holiday and/or its duration.
- Obtain overview of location(s):
  - *Explore the location* – when at a destination, users sometimes opt to 'get to know' the surrounding area through physical exploration (e.g. via walking, driving, etc.).
  - *Determine what's in the immediate area* – when a user is unfamiliar with their current location, they may seek information about their immediate surroundings.
    - → Current location and orientation – knowledge of the user's physical location (e.g. an address) and their orientation (absolute and/or relative to recognisable objects).

      GC: location and orientation are inherently geospatial measures.
    - → Indicators – recognisable information in the surrounding environment providing the user with knowledge about where they are (e.g. street signs, landmarks).

      GC: such entities provide geospatial cues about a user's current location.

[4] Considered non-geospatial.

- *Find out local-level detail about the location* (also associated with 'Select destination(s)') – prior to or during a holiday, users may seek detailed information about a particular location (e.g. when to choosing to visit and/or stay there).
  → Local knowledge – lesser known and/or fine-grained information about the location (sourced from local inhabitants or first-hand experience).
  GC: may comprise geospatial information (i.e. physical attributes, locations and proximities).
  → Physical attributes – information characterising the local environment (e.g. topography, climate).
  GC: such entities are distributed over geographical space and, in some cases, time.
  → Facilities and services[4] – the type and range of amenities available in and around the location (e.g. banks, food outlets, public transport).
  → Locations and proximities – the physical locations of, and distances to/between, objects that are relevant to the user (e.g. facilities/services, accommodation, attractions, events, activities) in and around the location.
  GC: locations and distances are inherently geospatial measures.

- Find suitable accommodation:
  - *Identify & compare lodgings* (also associated with 'Select destination(s)') – users need to choose one or more places to sleep during a holiday, with such decisions made both prior to and/or during a trip.
    → Potential lodgings – knowledge of lodgings where the user may potentially stay.
    GC: each lodging is positioned in geographic space.
  - *Find out the characteristics of each lodging* – before choosing to stay at a given lodging, users generally find out some level of detail about the accommodation on offer.
    → Facilities and features[4] – the amenities offered by the lodging (e.g. personal ensuites, breakfast included).
    → Location and proximity – the physical location of the lodging and its distance to objects of interest (e.g. the local town, the beach).
    GC: locations and distances are inherently geospatial measures.
    → Costs involved[4] – the total monetary cost of the accommodation, including extras (e.g. breakfast, car parking).
    → Contact details[4] – the details required for communicating with the lodging's operators (e.g. phone/fax number, email address).
    → Applicable dates / availability – whether the lodging is available for the dates required.
    GC: temporal limitations may impact on the choice of lodging and/or the timing of the user's stay.
    → Restrictions – anything that will place limits on the user's stay at the lodging (e.g. minimum number of nights, pets not allowed).
    GC: temporal limitations may impact on the duration of the user's stay.

→ Local knowledge – lesser known and/or fine-grained information about the lodging (sourced from local inhabitants or other guests).

GC: may comprise geospatial information (i.e. location and proximity, restrictions).

- *Determine the accessibility of each lodging* – a lodging's perceived accessibility (i.e. ease of access, suitability) depends on numerous factors, assessed according to the user's personal criteria.

→ Facilities and features; Location and proximity; Costs involved; Contact details; Applicable dates / availability; and Restrictions – see previous task.

→ Personal criteria – the range of personal preferences and constraints that will affect the user's final choice of lodging (e.g. 3 or more stars, low cost).

GC: may relate to geospatial entities (e.g. locations and proximities, applicable dates, restrictions).

- Determine route:
  - *Identify & compare routes* (also associated with 'Select destination(s)') – whether travelling to/from a holiday destination, between destinations or to satisfy another need for movement between locations, users generally pre-determine (formally or informally) the route they will follow.

→ Potential routes – knowledge of routes which the user may potentially follow.

GC: each route is distributed in geographic space.

→ Start, end and interim locations – potentially known locations which the route must cover.

GC: each 'stopping' point is located in geographic space.

- *Find out the characteristics of each route* – before selecting a particular route, users sometimes choose to find out some level of detail about it.

→ Length estimate – the total distance and time anticipated for completing the route.

GC: distance and time are inherently geospatial measures.

→ Route qualities – the characteristics of the route itself (e.g. scenic, fast, easy).

GC: potentially based upon geospatial factors (e.g. distance/time length, proximity of landmarks, physical attributes).

→ Transportation mode[4] – the mode(s) of transportation involved in completing the route (e.g. car, plane, rail, foot).

→ Locations and proximities – the physical location/path of the route and its distance to objects of interest (e.g. the user's home, towns, the coast, activities).

GC: locations and distances are inherently geospatial measures.

→ Costs involved[4] – the total monetary cost of travelling the route (e.g. airfares, petrol, tolls).

→ Contact details[4] – the details required for communicating with a route's operators (e.g. airlines, train stations).

→ Requirements[4] – anything that must be accomplished in order to travel the route (e.g. bookings, toll payments).

→ Local knowledge – lesser known and/or fine-grained information about the route (sourced from local inhabitants or first-hand experience).

GC: may comprise geospatial information (i.e. length, qualities, modes, locations and proximities).

- *Determine the accessibility of each route* – a route's perceived accessibility (i.e. ease of access, suitability) depends on numerous factors, assessed according to the user's personal criteria.

→ Length estimate; Route qualities; Transportation mode; Locations and proximities; Costs involved; Contact details; and Requirements – see previous task.

→ Personal criteria – the range of personal preferences and constraints that will affect the user's final choice of route (e.g. shortest, passes through a particular town).

GC: may relate to geospatial entities (e.g. 'stopping' points, lengths, qualities, modes, locations and proximities).

- Find things to do / of interest:
  - *Identify & select pursuits* – prior to or during a holiday, users seek things to occupy their time while they are away.

→ Potential pursuits – knowledge of the pursuits and pursuit types (e.g. sights, tours, activities, events) which the user may potentially take part in.

GC: each pursuit is positioned/distributed in geographic space.

  - *Find out the characteristics of each pursuit* (also associated with 'Obtain overview of location(s)') – for certain pursuits, users require some level of detail about what is involved.

→ Features[4] – the characteristics of the pursuit (e.g. hiking trail difficulty, free wine tastings).

→ Location and proximity – the physical location/distribution of the pursuit and its distance to objects of interest (e.g. the user's accommodation, other pursuits).

GC: locations and distances are inherently geospatial measures.

→ Costs involved[4] – the total monetary cost of taking part in the pursuit (e.g. entry fees, transportation).

→ Contact details[4] – the details required for communicating with a pursuit's operators (e.g. phone/fax number, email address).

→ Restrictions – anything that will place limits on the pursuit (e.g. change in weather conditions, opening/operating hours).

GC: temporal limitations may impact on the timing of the pursuit and/or its duration.

→ Requirements[4] – anything that must be accomplished in order to take part in the pursuit (e.g. bookings, car hire).

→ Local knowledge – lesser known and/or fine-grained information about the pursuit (e.g. sourced from local inhabitants or other visitors).

GC: may comprise geospatial information (i.e. location and proximity, restrictions).

- *Determine the accessibility of each pursuit* – a pursuit's perceived accessibility (i.e. ease of access, suitability) depends on numerous factors, assessed according to the user's personal criteria.
  - → Features; Location and proximity; Costs involved; Contact details; Restrictions; and Requirements – see previous task.
  - → Personal criteria – the range of personal preferences and constraints that will affect the user's final choice of pursuits (e.g. interests, experience, cost).

    GC: may relate to geospatial entities (e.g. locations and proximities, restrictions).

6.5.5.3 Information sources and tools

In addition to developing the AND/OR graphs, during the extraction of the users' information requirements an additional classification was performed on the data:

Information source/tool (e.g. local tourist maps – printed)

↳ **Example(s)** (e.g. CBD maps, free brochures, Lonely Planet™ guides)

↳ **Information requirement(s)** (e.g. sights, activities, locations, proximities, orientation, distances, timings)

This process served not only to verify and refine the information requirements that had been added to the AND/OR graphs, but also provided insight into the information sources and tools users' employed during their decision-making and problem solving tasks. The resulting list (Table 6.5) was especially useful for ensuring that the cartographic UI design models, as a minimum, provided equivalent informational support. Again, only those requirements related to geospatial information were considered during the design phase.

Table 6.5 Users' current information sources and tools.

Source / Tool	Examples	Information
Online information		
driving directions	Whereis	timing / length of route; directions
accommodation	Google; specific lodgings; hostel listings; Wotif; Octopustravel	accommodation search; availability; facilities; price; location; restrictions; contact details
maps	RACV; Whereis; QLD tourism; street-directory.com; specific accommodation; Google	location; proximity; orientation; distance; transportation; accommodation; time estimates
destination details	Google; CitySearch, Visit Victoria; Dreamworld; QLD tourism; Bureau of Meteorology; Weather Channel; Octopustravel	activities; sights; tours; operating hours; weather; food options; transportation; events; validation of information
flights	Virgin Blue; Qantas; JetStar	cost; bookings
event bookings	Ticketek	event information; cost; bookings

Table 6.5 (cont.) Users' current information sources and tools.

Source / Tool	Examples	Information
Printed information		
free brochures/ guides/ pamphlets/ magazines	advertising; tourist brochures; 'What's On' magazines	tour routes; local maps; transportation; activities; directions; time estimates; validation of information
guide books	RACV camping guide, Lonely Planet guides	accommodation; food options; things to see and do
road/ navigational maps	VicRoads country directory; Melway; Australian Road Atlas; RACV guides; car rental maps; Explore Australia; bushwalking maps	routes; navigation; location; destination overview; activities; sights; transportation
local tourist maps	CBD maps, free brochures, Lonely Planet guides	sights; activities; location; proximity; orientation; distance; time estimates
newspapers	The Australian	weather
timetables	public transport	departure times; stop locations
Local visitor information (in situ)		
	Victorian Information Centres; information booths; B&B consolidation agencies; tour desks; local (visitor) radio stations	activities; sights; events; accommodation; bookings; food options; location; directions; recommendations; weather
Locally-informed knowledge, assistance, suggestions		
	local operators; accommodation owners; friends; tour guides; bus drivers; police; taxi drivers; other travellers	activities; sights; accommodation; routes; weather; time estimates; directions; distances; location; orientation
Signs		
	road signs; advertisements; signage (services); street signs; tourist information; route markers	accommodation; sights, activities; navigation; distances; orientation; direction; transportation
Landmarks		
	coast; airport; main roads; lakes, creeks, mountains; buildings	orientation; direction; location
Other		
custom maps	hand drawn (subsets of other maps); mud maps[5]; annotations	location; proximity; orientation; directions
hand-written notes	restaurants	addresses
compass	digital, analogue	orientation; direction
communications	Telephone (fixed, mobile); email	accommodation; activities; directions; transportation
memory	previous routes	navigation

6.5.5.4 Unresolved traveller needs

While the users' tasks and requirements were being extracted from the data, it became evident that there were numerous problems that users encountered while travelling, relating to geospatial

[5] An Australian term for 'sketch map', referring to an indicative map of a region including relevant features, which is drawn from observation/memory, as opposed to exact measurements.

information. A list of these was compiled, incorporating eight 'problem' themes: timing of routes, lack of distance information, unknown/un-researched events, limitations of maps, incorrect information, limitations of online information, lack of signage and difficulties finding suitable food options. Upon their comparison with the 11 travel-related problems identified by the user profiling (Table 5.4), it was found that each of the interview themes could be equated with one or more of the questionnaire themes and, furthermore, the combined list of themes could be summarised into a much smaller (and more manageable) sub-set of five major problem types (see Table 6.6). These problems were deemed relevant to the modelling task, and thus the design models, since they represented unresolved geospatial information requirements.

Table 6.6 Major travel problems encountered by users, relating to geospatial information.

Problem	Description	Information requirements
Lack of signs	Signage, in general, is found to be highly variable around Australia; including street signs (from major roads through to remote streets) and signs giving directions to facilities/services (e.g. petrol stations, lodgings).	• User's current location related to the position of the entity that they seek.
Inappropriate routes	Uninformed navigational decisions, wrong turns and/or a poor sense of direction can lead to an unsuitable route being followed (e.g. not the fastest, shortest, safest, most scenic etc.).	• Reinforcement of the user's position along a route; deviations from the route. • Available route types.
Finding landmarks	Where landmarks (including street signs) are not present, difficult to see or have been removed, personal orientation is jeopardised.	• Non-landmark based support for orientation. • User's current location related to the position of the landmark(s) they seek.
Missing information	Difficulties gaining access to (or not being made aware of) specific local information, when and where it is needed; including directions, distances, road/traffic conditions, speed limits, location of services and events.	• Ready access to comprehensive micro-level information about a location. • Alerting of important information.
Poor quality information	Published information (online, brochures, maps) can be inaccurate, incomplete, out-of-date or simply wrong; e.g. accommodation, activities, food options, roads, pricing, transportation, weather, etc.	• Accurate, up-to-date information, where possible. • Age of presented information.

6.5.5.5 Future desires

Although the users' current tasks and information requirements had been mapped to their goals and their travel-related needs defined, this stage of the modelling process was not yet complete. As identified in Section 6.3.2.1, the final component of each interview involved a discussion of the user's opinions of, and preferences for, future geospatial information while on holidays (assuming none of the current access restrictions). The resulting data had the potential to enhance the cartographic UI design models, in terms of specific information requirements, and in some cases promised a level of user-defined innovation. Table 6.7 describes the information requirements most commonly identified by the users and/or those considered particularly novel.

Table 6.7 Users' information requirements considering the use of a DHR travel mLBS during future holidays.

Information	Description
Context-sensitive route directions	Users wanted an awareness of their position built into any route directions provided by the system. In this way the directions could provide navigational support specific to their current situation, for example remaining time/distance to the destination.
Real-time road conditions	Pertaining to potential and/or chosen routes, users desired prior knowledge of road conditions such as closures, works, surfaces (paved/gravel), sun-glare, speed limit, weather, traffic and events.
Locations of POIs	Users anticipated high utility in being able to readily locate and/or define the location of a range of landmarks, including service stations, tourist attractions, information centres, shops, toilets, rest stops, swimming flags, banks & ATMs and emergency services.
Itineraries	Where required, users wanted itineraries to be managed by the system, which could then provide information and services such as timing/length of routes, incorporation of road conditions, 'stopping' points and scheduled activities, and alerts/reminders for time-critical events.
Route alternatives	Information relating to route types was desired by users so that they may make informed decisions throughout their travels. Of particular interest were alternative scenic options, different transportation modes, and characteristics such as fastest, shortest, most cost effective and safest.
Proximity-based alerts	The desire for positional awareness also uncovered the users' preference for receiving alerts based on their proximity to things of interest, for example activities, food outlets, accommodation and special offers – provided these were not found to be intrusive and were based on the user's personal criteria.
Awareness of events	Users' cited a desire to be made aware of random, infrequent and/or seasonal events that might affect their planned travel, such as town closures, local weather (warnings) and changes in time zone.
Destination summaries	Upon selection of a destination, and/or on approach to a location, users wanted to be presented with a brief summary or guide to that place (including activities, attractions, etc.)

In addition to this set of users' desires and preferences for information during travel, a number of user-specified requirements were identified relating to the general design of the DHR travel mLBS:

1. The system should provide information that is not only searchable but, in some cases, can be 'pushed' to the user to make them aware of it (however this should remain under the user's control – see requirement c). Examples of such information included: proximity-based alerts; random, infrequent and/or seasonal events; and changes in time zone.
2. A system of profiling users' goals, preferences, interests, criteria, etc. was preferable to tailor the information presented, making it relevant to the user, with the following provisos:
   - At the time of request there should always be an option to access a wider or narrower range of information.
   - The user should be able to change their profile details at any time.
   - The personal information supplied by users should not be used for any other purposes.
3. Push services were acceptable to most users, but only where:
   - they provide information (i.e. they do not comprise advertising or promotions);

- their delivery is under the users' control (i.e. users must be able to opt in or out at any time); and
- they are tailored to the user's context and profile.

4. Users wanted the ability to save specific information for later reference. For example, user-defined POIs and destination summaries.
5. Mindful of the small screen sizes inherent in mobile devices, users stated a desire for manipulable displays (e.g. zooming, panning functionality), to aid in information viewing.
6. In terms of overall system design, users were generally seeking support for their decision-making and problem solving tasks, rather than a 'travel guide' which lead them along their journey. This idea is upheld by similar studies such as that by Brown & Chalmers (2003), who advocate systems which facilitate users' enjoyment of their travel experiences (including the solving of problems) by providing support for "the flexible nature" of their plans.

6.5.6 Final scenarios

The last step in the modelling process was to produce a final refinement of the scenarios, adding tasks and requirements while combining existing scenarios and/or producing new scenarios, where appropriate. This stage also involved verification and validation of the user task analysis models using the completed scenarios. The final set of five scenarios is presented below. These were useful for the development of the cartographic UI design models, while being integral to their evaluation.

Scenario 1

Lisa and her family have been staying at a friend's lakefront timeshare in Lakes Entrance for almost a week and have decided to spend their last day driving around and doing a few things in the wider area. She uses the Holiday Assistant to identify a number of activities to do in the region – the kids' enjoyment is her number one priority, but she is also mindful of keeping costs down. When she's finished making her selections, Lisa realises that there are a couple of things she needs to check. Regarding a visit to Buchan's limestone caves, she contacts the operator to confirm their opening times and to book a tour. Also, before deciding on a particular bushwalk, she makes sure that it is suitable for young children. Lisa then uses the service to put together a plan for the day, including an appropriate route – they need to be back by dinnertime and so must be organised to make the most of their limited amount of time. Finally, she opts to receive real-time updates throughout the day, including changes to road conditions and the weather, and also asks to see the location of amenities along their route.

Scenario 2

Daniel and his girlfriend Kate have decided that they've seen enough of Adelaide and want to travel into the Flinders Ranges. They are trying to stick to a holiday budget and need to keep their accommodation and transportation costs down in order to do so. Using the Holiday Assistant, Daniel reads a description of the Flinders Ranges before searching for specific information on transportation options from Adelaide, looking mainly at their flexibility and cost. Next he queries all of the low cost accommodation within the region, which matches their personal criteria. Combining both sets of information, he and Kate decide to rent a car since, although it costs a bit more than some of the other options, it will allow them to reach the cheaper lodgings while offering lots of flexibility for exploring once there. They use the service to book their first two night's accommodation (saving a shortlist of other lodgings for use later in the trip) and to call a car rental agency. Daniel also asks to receive alerts for any discount accommodation offers near to their location, as well as any local weather warnings.

Scenario 3

At the end of a five-day conference in Newcastle, Linda feels like taking a few extra days before returning home, to go somewhere she can just relax and not feel any pressure to be active. She'd like a destination that's more remote, but not too far away from where she is now, and that has a range of accommodation options with day-spa facilities. She does a search using the Holiday Assistant on retreat-style destinations and accommodation within 100km of Newcastle. After reading the destination summaries retrieved by the service and narrowing down the list of potential lodgings, she requests more detail about a selection of these, including their facilities and current availability. Before making her final decision, Linda looks for information relating to major events in each region or anything else that may affect her stay. Based on this research, she chooses her destination, saves a list of suitable lodgings, and prepares to drive straight there, confident that she won't need to make a booking.

Scenario 4

Kevin has been sent to Perth by his company for a couple of weeks, and it's a city he's never been to before. He's thinking of taking his family along on his next, inevitable visit and making it into a holiday for them, so he maximises his non-work time to experience and get to know the city and surrounding area as preparation. He starts by using the Holiday Assistant to find out as much detail as possible about Perth, starting with a general summary and then moving onto the layout of the area as well as nearby activities that he thinks his family would enjoy doing. He also decides to explore the city on foot, so that he can form a mental map of it, venturing out from his hotel during his free time, walking around the main streets and shopping strips. After a particularly long Sunday afternoon's walk on the outskirts of the city, Kevin becomes disoriented and realises that he doesn't know where he is. He looks around but can't see any street signs, nor people to ask for directions. He pulls out the Holiday Assistant which tells him his current location with respect to a number of recognisable landmarks. He then asks the service to guide him back to his hotel.

Scenario 5

Daniel and Kate have rented a car and are about to embark on the next stage of their trip – a journey north from Sydney to Brisbane. To make their trip more enjoyable, they'd like to follow a route that has a variety of things to do and places to visit along the way. Daniel enters their start and end locations into the Holiday Assistant and asks it to show him the three most scenic routes between the two, highlighting the main towns and activities that match their interests along the way. After comparing the routes they decide that none is exactly right for them and so they make another request, this time asking for a single route that provides access to the two activities they particularly want to undertake. They save the route, noting the times and distances involved so that they have a rough idea of where they will need to stop and find accommodation each night. When they set off on their journey the next morning, Daniel loads the route and instructs the service to guide them on their way, providing real-time directions and offering a location summary whenever they make a stop-off.

6.5.7 Augmenting the user profile

Table 5.6 highlighted a number of user profile characteristics for which further investigation was required. Of these, four different user group characteristics were identified for inquiry through the user task analysis. Each of these is discussed below, with respect to how they were addressed and the relevance of the outcomes to the cartographic UI design models.

6.5.7.1 Gender of travel companion(s)

The user profile speculated that people generally travel with companions of the opposite sex. Hence, despite the dominance of males contributing to the user profile data, it was believed that each gender should hold equal weight in the design. In order to verify this, the user task analysis interviews sought information about each participant's travelling companion(s). The results were thus:

- Female participant – male travel companion (husband)
- Female participant – male and female travel companions (husband and daughter)
- Female participant – male travel companion (partner)
- Male participant – female travel companion (wife)
- Male participant – no travel companions (work-related travel)
  – male and female travel companions (family and friends)
- Male participant – female travel companion (girlfriend)
- Male participant – female travel companion (wife)

- Male participant – male and female companions (friends)

This information supported the user profiling assumption that the target users were equally likely to be male or female, thus requiring design models that accounted for accepted differences in gender approaches to, and abilities with, navigation and other geospatial tasks (Kimura 1999).

6.5.7.2 Geospatial information needs for different travel durations

The user profiling suggested that a user's geospatial information needs would differ according to their holiday duration. The user task analysis set out to investigate this assumption by focusing on specific travel events. The holiday durations of the interview participants ranged from 2 days to 2 weeks, falling into the short- and medium-term holiday categories. Whilst each trip was constrained in some way by other commitments, either at home or during the holiday, no clear pattern emerged with respect to the factors of time and geospatial information needs – indeed some users implied that they would have greater needs during a longer stay while others indicated the opposite. Perhaps more evident was the fact that the participants' geospatial information needs were largely dictated by their motivational and value-based primary goals (see Figure 6.4), their personal preferences for travel and their past travel patterns and experiences. Therefore, rather than attempt to contrive a relationship between holiday duration and geospatial information needs, it was deemed more important to support the individual needs evident in the user task models.

6.5.7.3 Preferences regarding technological platform for mLBS

While user profiling found that the target users' were more or less familiar with mLBS-related devices (particularly mobile phones and SmartPhones), it was deemed worthwhile to gather more specific preferences regarding the wireless technology used to access the 'Holiday Assistant' service. To this end, the user task analysis interviews found that participants were accepting of most types of handheld device such as advanced mobile phones, SmartPhones, handheld computers (e.g. Palm Pilot) and GPS receivers, with the exception of laptop computers. They did, however, specify a number of conditions including that the device should be intuitive, have a "decent-sized screen", be of a practical size (e.g. no bigger than a typical guidebook), and be more rugged than a basic mobile phone. They also preferred the concept of an "all-in-one" device, integrating mobile telephone communication with the required computing and positioning functionalities, while having the potential for everyday use. Furthermore, two of the participants stated a desire to utilise local wireless hotspots[6] to access data (as opposed, or in addition, to telecommunications networks).

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[6] A 'hotspot' is a geographic location (commonly an airport, library, hotel, etc.) containing short range radio network points which allow visitors to access public wireless broadband network services through wirelessly enabled mobile devices.

When the discussion turned to pre-trip research and planning, the interview participants overwhelmingly preferred the idea of using a stationary device (i.e. a desktop or laptop computer) with a fast Internet connection. The main reasons for this were the large screen size of stationary devices in comparison to handheld devices, the greater availability, speed and responsiveness of most wired Internet connections, the perceived difference in cost for data access (assumed to be much higher for handheld devices) and the presence of value-adding peripheral devices (e.g. mouse, keyboard, printer). As one user asserted: "I'd probably use my computer 'cos [*sic*] it's quicker, it's easier, it's more responsive and I can see more". Based on these responses, and in the interests of controlling scope, the decision was made to focus the design models on providing 'on-trip' support for travellers, and thus no consideration of 'pre-trip' research and planning. It should be noted, however, that a complete DHR travel mLBS would likely incorporate both levels of support, using a range of devices and networks across which the service is seamlessly integrated. Moreover, it was envisaged that much of the on-trip support built into the design models may be used for pre-trip activities, if the user so desired.

6.5.7.4 Maps characteristics causing difficulties

One of the implications from the user profiling was that if the design models incorporated maps, they should avoid undesirable map characteristics. This prompted the user task analysis to further investigate characteristics of travel-related maps that caused difficulties for members of the user group, with the results as follows:

- Inaccurate and/or non-existent scales.
- Out-of-date versions (e.g. Melway).
- Lack of travel time indicators (e.g. road conditions, speed limits, distances).
- Lack of topographical information (e.g. cliffs, hills).
- Poor information clarity.
- Insufficient landmark and road labelling for orientation and wayfinding.
- Missing legends.
- Little information about surrounding areas.
- Too simplified, not enough local detail (e.g. small roads, POIs).
- Too detailed, more than what is needed.

This highly condensed list not only highlighted those things to think about when designing maps for use within the service, it also demonstrated the different preferences of individual users – take for example the final two items which show that while some users preferred high detail in their maps, others only wanted enough information to satisfy their immediate needs. Such preferences are of course dependent on a user's context, goals and needs at the time of viewing the map, but they did serve to further emphasise the need for the design models to be mindful of individual users' needs.

6.5.7.5 Instances of users being lost (along with related geospatial needs)

The user profiling speculated that although the users claimed to have few issues with losing their way, they do in fact experience times when they are lost whilst travelling in unfamiliar locations, however trivial they may consider such circumstances. The user task analysis interviews sought to confirm or deny this, asking participants about specific instances where they had been lost while on holidays. Again the users struggled to recall instances where they had 'felt' lost, however they did cite situations of disorientation and uncertainty while navigating. Examples of this included: feelings of travelling in the wrong direction or on the wrong road; not being able to find their accommodation; and suddenly being in an unfamiliar place (e.g. having exited a building via a different door). To obtain further insight the participants were asked what they did in such situations, with common answers being to: stop and check the information they had at hand; look for cues within the environment (e.g. landmarks, signs); ask someone local for help; go back the way they had come; and/or continue on the current path until something in the environment was recognisable. The outcome of this inquiry was that, while users do not struggle with feelings of being "lost" (perhaps too strong a word) during their holidays, they do encounter instances where access to situational support may prove useful.

6.5.8 Environment of use

The only factor remaining to complete the user task analysis was consideration of the environment of use for the DHR travel mLBS upon which the cartographic UI design models would be based. As Hackos & Redish (1998) acknowledge, a system must fit into the environment within which it is to be used, otherwise users may find it difficult and/or frustrating to use. Here they advocate consideration of the three usage environment components – physical, social and cultural – during the analysis of users' goals and tasks, noting that (as a minimum) those aspects most important to the design must be identified. Whilst a lack of direct observation meant that first-hand data could not be collected relating to the environment of use for the DHR travel user group, anecdotal evidence from the interviews provided sufficient information for discussion here.

6.5.8.1 Physical environment

In Chapter 2 the general characteristics of mobile environments and mLBS were identified, incorporating device- and network-related aspects such as mobility, display, interaction and performance, as well as the situational aspects of dynamic settings, including changing location and time. These and other factors combine to necessitate the following considerations relevant to the cartographic UI design models[7] (based on Hackos & Redish 1998):

- Location of workspace – considering the mobility of the devices, networks and users involved, mLBS can potentially be used anywhere (e.g. in a moving car, over coffee in a hotel dining room, out walking in bright sunlight, and so on), leading to a range of design-related issues embodied by each of the factors below. An additional consideration related to users' not wanting to carry bulky manuals around on their holidays, therefore all supporting information (e.g. help, training documentation) needed to be incorporated into the service.
- Background noise and other distractions – mLBS can be accessed under a range of conditions, some of which may be noisy (e.g. at a rest stop beside a busy road) and/or contain other distractions (e.g. young children requiring supervision). This had several implications. Audible prompts, feedback, etc. may be difficult to hear in a noisy environment and inappropriate in a quiet environment. Concentration may also be compromised by noise and distractions, impacting on the learning and performing of tasks and, possibly, loss of information.
- Light levels – again these can be highly variable, with the time of use potentially ranging from morning through night. The impacts here related to users having difficulty seeing screen elements and/or device controls, as well as the visibility of colours used within the interface.
- Danger – mLBS use occurs in uncontrolled environments (essentially, 'out in the real world'). This in itself presents dangers to users who must remain aware of their surroundings, yet may be distracted by the service. Therefore any mLBS design must endeavour to minimise distraction from the immediate environment.

6.5.8.2 Social environment

The social environment of use concerns the users themselves and the other people with whom they may interact while on holidays (e.g. travel companions, other travellers). Those aspects of the social environment which required consideration within the cartographic UI design models were[8] (again, based on Hackos & Redish 1998):

- Accuracy and speed of use – the users of the service are on holiday. With this in mind, they do not want to spend more time than is necessary using the service to find the information they need.

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7 Note, a number of additional factors within the physical environment also affect the use of mLBS for example: access to required devices; presence of dirt, dust, pollution and other environmental hazards; temperature, humidity and other weather-related factors; and access to power sources and telecommunications networks. Since these were largely beyond the control of the cartographic design models, they were excluded.

8 Note, additional factors within the social environment also affect the use of mLBS for example: information sharing between users. Since these were largely beyond the control of the cartographic design models, they were excluded.

- Access to help resources – if they experience problems with accessing information, users should have ready access to help facilities, wherever they are.
- Interaction between the physical and social environments – the settings in which mLBS are used may be inherently social (e.g. during a tour) requiring, for example, consideration of the use of audible prompts/feedback lest other people are disturbed and/or the user is embarrassed.

6.5.8.3 Cultural environment

The cultural component of the usage environment was considered largely beyond the scope of the research, with no notable cultural differences perceived between users during the user profiling and user task analysis, nor any specific data collected relating to such (mostly as a result of scope control). Despite this, however, two cultural factors were considered relevant to the cartographic UI design models:

- Use of language – including avoidance of technical jargon and employment of the users 'own words'.
- Suitability of icons, sounds and imagery – these should not be offensive to users in any way.

6.6 Discussion

The detailed user task analysis was at this point complete, having revealed various aspects of the users' travel experiences and produced a useful interpretation of the data. From here, efforts could begin for translating the user profile and user task models into a set of cartographic UI design models for the ongoing research. First, however, it was necessary to assess the interview process used to generate the user task analysis data and to discuss the accuracy and rigour of the findings obtained.

6.6.1 Critical Incident interviews

In Section 6.3.1 a number of different alternatives for data collection were compared and contrasted, resulting in the ultimate selection of Critical Incident interviews. This technique promised to provide an optimal balance between the level of detail required (i.e. comprehensive goals and high-level tasks and requirements held by individual users), the resources available (one principal investigator constrained by limited time and funding) and what was possible (e.g. observing users whilst on holiday was inappropriate). Based upon Critical Incidents, the interviews were also largely structured (i.e. standardised). As opposed to unstructured or guide-style interviews, structured interviews provide for consistency in the resulting data with each individual asked an identical sequence of pre-determined questions (Kirwan & Ainsworth 1992). Other benefits promised by this technique included: the investigator's high familiarity with interviews, as opposed to the alternative methods; the collection of open-ended, qualitative data through careful wording of questions and probes, designed to elicit the users' own words, thoughts and insights; uniformity in the breadth and depth of the information gathered from each user; efficiency in the use of interview time through the prioritisation and focusing of questions; simplification of the data analysis process with responses simple to locate and compare; and the presence of a specific data collection instrument, readily accessible to users of the research findings (Patton 2002).

Whilst each of these advantages was fulfilled during the actual design and conduct of the interviews, a number of limitations were also evident and, where possible, mitigated. The first of these was the rigidity of traditional structured interviewing, whereby no allowance is made for the pursuance of topics not anticipated prior to the interview's design. To alleviate this restriction, a partial 'guide-style' approach was incorporated whereby the structured interview format was followed, however additional topics were explored at the interviewer's discretion (Patton 2002). After the first interview in particular, some topics were added to the instrument as questions for inclusion in the remaining interviews. The second limitation was the anticipated reliance on users' accurate recollection of events during their holidays, with the shortcomings of human memory potentially leading to important information being forgotten, omitted or distorted (Kirwan & Ainsworth 1992). Although the extent of this was impossible to measure without accompanying observations, its impact was minimised by concentrating on one specific holiday (i.e. Critical Incident) for each user. In this way, users recounted actual events "situated in their real experience", rather than providing generalisations or speculations (Hackos & Redish 1998, p.140). Furthermore, the questions were not mutually exclusive, being designed not only to elicit specific details, but also to 'jog the user's memory' about their holiday, with the artefact presentations serving a similar purpose. A final limitation was the large amount of time required to process and analyse the interview data, using videotape footage and notes taken throughout each session. This being a necessary part of the user task analysis process, it was not considered a major disadvantage and was partly minimised by the small breadth of the sample size (although the depth of the analysis was maximised).

6.6.2 Goal-driven user task modelling

The goal-driven task modelling results presented in Section 6.5 constitute the analysis, and thus the findings, for the user task analysis. Whilst the written explanation makes the process appear quite linear, it was in reality one of continual theme refinement and abstraction, followed by verification, validation and revision of the results. It is therefore appropriate to discuss the accuracy and rigour of the final outcomes. While rigour was ensured through careful selection and strict application of the Critical Incident interview data collection technique (refer to the previous section), accuracy was addressed throughout the analysis process. Again using Creswell

(2003) for guidance, the following five accuracy checks were applied to varying degrees for this phase of the research:

- **Rich, thick description:** The findings of the user task analysis were conveyed (as narrative summaries, personas, user models and scenarios) using a high level of detail in order to express the interviewees' travel-related goals, tasks and requirements.
- **Member checking:** As an early cross-check, the interviewees were given the opportunity to assess the accuracy of the user task interview narrative summaries, providing amendments and additional information wherever necessary.
- **Clarification of researcher bias:** As in any qualitative study, the research makes no claim that this interpretation of the user task analysis data is 'correct' (Janesick 2000). It is, by definition, the researcher's own interpretation – subject to personal knowledge, experience and unavoidable levels of judgement – albeit supplemented by such unbiased accuracy checks as member checking and peer debriefing.
- **Triangulation:** Throughout the user task analysis, the user profile (as a disparate data source) was used in addition to the interview data in order to verify and/or supplement the results. Furthermore, the combination of multiple methods within the modelling process (AND/OR graphs, with personas and scenarios) provided further justification and elaboration of the identified themes.
- **Peer debriefing:** As a postgraduate research project, the study benefited from having a number of peers (i.e. supervisors, consultants and presentation audiences) who provided continual feedback on its findings. This was no less the case for the user task modelling, with the conclusions drawn in Section 6.5 validated by these parties following the treatment of all questions raised.

6.7 Chapter Summary

This chapter has described the process by which the travel-related goals, tasks, requirements and usage environments of the target user population were specified and understood. The box below summarises the major techniques employed throughout this phase and the outcomes produced. Although the user task analysis results are but one interpretation of the data, the selection of techniques and conduct of the data collection and modelling activities were considered successful in producing valuable insights into the target users' goals, tasks and information requirements. Furthermore, as with the user profiling, this stage of the study provided important experience to the researcher in terms of the design and conduct of interviews as well as modelling data and interacting with users. With its varied collection of results – AND/OR graphs, personas, scenarios, current information sources/tools, geospatially related travel problems, future information requirements and environment of use descriptions – the user task analysis made a major contribution to the next and final phase of the research: iterative design and evaluation. The next chapter details the first iteration of this, whereby the user profiling and user task analysis outcomes were input into the development and evaluation of preliminary cartographic UI design models.

- Structured, Critical Incident interviews (without observation), that focused on users' specific holiday experiences, were selected to gather the user task analysis data, with a research-specific instrument developed and pilot tested for this purpose.
- Purposeful criterion sampling, based on the user profiling data, was employed to obtain a sample of users, with eight participants involved in the individual interviews.
- Various data were gathered for each user, with respect to a specific, recent domestic holiday; including their pre-trip, on-trip and post-trip goals/sub-goals (motivational, value- and action-based), tasks, actions, behaviours, experiences, intentions, desires, expectations and emotions.
- A goal-driven modelling technique was developed and employed to analyse the interview data, producing a number of research products:
  - eight narrative summaries;
  - four representative **personas**;
  - six **AND/OR graphs** describing the users' current goals, tasks and information requirements (geospatial and non-geospatial), including the interrelationships between these; and
  - five representative **scenarios**.
- Additional research products from the user task analysis included:
  - users' current geospatial information sources and tools;
  - users' unresolved needs and desires relating to geospatial information when travelling;
  - users' preferences and desires for the design of a DHR travel mLBS;
  - the results of investigations into outstanding items from the user profile; and
  - a discussion of the usage environment for the cartographic UI design models.

7 Phase III: Preliminary Design

7.1 Introduction

With the results of the user profiling and user task analysis in hand (Chapters 5 and 6), the Pre-Design phase of the research was complete. Revisiting the activities of User-Centred Design (UCD) presented in Figure 4.1, this signified that the *context of use* for the proposed DHR travel mLBS had been specified and understood, as had the *target user requirements*. All of this was accomplished in preparation for the next and final phases of the research – Iterative Design and Evaluation – comprising the cyclical production of cartographic design solutions and their evaluation against the specified requirements through the involvement of representative users. In paraphrasing Gould & Lewis (1985), Rubin (1994) provides justification for these upcoming activities, stating that "true iterative design allows for the complete overhaul and rethinking of a design through *early* testing of conceptual models and design ideas" (p.12). Indeed, through ongoing evaluation during the development lifecycle, conceptual models and design ideas can be continuously tested, validated and refined, not only ensuring a rigorous design process but also less expenditure of effort in ensuring usability once development is complete (Gould & Lewis 1985; Mayhew 1999). Moreover, unavoidable gaps in the Pre-Design requirements specification may be overcome through testing potential design features with representative users – a key principle of UCD – followed by the modification of false assumptions and overall improvement of the product (Dix *et al.* 1998).

This chapter describes the first iteration of design conducted for the research, the evaluation of which is documented in Chapter 8. It begins with a comprehensive definition of the qualitative usability goals applicable to the remaining research (Section 7.2), which is followed by a detailed description of the preparations leading up to the design activities, including: the definition of the design's aims and scope (Sections 7.3.1 and 7.3.2), the use of a prototype to specify and embody the design (Section 7.3.3); decisions and constraints relating to the development platform (Section 7.3.4); and important design guidelines and principles for consideration (Section 7.3.5). The remainder of the chapter describes the development of the design solutions (Section 7.3.5.2), culminating in cartographic UI preliminary design models (Section 7.5), with the success of the preliminary design process then discussed (Section 7.6).

7.2 Usability Goal Setting

Prior to beginning the design activities for any project, it is important to set goals upon which efforts will be focused and against which potential design decisions are assessed. Such goals may also "serve as acceptance criteria during usability evaluation, especially towards the end of the design process" (Mayhew 1999, p.124). Put more simply, usability goal setting provides an "idea of the level of usability to be strived for" when designing a product (Nielsen 1993, p.80). Usability goals are based primarily on the outcomes of the pre-design activities – for this research the User Profile and goal-based user task analysis – and they can be broadly categorised as either *qualitative* or *quantitative*. Qualitative usability goals are general, non-quantifiable and suited to guiding initial design efforts. Conversely, quantitative usability goals are objective and measurable, making them appropriate for use as evaluation acceptance criteria (Mayhew 1999). The latter can be broken down further into a number of overlapping sub-categories: ease-of-use vs. ease-of-learning goals; absolute vs. relative goals; and performance vs. preference/satisfaction goals – these are discussed further in Chapter 9. When formulating usability goals, decisions must be made regarding their scope (e.g. broad, task-based vs. narrow, feature-oriented): for this research, the preference is for broad, goal/task-based usability goals, in keeping with the focus of the goal-driven user task analysis. Finally, the ultimate set of usability goals should be prioritised, using the pre-design analysis of the users and their goals/tasks to determine appropriate weightings (Mayhew 1999; Nielsen 1993). Mayhew (1999) goes on to suggest that quantitative usability goals should be developed from a subset of qualitative usability goals given highest priority.

Although it is generally recommended that both qualitative and quantitative goals be set prior to producing design solutions, the study's goal of designing useful cartographic UI components, as opposed to developing a fully functional system, made it difficult to initially define quantitative usability measures. Furthermore, in keeping with the qualitative focus of the study, it was the researcher's belief that the preliminary design and evaluation activities would be best served through concentration on the qualitative aspects of the cartographic interface, with the outputs of the evaluation then expected to aid in the formulation of a small set of quantitative usability goals for the next design iteration (this was also supported by the selected evaluation approach – see Section 8.2.2). For these reasons the usability goals described below are qualitative only.

7.2.1 Qualitative usability goals from the User Profile

In formulating the complete list of qualitative usability goals for the research, the first step was to revisit the user profiling outcomes, comprising a range of user characteristics summarised in Table 5.6. The design model implications listed alongside each characteristic proved the most logical place to source the goals and, along with supplementary results from the user task analysis

– many of which were aimed at specifically addressing gaps in the User Profile (see Section 6.5.7) – yielded the following high-level qualitative usability goals for the cartographic design:

1. individual users' (incl. male vs. female) different approaches to and abilities with geospatial tasks must be accommodated (e.g. geospatial experience and knowledge, need to reorient maps, orientation awareness, memory of routes, route formats);
2. visual components communicating geospatial information must be optimised for users with colour blindness and/or difficulty seeing fine detail;
3. access to geospatial information must be self-explanatory, while being easy to learn and remember (for new and moderate-use users);
4. access to geospatial information must accommodate frequent users who rapidly become familiar with the interface, developing different information access requirements;
5. different levels of geospatial information detail must be provided, most importantly at the local-level (e.g. landmarks, weather, attractions, activities, events);
6. the currency, accuracy and quality of the geospatial information represented should be maximised, and conveyed where known;
7. geospatial information should be tailored to increase its relevance to individual users;
8. map characteristics that commonly cause difficulties for members of the user group should be avoided (see Section 6.5.7.4);
9. disparate geospatial information must be seamlessly presented.

7.2.2 Qualitative usability goals from the user task analysis

The second and final step in defining the qualitative usability goals involved referring to the outcomes of the user task analysis in order to derive goals more closely associated with specific user goals/tasks and environments of use. Beginning with the former, a set of five goals was drawn directly from the AND/OR graphs in Figure 6.5 to Figure 6.9, comprising users' **action-based goals** and associated <u>high-level tasks</u>:

1. The user may employ the system to <u>identify and compare potential destinations</u>, based on the <u>destinations' relative accessibility</u> factors, enabling them to **select a holiday destination**;
2. The user may employ the system to <u>find out local-level detail</u> about a place and/or <u>determine what is in their immediate area</u>, in order to **obtain an overview of the location**[1];
3. The user may employ the system to <u>identify and compare potential lodgings</u>, based on the <u>lodgings' relative characteristics and accessibility factors,</u> enabling them to **find suitable accommodation**;

[1] Based on its description in Section 6.5.5.2, a third high-level task for this goal – 'Explore the location' – was deemed irrelevant to the design models and so was excluded from the remainder of the research.

4. The user may employ the system to identify and compare potential routes, based on the routes' relative characteristics and accessibility factors, enabling them to **determine a route** to follow; and
5. The user may employ the system to identify, select (and potentially schedule) pursuits, based on the pursuits' relative characteristics and accessibility factors, enabling them to **find things to do / of interest**.

Turning then to the physical, social and cultural environment of use (Section 6.5.8), a final set of qualitative usability goals for the cartographic UI design models was determined, comprising:

1. the incorporation of, and ready access to, necessary support information (e.g. help, user guides) – mobile users do not want to carry manuals with them;
2. auditory outputs should not be used in isolation from other representation forms – the service may be operated within a range of noise levels, with sound output being inappropriate and/or difficult to hear at times;
3. screen-based elements must be viewable in bright (day) to low (night) light levels;
4. the user should not be unduly distracted from the surrounding environment;
5. clear, non-technical language must be employed, incorporating the users' own terminology, where possible; and
6. representations must be universal and non-offensive.

7.2.3 Prioritising the usability goals

As stated above, the final step in usability goal setting is to prioritise defined goals according to their importance to the design. Indeed, while the complete list of qualitative usability goals provided comprehensive guidelines for formulating and evaluating the cartographic design for the research, as Mayhew (1999) identifies, "it is easy to enumerate a long list of generic and specific usability goals for a project but often very difficult to achieve them all" (pp.135-6). Therefore a classification is appropriate whereby those goals which **must** be satisfied in order to ensure the success of the design are given the highest priority, whilst those which are important, but not mandatory to the design are given the lowest priority. The number of priority levels and their individual definitions are generally related to the end product of the UCD process, however with this stage of the research focused on preliminary, qualitative aspects of the design, it was deemed more appropriate for the time being to classify the set of goals as simply either: (1) directly applicable to the preliminary design; or (2) indirectly (and thus less) applicable to the preliminary design. Furthermore, the classification process was postponed until the aims of the initial design and evaluation iteration were established (Section 7.3.1) and its scope set (Section 7.3.2), so that the prioritisations would be more informed.

7.3 Preparation for Design

7.3.1 Aims

According to Hackos & Redish (1998), not enough is known "about translating the outcomes of [Pre-Design activities] into specific designs to arrive at an optimal design on the first attempt" (p.347). It is logical then, to think of the design process as one of continual exploration and evolution which may begin with something quite rudimentary, but ends with a final 'product' satisfying each of the defined usability goals. With this in mind, the aims of the preliminary design (and its subsequent evaluation) activities were carefully considered and defined, resulting in a largely exploratory focus:

- **(a)** evaluate initial (qualitative) conceptual models of the users' goals, tasks and requirements;
- **(b)** trial and compare a preliminary selection of alternative design techniques for representing, presenting and interacting with geospatial information; and
- **(c)** commence the specification of cartographic UI design models for a DHR travel mLBS.

In keeping with the principles of UCD, the high-level approach planned for satisfying these aims was to: (1) generate design ideas; (2) build these into a prototype; and (3) test the prototype/design. Furthermore, it was decided to incorporate elements of *participatory design*, which is described by Nielsen (1993) as the involvement of users in the design process "through regular meetings between designers and users" – the justification being that even after extensive pre-design activities, "one still cannot know the user sufficiently well to answer all issues that come up in doing the design" (p.88). Whilst formal participatory design techniques effectively make representative users *part of* the design/development team (Namioka & Rao 1996; Rubin 1994), it was decided (considering the scope of the project) to forgo this, and instead limit potential end users' involvement to the *evaluation* of the completed preliminary design/prototype. This is an acceptable approach based on recognition that full benefit from the involvement of representative users is gained by presenting them with potential design solutions in an understandable form for their feedback (Nielsen 1993), such as in a prototype evaluation.

7.3.2 Scope and approach

Before beginning the physical design process, the scope and approach of the development efforts had to be set, including the classification of qualitative usability goals relevant to this stage of the research. The first of the preliminary design aims was the driver for this, requiring that the design embodied the conceptual models of the users' goals, tasks and requirements. This initially set the design scope to coverage of the components included within the AND/OR graphs produced during the user task analysis (reflected in the first five usability goals of Section 7.2.2), namely those relating to the action-based goals: 'Select Destination(s)'; 'Obtain overview of location(s)'; 'Find suitable accommodation'; 'Determine route'; and 'Find things to do / of interest'. From here, scope refinement was undertaken to (a) address established user requirements, (b) maintain the overall research scope, (c) minimise duplication of effort and (d) provide greater focus for the design, thereby allowing more in-depth analysis of the results.

First, the goal 'Select Destination(s)' was excluded from the design based on results from the user profiling and user task analysis (see Section 6.5.7.3) which indicated that the target user group expected to find the proposed mLBS most useful during their 'on-trip' decision-making, preferring instead to employ the desktop Web during their 'pre-trip' planning. Since destination selection is primarily a 'pre-trip' activity (as evidenced by the user data), it was therefore considered out-of-scope. Second, it was concluded that, since the goals 'Find suitable accommodation' and 'Find things to do / of interest' involved very similar conceptual models (i.e. geospatial tasks and information requirements), their achievement would likely involve similar sequences of action and cartographic representation forms. Therefore it was considered unnecessary to produce detailed design models for both, with 'Find suitable accommodation' subsequently excluded from the design. Finally, the goal 'Determine route' was reduced to playing only a minor role within the design based on a decision to exclude route guidance representations from the cartographic UI design models. The justification for this concerned the considerable body of research already concentrating on representation, presentation and interaction techniques for route selection and guidance in both vehicle navigation systems (Section 3.3.3) and for pedestrian navigation (refer to the case studies documented in Section 3.3.1 and other research projects cited throughout Section 3.2.2). Therefore, in the interests of breaking new ground with the current research, it was deemed inappropriate to make this goal a focus of the design; however pathways to achieving this goal were considered important and were thus incorporated. This left a much-limited, yet more manageable scope for the preliminary design (and the remainder of the research) comprising a focus on just three goals: **Obtain overview of location(s)**, **Find things to do / of interest** and, to a lesser extent, **Determine route**. The first goal, in particular, was considered of paramount importance to the design models based on the user task analysis results which identified that obtaining a location overview was a common starting point for users, often leading onto tasks related to each of the other goals.

The approach for undertaking the design was based on the set of scenarios developed alongside the aforementioned AND/OR graphs during the user task analysis (as recommended by Mayhew 1999). Through their description of specific usage episodes for, and paths through the conceptual models, the scenarios were intended to provide guidance for developing (and later evaluating) the cartographic UI design models, constituting an approach known as *scenario-based design*, which offered numerous advantages such as:

- raising questions for the design to address;
- evoking empathy for users in a situation of use;
- emphasising the dynamic flow of activity during the final system's use;
- concretely fixing an interpretation, while being open-ended and easily revised, thus helping to manage the "fluidity of design situations";
- evoking reflection in the context of design activity, helping to coordinate design action and reflection; and
- affording multiple views of an interaction, helping to manage the many consequences of a given design decision. (Carroll 2000, pp.38-9)

Revisiting the five scenarios (Section 6.5.6), it soon became evident that not all were relevant to the newly established scope. In particular, scenarios 2, 3 and 5 were focused on achieving goals which had since been excluded from the design (see above). Therefore, it was resolved to set these aside and thus base the design activities chiefly on Scenarios 1 and 4, which together addressed the design scope:

Scenario 1

Lisa and her family have been staying at a friend's lakefront timeshare in Lakes Entrance for almost a week and have decided to spend their last day driving around and doing a few things in the wider area. She uses the Holiday Assistant to identify a number of activities to do in the region …

Major Goals: Find things to do / of interest, Determine route.

Geospatial Information: routes, events, locations, itinerary.

Scenario 4

Kevin has been sent to Perth by his company for a couple of weeks, and it's a city he's never been to before. He's thinking of taking his family along on his next, inevitable visit and making it into a holiday for them …

Major Goals: Obtain overview of location(s), Find things to do / of interest.

Minor Goals: Determine route.

Geospatial Information: location layout, current location, orientation, landmarks, routes.

Again to provide greater focus and thus allow more in-depth analysis of results, the decision was made at this point to further narrow the scope by selecting just one scenario upon which to base the design. Ultimately *scenario four* was selected, due to its incorporation of both 'Obtain overview of location(s)' and 'Find things to do / of interest' as major goals and 'Determine route' as a minor goal. Despite this scenario relating to only one of the four defined personas (Section 6.5.3), those remaining were not disregarded, with each 'consulted' throughout the design process to ensure that the end result satisfied their individual goals and needs. In fact, at this point it was considered beneficial to make the scenario neutral (i.e. removing the persona's name) so that the design could proceed independently. After 'neutralising' the scenario, its form was thus:

Preliminary Design Scenario

You have been sent to Perth by your company for a couple of weeks and it's a city you've never been to before. You're thinking of taking your family along on your next, inevitable visit and making it into a holiday for them, so you maximise your non-work time and get to know the city and surrounding area as preparation. You start by using the Holiday Assistant to find out as much detail as possible about Perth, starting with a general summary and then moving onto the layout of the area as well as nearby activities that you think your family would enjoy doing. You also decide to explore the town on foot, so that you can form a mental map of it, venturing out from your hotel during your free time, walking around the main streets and shopping strips. After a particularly long Sunday afternoon walk, you become disoriented and realise that you don't know where you are in relation to your hotel. You look around but can't see any street signs, nor people to ask for directions. You pull out the Holiday Assistant which tells you your current location with respect to a number of recognisable landmarks. You then ask the service to guide you back to your hotel.

✧ ✧ ✧ ✧

With the aims, scope and approach of the preliminary design activities now determined, the qualitative usability goals detailed in Section 7.2 could be prioritised, with the outcome presented in Table 7.1. As discussed in Section 7.2.3, each goal was to be classified as either 'directly applicable to the preliminary design' or 'indirectly applicable to the preliminary design'. The essential differentiating factor was whether or not a usability goal's satisfaction was specifically **required** in order to achieve the preliminary design aims (including whether or not it supported the preliminary design scenario). Therefore once prioritised, achieving each Priority 1 (P1) goal was integral for: (a) evaluating the conceptual models of the users' travel-related goals, tasks and requirements; (b) trialling and comparing a number of alternative design techniques for representing, presenting and interacting with geospatial information; and (c) commencing a cartographic UI design model specification. In contrast, Priority 2 (P2) goals were deemed to play an important, but more ancillary and/or supportive role in achieving the preliminary design aims, and were therefore anticipated for consideration only after all P1 goals had been addressed and/or during the next design phase.

Table 7.1 The prioritised qualitative usability goals.

P1 – directly applicable to the preliminary design	
Relevant to design aim (a) – conceptual model evaluation	
A	user may employ the system to obtain an overview of a location
B	user may employ the system to find things to do / of interest
C	user may employ the system to determine a route
Relevant to design aim (b) – alternative representation, presentation and interaction forms	
D	individual users' different approaches to and abilities with geospatial tasks accommodated
E	different levels of geospatial information detail to be provided
F	map characteristics causing difficulties for members of the user group to be avoided
G	auditory outputs not to be used in isolation from other representation forms
H	clear, non-technical language to be employed
I	representations to be universally non-offensive
J	visual components optimised for users with colour blindness and/or difficulty seeing fine detail
P2 – indirectly applicable to the preliminary design	
K	geospatial information access to be self-explanatory, while being easy to learn and remember
L	geospatial information access to accommodate frequent users
M	incorporation of, and ready access to, necessary support information
N	geospatial information tailored to increase relevance to individual users
O	disparate geospatial information to be seamlessly (re)presented
P0 – beyond the design scope	
P	user may employ the system to select a holiday destination
Q	user may employ the system to find suitable accommodation
R	the currency, accuracy and quality of the geospatial information represented should be maximised and conveyed
S	screen-based elements to be viewable in bright-to-low light levels
T	user should not be unduly distracted from the surrounding environment

Of final note is the third priority level included in Table 7.1 (P0), which was created to house those goals considered as being beyond the design scope altogether. It is pertinent to provide here some brief justification for making each P0 classification:

P – Excluded from the design due to being a pre-trip activity (see above discussion).

Q – Excluded from the design due to its similarity to B (see above discussion).

R – Data sourcing was considered beyond the scope of the research.

S – Device-dependent / unable to be adequately tested within the scope of the research: neither multiple devices (Section 7.3.4.1) nor field testing (Sections 8.2.2.1 and 10.2.1) were incorporated.

T – Unable to be adequately tested within the scope of the research: field testing was not incorporated (Sections 8.2.2.1 and 10.2.1).

The discussion in Section 7.4 highlights when and where the various usability goals were applied throughout the design (designated by the notation **ug*L***). Note that, while the focus of the design efforts was placed on achieving the P1 usability goals, attention to some P2 goals was also required, mostly due to their supporting nature.

7.3.3 Design specification

Design specifications can take on many forms, including metaphors, (essential) use cases, use scenarios, use sequences, use flow diagrams, content models, use workflows, use hierarchies, navigation maps, sketches, dramatisations and UI prototypes (Hackos & Redish 1998; Constantine 2000). Whilst the literature provides various recommendations for producing designs, it is clear that the process ultimately followed depends upon the nature of a given project – i.e. there is no single best procedure. As detailed above, the current research had, to this stage, already produced a number of design documents in the form of a user profile, conceptual models (AND/OR graphs), scenarios and personas, however a tangible design specification remained outstanding. Considering the exploratory aims and scope of the preliminary design activities, in particular their emphasis on enabling the comparison of alternative cartographic representation, presentation and interaction techniques for a single scenario, it was decided that the most appropriate course of action would be to specify the design through the development of a prototype.

Prototypes are "artefacts that simulate or animate some but not all features of the intended system" (Dix *et al.* 1998, p.205). It is generally accepted that prototyping is a necessary part of the iterative design and evaluation process, enabling the exploration of numerous evolving design concepts in rapid time and at low cost, prior to final product implementation (Dix *et al.* 1998; Nielsen 1993; Rubin 1994). During the early stages of the design process, experts recommend the use of *low-fidelity* prototypes that support rapid redesign, often make use of mediums other than the final delivery platform (e.g. paper-based mock-ups) and compromise on one or more of the following (with respect to the final product): breadth of features (vertical prototyping); degree of functionality (horizontal prototyping); similarity of interaction; and aesthetic refinement (Virzi *et al.* 1996; Nielsen 1993; Maguire 2001; Liu 1997). Progressively *higher-fidelity* prototypes are favoured later in the design cycle (Nielsen 1992; Maguire 2001), these being much closer to the final product implementation in terms of platform, breadth, functionality, interaction and aesthetics. Although their primary purpose is to embody the design in a form that can be easily evaluated by representative users (Nielsen 1992), prototypes may additionally serve to enable the exploration of design ideas whilst encapsulating the design specification itself (Nielsen 1993; Mayhew 1999) – this being the case for the current stage of the research.

A number of techniques available for prototyping are defined in the literature, ranging from *storyboards* – non-functional graphical mock-ups of the UI – to *limited functionality simulations* – mimicking the system's intended functionality, including interactivity – and *high-level programming support* – much closer in behaviour, form and function to the final product (Dix *et al.* 1998; Maguire 2001). Ultimately, a limited functionality simulation was chosen for the prototyping since, given the resources available, it was expected to be the most rapid and efficient technique for prototype development and revision, throughout the iterative design and evaluation phase. Furthermore, the decision was made to follow an *evolutionary* prototyping approach – whereby the prototype becomes the basis for the next design iteration, with the final product evolving from a limited, initial version to its final release (Dix *et al.* 1998). Whilst other approaches were available (e.g. *throw-away* [2] and *incremental* [3] prototyping), this was considered the most appropriate method, based on the aims and scope of the preliminary design. The following section describes the platform on which the prototype was built.

7.3.4 Platform capabilities and constraints

At this point it was necessary to complete one of two remaining pre-design components of the research plan and thus select the technological platform for the DHR travel mLBS, in order to define the scope of possibilities for the design. The decision was made to relate this primarily to the prototype used to specify and evaluate the cartographic UI design models, as opposed to the end product, since the research was focused on developing and assessing useful design models rather than a fully functional system (which was beyond the scope of the study). In light of this it may be argued that the ultimate usefulness of the design models is dependent on the final delivery platform. It has been recognised, however, that the ideal situation for UCD involves generating an optimal design based on established user requirements and only then selecting a hardware/software platform that supports and facilitates development (Mayhew 1999) – which was indeed possible for the research, possessing none of the organisational and/or political

[2] *Throw-away prototyping*: the design knowledge gained from iteratively building/revising and testing the prototype is fed into the final product, but the prototype itself is ultimately discarded (Dix *et al.* 1998).

[3] *Incremental prototyping*: the final product is built and tested as separate components, one by one; the final product is released as a series of products, each containing an additional component (Dix *et al.* 1998).

constraints that generally prevent this from occurring in a commercial product. Furthermore, with an evolutionary prototype planned and a detailed knowledge of the technical constraints impacting mLBS (Section 2.4.2), the similarity of the prototype's development environment to the end usage platform meant that the eventual usefulness of the models would not be compromised.

7.3.4.1 Device selection

A number of decisions were made with respect to the prototype's technological platform, largely focusing on the interaction/presentation device, for which six generic requirements were determined (listed here in order of importance):

1. *Highly mobile* – it must be easily taken anywhere without being obtrusive and cumbersome;
2. *Able to be wirelessly connected to the mobile Internet* – for eventual access to online content and server-side processing;
3. *Locatable* – it must ultimately be possible to determine the physical position of the user, e.g. via mobile phone networks and/or GPS, to an appropriate level of accuracy;
4. *Accessible* – in terms of low cost and high availability;
5. *Interactive and multimedia-capable* – in terms of the UI, to capitalise on the offerings of Multimedia Cartography; and
6. *Useful* – the utility and usability of the technology itself.

As shown in Section 2.3.1.3, the range of portable technologies potentially relevant, and currently available, to the research could be categorised as: tablet computers, palmtop computers, data- or voice-centric Personal Digital Assistants (PDAs), 'basic' mobile phones, SmartPhones and dedicated, custom-built devices. Considering the first four requirements together – a *mobile*, *connected*, *locatable* and *accessible* solution, preferably within a single device – all but the voice-based communication technologies were eliminated. Whilst palmtop and tablet computers are 'portable', they cannot be considered truly 'mobile' considering: (a) their substantial weight relative to other devices and/or (b) their preferable use resting on a flat surface, which makes them unsuitable for 'on the move' operation (Weiss 2002). Although highly mobile, data-centric PDAs require external devices (e.g. a mobile phone) in order to connect to the mobile Internet through one of Australia's wireless radio networks (e.g. GSM/GPRS, CDMA, W-CDMA[4]), thus they were not ideal solutions. Moreover, at the time the platform was being selected, most available devices required an additional auxiliary device (e.g. a GPS receiver or mobile phone) to

[4] Refer to Section 2.3.1.4 for an explanation of these terms and wireless radio networks in general.

receive/transmit positions, again making this technology an unsuitable choice[5]. In terms of accessibility, to reduce the impact of cost on the usefulness of the geospatial information services at the centre of the research, it was preferable to make use of available technology (of a modest price) which the end users may either already possess, or else could justify purchasing on the basis that they could use it for other common activities (e.g. voice communication, organiser, etc.). Hence, dedicated, custom-built devices were also considered inappropriate.

Concentrating on the *interactivity and multimedia capabilities* of the technology platform, Table 7.2 lists those device types not yet eliminated from consideration, along with their distinguishing features and methods for content presentation. Feature-rich voice-centric PDAs and SmartPhones each have greater sophistication and flexibility than basic mobile phones in terms of multimedia presentation and interaction techniques. Not only are their screens larger, with higher resolutions and more colours, these 'computer-enabled' devices also feature sophisticated mobile development environments that provide for the creation of custom, native applications that can make use of the specific device's multimedia features in new and innovative ways. Furthermore, whilst most basic mobile phones access the mobile Internet using a text-based WAP browser, in general PDAs and SmartPhones provide an experience more akin to a desktop Web portal, incorporating graphics and UI widgets (e.g. drop-down menus, buttons, text entry fields). Considering all of this, it was deemed appropriate to exclude the basic mobile phone platform.

Table 7.2 Potential device types for the research.

Development Environments	Content Presentation	Common Features
Basic Mobile Phone		
• Limited run-time environments (e.g. BREW®, J2ME™)	SMS, MMS Email WAP i-mode HTML/XHTML Server-side applications	• Voice communication • Contact management • Camera – photo, video (some devices) • Messaging (SMS, MMS) • Mobile Internet • Vibration • Small screen, low-medium resolution • Keypad input

5 Since the time when the technology platform was selected, various PDAs and SmartPhones embedded with GPS receivers have become readily available (e.g. Mio A701, i-mate K-Jam). While these were too late to be of benefit to the research, such advancement in handheld device technology bodes particularly well for future mLBS applications.

Table 7.2 (cont.) Potential device types for the research.

Development Environments	Content Presentation	Common Features
Voice-Centric PDA		
• Palm OS® SDK • MS Windows Mobile™ Pocket PC Phone SDK • Java™ Platform	Email Web Portal Native (client-side) applications	• Personal Information Management • Messaging (IM, Email) • Mobile Internet • Full operating system • Software, custom applications • Desktop synchronisation • Large screen, high resolution • Touch screen input • Voice communication • GPS receiver (selected newer devices)
SmartPhone		
• Palm OS® SDK • MS Windows MobileTM SmartPhone SDK • Symbian OSTM • Series 60 SDK • UIQ SDK • JavaTM Platform	SMS, MMS Email WAP I-mode Web Portal Native (client-side) applications	• Voice communication • Personal Information Management • Camera – photo, video (most devices) • Messaging (SMS, MMS, IM, Email) • Mobile Internet • Full operating system • Software, custom applications • Desktop synchronisation • Vibration • Medium screen, medium-high resolution • Keypad/keyboard input • Touch screen input (certain devices) • GPS receiver (selected newer devices)

Thus the decision was reduced to voice-centric PDAs versus SmartPhones. Even with the information listed in Table 7.2, the difference between these two technologies is not immediately clear. Each has computer-enabled capabilities – a full operating system (OS), application development platform, information management, powerful processor, Web browser – and voice communication. Moreover, many share common development environments (e.g. Palm OS, MS Windows Mobile). According to Peng and Tsou (2003), the main differentiation is in their respective form factors, including size and input method (refer to Figure 7.1). Traditionally, PDAs are 'pocket-sized' while SmartPhones, like basic mobile phones, can be held and operated with one hand. This translates directly to an associated difference in screen size (favouring PDAs). In terms of input, the PDA generally possesses a touch screen interface, often incorporating a virtual *qwerty* keyboard and/or handwriting recognition. Again, like mobile phones, SmartPhones enable input via a physical keypad. In reality, however, the distinction is not this simple with new and emerging SmartPhones continually blurring the line between the two technology platforms; one example of this is the i-mate K-JAM SmartPhone (promoted as both a mobile phone and a PDA), which features a large touch screen **and** a physical keyboard/keypad for input.

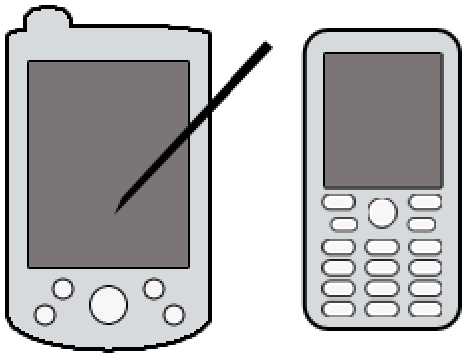

Figure 7.1 General difference in appearance between (a) a PDA and (b) a SmartPhone.

Given the multimedia-based similarities between voice-centric PDAs and SmartPhones it was envisaged that, regardless of the selection for the research, the final cartographic UI design models would be applicable to either platform. Nonetheless, a decision was required for the prototype and essentially came down to the sixth and final technology platform requirement – *usefulness*. At the time the platform was being selected, a worldwide decrease in sales of **data**-centric PDAs had been observed, directly attributable to an increase in SmartPhone sales (ITMarketer 2003). Furthermore, market analysts predicted this trend to continue (canalys.com 2004), amid speculation that users "don't want to carry two separate devices to manage their personal contacts and make phone calls" (IDG News Service 2004) – the latter being evident in the user task analysis data (Section 6.5.7.3). This was augmented by the expectation (and has since been observed fact) that SmartPhones would continue to decrease in cost over the coming years (International Developer Magazine 2004), likely becoming more affordable than PDAs. It appears then that users see greater utility in SmartPhones and, following on from this, **voice**-centric PDAs, which have also experienced growth, but continue to be outsold by SmartPhones (by almost 20-1 in Europe, the Middle East and Africa during 2003 - canalys.com 2004). Comparing the market drivers, SmartPhones can be seen as capitalising on the (largely consumer-based) mobile telephony market while voice-centric PDAs are driven by enterprise and professional markets (gizmag 2003; canalys.com 2004). This is justified by the form factor variation (Figure 7.1), as well as another major difference between the device types: originally developed as portable computers, PDAs are superior in their processing power and generally have greater functionality than SmartPhones (SmartHouse Magazine 2004; The Age 2003). In terms of usability, it is impossible to claim that one type of device is more usable than another, due to the wide variety of devices available within each category.

Considering all of the above information and the consumer focus of the target user population, the *SmartPhone* was selected as the hardware platform for the prototype. While made in isolation from the user profiling, this decision was supported by its results – which indicated that the target users were more familiar with the operation of mobile phone-like devices compared with PDAs (see Section 5.5.2.3). Furthermore, this selection catered to most (if not all) of the device-related conditions specified by users during the user task analysis – e.g. intuitive use, practical size, "all-in-one" functionality, useful on an everyday basis (Section 6.5.7.3). This was not the endpoint of the selection process, however, with a number of application development platforms/languages (and corresponding devices) available, including:

1. Palm OS (C /C++) [6, 7];
2. MS Windows Mobile SmartPhone SDK[8] (Visual Studio .NET or eMbedded C++) [9, 10];
3. Symbian OS Series 60 SDK (C++);
4. Symbian OS UIQ SDK (C++);
5. Java Platform (J2ME) [11]; and
6. XHTML Mobile Profile (XHTML-MP).

Since the research was focused on the development of cartographic UI design models using a prototype, and not on the creation of a fully functional system, any one of these platforms was suitable for the study. Hence there was no 'most appropriate' choice, with the selection falling instead to maximising the efficiency and effectiveness of the development environment with which to demonstrate and evaluate the research concepts. With this in mind, the suitability of developing on each of the platforms was considered in terms of: (a) the availability of resources within the industry partner Webraska, and hence the support available within the company; and (b) the principal researcher's existing skills and experience. Dealing with the first factor, Webraska had current personnel experienced in the Windows Mobile SmartPhone SDK and the Java Platform, with additional skills in C and C++ programming, HTML/XHTML and JavaScript; however there existed little knowledge of the Palm and Symbian development environments within the Australian office. Looking to the second factor, the researcher's existing skill set consisted of HTML/XHTML, as well as some JavaScript, Visual Basic, C programming

6 C – a programming language developed at Bell Laboratories in the early 1970s as a system implementation language for the Unix OS.
7 C++ – an object-oriented extension of the C programming language, developed between 1983 and 1985.
8 SDK – acronym for 'Software Development Kit'.
9 Visual Studio .NET – a comprehensive, multi-language Web development tool.
10 eMbedded C++ – a streamlined version of C++, omitting the larger features that are not as desirable for embedded applications (e.g. mobile phones, printers, cameras, televisions, VCRs, other appliances).
11 J2ME (Java 2 Platform Micro Edition) – a software-only development platform, comprising a Java virtual machine and the Java programming language, targeted at consumer and embedded electronics.

and Java. It did not include any exposure to C++, J2ME, Visual Studio .NET or embedded programming. Following discussions with Webraska personnel, the decision was made to develop the prototype using the XHTML-MP (based on XHTML). This was believed to be the most time-efficient option, based on the researcher's existing skill set – i.e. as opposed to learning an entirely new application development environment.

At this point, only the selection of the actual device remained, with numerous SmartPhone models available in Australia at the commencement of the design phase (note, being a *simulated functionality* prototype, it was not necessary at this stage to select a wireless network or positioning technology for specifying/evaluating the design). The final choice was made based on the presence of a browser supporting the XHTML-MP, input/output techniques being relatively familiar and/or intuitive (i.e. resembling a standard mobile phone as opposed to a PDA), the presence of a sizeable, high resolution screen and, ultimately, the availability of a suitable device[12]. The following section summarises the features of the selected SmartPhone – the i-mate™ SP5 – that were considered relevant to the design.

7.3.4.2 Hardware and software features

Before beginning the design process, it was important to identify the specific UI capabilities and constraints inherent in the selected platform and therefore define boundaries for the prototype's development. Beginning with the development environment, the operating system for the i-mate™ SP5 was identified as Microsoft Windows Mobile 5.0 SmartPhone Edition, which incorporated Internet Explorer Mobile as its Web browser. Together these supported version 1.1 of the XHTML-MP which, being a subset of XHTML, did not contain every aspect of the XHTML language. Therefore, in preparation for the design, the supported entities were identified and assembled for later reference (see Appendix C). Of particular note was the XHTML-MP's support of certain:

- Elements – e.g. BGSOUND, IMG, MAP, TABLE;
- Controls – including buttons, checkboxes, radio buttons and textboxes;
- Events and event handlers – specifically 'onload' and 'onclick';
- Scripting Languages – Microsoft Jscript[13] only; and
- External style sheets – specifically Cascading Style Sheets.

With the majority of the prototype's functionality simulated, the only other major platform consideration involved which of the device's input and output capabilities could be exploited for

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[12] The device itself was sourced through Tenzeng, a consultant to the research.
[13] Similar to JavaScript.

the design using the XHTML-MP. Upon some investigation it was found that, excluding vibration, each of the i-mate™ SP5's interaction facilities was available (at least to some extent) for incorporation into the prototype. Illustrated in Figure 7.2, these comprised:

- *Input tools*
  - Numbered keypad – enabling number and/or text entry (e.g. into textboxes) and number-based selection.
  - Joystick control – allowing screen navigation (i.e. scrolling) and selection.
  - Microphone – for voice input (note, this was ultimately simulated in the prototype).
- *Output tools*
  - LCD screen – a 2.2-inch 'transflective' display with 64,000 colours and 240×320 pixel resolution (i.e. QVGA); supporting various image formats (JPG, GIF, PNG, BMP and animated GIF) and video formats (MPEG, AVI).
  - Speakers – for sound output, supporting audio formats including WAV, MP3, AAC and WMA (note, Internet Explorer Mobile uses the Windows Media Player plug-in to play sound files).

Figure 7.2 Interaction tools for the i-mate™ SP5.

While additional platform constraints inevitably became apparent as the design progressed, knowledge of the aforementioned factors was deemed sufficient for commencing the design process. Prior to doing so, however, the final pre-design component of the research plan had to be addressed.

7.3.5 General design guidelines and principles

Since a major part of Iterative Design and Evaluation is the testing of UI designs by real users to ensure their utility and usability, these factors had to remain a focus throughout the design process itself. Whilst the qualitative usability goals (Table 7.1) were generated specifically for this purpose, it was important to also build on the experiences of other researchers by founding the design work on accepted UI and cartographic design guidelines and principles.

7.3.5.1 User interface design

Thousands of UI guidelines are available, ranging in detail from very general to narrowly focused, with most relating to design for desktop devices (Shneiderman & Plaisant 2005; Liu 1997; Nielsen & Molich 1990; Hoh & Thomas 2000). Numerous researchers have endeavoured to condense this proliferation into smaller, more manageable sets of usability principles considered "more fundamental, widely applicable and enduring" (Shneiderman & Plaisant 2005, p.66), while being less intimidating to designers and developers (Nielsen & Molich 1990). Most prominent of these are Donald Norman's seven principles for 'The Design of Everyday Things' (Norman 1990), Ben Shneiderman's 'eight golden rules' of interface design (Shneiderman & Plaisant 2005) and Jakob Nielsen's ten 'usability heuristics' (Nielsen 1993), each addressing similar fundamental design concepts. Based primarily on Nielsen's (1993) heuristics – with selected definitions supplemented by Shneiderman & Plaisant (2005) and Norman (1990) – the following list of UI design principles was adopted and consulted throughout the design phase:

1. **Simple and natural dialogue** – between the user and the system, maintaining the users' control (or appearance thereof) of the dialogue. The UI should be simplified as much as possible whilst matching the users' tasks, intentions and expectations in as natural a way as possible, also minimising the need for user navigation; "the ideal is to present exactly the information the user needs – and no more – at exactly the time and place where it is needed" (Nielsen 1993, p.116). Major considerations include:
    - Applying graphic design principles to assist users' understanding of the UI structure and for prioritising user attention; e.g. applying the gestalt rules for human perception to screen layouts – "things are seen as belonging together, as a group, or as a unit, if they are close together, are enclosed by lines or boxes, move or change together, or look alike with respect to shape, color, size, or typography" (Nielsen 1993, p.117).
    - Careful use of colour, including a maximum of five to seven different colours, non-reliance on colours (i.e. the UI should be usable in monochrome and by colour blind users) and the use of colour only for categorising, differentiating and highlighting, as opposed to 'giving' (quantitative) information.

- 'Less is more' for screen information content, features and interaction mechanisms, so as to avoid confusing novice users and/or slowing expert users down.

2. **Speak the users' language** – all terminology within the UI (including words and non-verbal elements, such as icons) should be based on the users' own language rather than technical terms and/or less precise everyday language. This refers not only to the users' native language, but also to any specialised domain terminology they may have. Furthermore, all interactions should be viewed from the users' perspective, for example: 'You have saved Perth to your destination list', rather than 'The destination Perth has been saved'.
3. **Minimise load on users' memory** – "a person should not be required to remember more than about five unrelated items at one time" (Norman 1990, p.191); i.e. the UI should not require users to unnecessarily remember, recall and/or guess at information that can be otherwise stored and retrieved by the system. For example, users may be presented with lists from which to make selections, requiring recognition rather than recollection; however care should be taken not to oversimplify and to match object visibility with user needs (as per #1) so that the salience of important information is not lost. Additionally, a small number of pervasive rules should be applied throughout the UI to reduce load on users' memory of system behaviours, whilst tasks should be structured such that they minimise the need for planning or problem solving.
4. **Be consistent** – "If users know that the same command or the same action will always have the same effect, they will feel more confident in using the system" (Nielsen 1993, p.132). User recognition of the information they require is aided by presenting the same information in the same location (i.e. layout) and with consistent formatting (i.e. colour, capitalisation, fonts) throughout the interface. Similarly, consistency is also important for system functionality, particularly in sequences of actions/outcomes for related tasks.
5. **Provide informative feedback** – both positive and negative, in clear and specific terms, for every user action so as to apprise them of the system's current state and to show how input is being/has been interpreted. Particularly important situations for providing feedback include: at the completion of a group of actions; during lengthy operation-response times (>10 seconds); for 'too fast' system responses; and when system failure occurs.
6. **Provide clear exits and action reversal** – offering users a highly visible and "easy way out of as many situations as possible" (Nielsen 1993, p.138). This will reinforce the user's feelings of control over their dialogue with the system by making it possible and simple to recover from any errors they make, whilst encouraging them to explore unfamiliar options. Exits may be provided to 'cancel' an operation in progress or they may take the form of an 'undo' function, in each case returning the system to its previous state.

7. **Provide shortcuts** – for frequent users to speed up their interaction with the system. Examples include: abbreviations; special command keys; double-clicking to perform common operations; universal buttons for direct access to important functions; user-defined 'bookmarks'; and access to user interaction histories (such as via a 'back' button).
8. **Provide good error messages** – which are: (1) clearly phrased in human-readable language (i.e. no obscure codes); (2) specific; (3) constructive, offering advice to help the user in solving the issue; and (4) polite, being non-intimidating or blaming the user. In line with principle 6, the UI should also facilitate error recovery.
9. **Plan for errors** – preventing them from occurring, wherever possible; e.g. to remove the risk of spelling errors, make the user select an item from a list rather than typing in its name. Where errors cannot be eliminated, their frequency should at least be reduced (e.g. requiring confirmation before performing a dangerous action) and error recovery enabled.
10. **Provide good help facilities** – in an appropriate form (e.g. printed manuals, online documentation), which guide basic system use as well as more advanced usage. Search and look-up of help materials should be task-oriented to assist users in finding the information they need quickly and efficiently. Online help should be context-sensitive.

As mentioned above, these generic design principles were primarily developed for larger, more traditional UIs – i.e. the desktop computing environment. Whilst also generally applicable to the mobile medium (Hoh & Thomas 2000), it was considered valuable to seek additional UI guidelines specific to mobile, handheld devices. Being a relatively 'young' field compared with desktop computing, few established collections of such principles exist, with most recommendations to be found within the results of independent research projects (Albers & Kim 2002). One exception to this is Scott Weiss' (2002) collection of 'UI Design Guidelines for Handheld Devices' – the culmination of 12 years experience in designing applications for handheld devices. Presented below, it is important to highlight the overlap between many of Weiss' (and others') principles, and those listed above.

11. **Design for users on the go** – users of handheld devices typically have immediate goals (being limited in both time and attention) so will likely want to perform instantaneous search and retrieval tasks, as opposed to information browsing.
12. **'Select' vs. 'type'** – text entry (via a keyboard/pad, handwriting recognition or other) is often difficult using a handheld device, therefore selection mechanisms may be offered instead of, or in addition to, text input, as appropriate.
13. **Be consistent** – [equivalent to 4] use of consistent terminology and interaction schema within/between applications will reduce the user's learning curve for new features.

14. **Imply user control** – [encompassed by 1] "provide the *illusion* that the user is in control" (p.68), for example by anticipating how the user will act on information and designing for this.
15. **Design Stability** – build safeguards into the design so that information is not lost when, for example, a network connection fails (i.e. the application state and context should be restored once the connection resumes).
16. **Provide feedback** – [equivalent to 5] UI screens should provide sufficient information (or else a clear path to such) about the system and current navigation options.
17. **Forgiveness** – [equivalent to 6] the UI must offer action reversal so that user errors may be easily rectified.
18. **Use metaphors** – from the real world (e.g. bookmarks) to assist users' learning and ease their adaptation to new applications (supplemented by Hoh & Thomas 2000).
19. **Clickable graphics should look clickable** – with defined borders and/or high contrast with the background; the opposite is true for static, non-linked graphics.
20. **Use icons to clarify concepts** – these can provide additional assistance to users.

In addition to these, some of the more ad hoc mobile design guidelines[14] that were followed during the design process include:

21. **Provide direct access** – [equivalent to 11] "small screen users seem to choose and prefer direct access strategies over less directed, browsing approaches"; direct search mechanisms, for example, should be provided, whilst information should be structured to provide focused navigation (Jones *et al.* 1999, p.1136).
22. **Reduce scrolling** – which can interrupt the user's primary task; this may be achieved through: fixing navigational features near the top of each page; placing key information at the top of the page; reducing/focusing the content of each page (Jones *et al.* 1999).
23. **Minimise navigation** – [encompassed by 1] by providing the information required by the user where and when it is needed, on a single page (Holtzblatt 2005).
24. **The page is the UI** – it is important to use a standard page layout which will support quick and personal scanning for information (Holtzblatt 2005).
25. **Consistent interface** – [equivalent to 4 and 13] "support consistent behavior within and across platforms" (Holtzblatt 2005, p.229) and within applications (e.g. shortcuts, feedback, look and feel, text entry), to better support users' ease of learning, recognition and recall (Hoh & Thomas 2000).

[14] Largely related to mobile Web design.

26. **Organise information by intent** – [encompassed by 1] information should be collected and presented together so as to address a specific intent / user goal (Holtzblatt 2005).
27. **Just-in-place information** – change the content in line with changes in context (e.g. spatial, temporal, task, activity); "simplifying the user interface on the basis of context reduces demands for user interaction and contributes to less required attention" (Kjeldskov 2002, p.275).
28. **Provide feedback and visibility of system status** – [equivalent to 5 and 16] to apprise users of the results of their actions; "for a device that can be used anywhere and at anytime, having auditory feedback is especially important" (Hoh & Thomas 2000, p.190).

Alluded to above, it is evident that there is a great deal of overlap (in terms of issues addressed) between many of the design principles adopted for the research, with numerous guidelines directly or indirectly affecting one another. Noting this and the subsequent need to avoid treating each principle as a separate entity, Hoh & Thomas (2000) advocate "a well integrated, and wholly formulated approach to design [for handheld, mobile devices] because of the limitations of size, display, and input methods" (p.191). This research has followed such recommendations by taking a holistic approach to the design process, as evidenced by the discussion in Section 7.4, which highlights when and where the design principles were applied (designated by the notation **DP*n***).

7.3.5.2 Cartographic design

Of equal, if not greater importance to the development of the cartographic UI design models was an adherence to cartographic design rules, an established set of which were available, albeit largely formulated for conventional printed maps. Whilst it is true that such guidelines "cannot be automatically applied" (Cartwright 2003, p.50) to other mapping genres (e.g. digital computers, the World Wide Web and the Mobile Internet) it may be argued that, at least in a general sense, each of the fundamental cartographic rules remains more or less applicable to the design of cartographic representations – in particular 2D (and potentially 3D) maps – within more contemporary communication mediums, and thus they should be considered by the research. Below is a brief conceptual overview of the map-based cartographic rules consulted throughout the design phase, drawn largely from a classification provided by Miller (1996), which was based on an extensive review of the cartographic literature.

ABSTRACTION[15]

1. **Selection** – making decisions, based on a map's purpose, presentation format and the intended user, about:

[15] The term 'cartographic abstraction' was originally suggested by Muehrcke (1978). In addition to selection and generalisation, abstraction also involves the process of dimensional transformation (i.e. scaling and projection).

- area coverage
- scale
- projection
- measurement level
- data variables
-

2. **Generalisation** – modifying a map's features, in order to maintain clarity (according to scale and complexity) and context (according to purpose and intended user), through the application of various operations, e.g.:
    - simplification
    - collapse
    - displacement
    - classification
    - refinement
    - symbolisation
    - combination
    - exaggeration
    - typification

GRAPHIC DESIGN[16]

3. **Symbolisation** – designing functional and aesthetically pleasing symbols, based on a map's purpose, measurement level and geographical feature/concept dimensionality, through the manipulation of:
    - visual variables (Bertin 1967; Bertin 1983)[17]: *primary* – shape, size, orientation, hue (colour), value (colour), chroma (colour); and *secondary* – arrangement (pattern), texture (pattern), orientation (pattern)
    - colour – hue, simultaneous contrast, number of hues (maximum 8-15), value, progression of value, visual efficiency, connotations and conventions (e.g. blue: water, green: vegetation, brown: surface-related)
    - typography – text placement, spacing, type, size, weight, colour, style, legibility
4. **Visual composition** – arranging map components (under limitations imposed by presentation format and area coverage) so as to maximise functionality and aesthetic appeal, with the aim of creating balance, contrast and legibility.
5. **Marginalia construction** – providing functional context for a map, based on its purpose, presentation format, scale and measurement level, through the design of components such as:
    - legend
    - orientation
    - metadata[18]
    - scale
    - title

STRUCTURAL DESIGN[16]

6. **Figure-ground organisation** – creating distinctions between visual components within a map based on their intellectual importance (according to purpose), through the exploitation of:

---

[16] Note, graphic and structural design are inextricably linked.

[17] The visual variables were briefly introduced in Section 3.2.2.1; the list presented here is based on refinements made to Bertin's original seven variables, as described by Robinson *et al.* (1995).

[18] For example currency and accuracy of the map content.

- Gestalt principles – heterogeneity, contour, surroundedness, orientation, relative size, convexity
- brightness and texture differences
- perceptual grouping – similar size, similar shape, proximity
- advancing and retreating contours, colour combinations, contrasting colours

7. **Hierarchical organisation** – creating visual levels of varying importance within a map, based on purpose, measurement level and symbolisation, through:
   - visual contrast – line characters and weights, texture contrasts, value contrasts, variation of detail, colour contrasts
   - graphical depth cues – overlay, aerial perspective, progression of size, value progression, chroma progression

With these base concepts in hand, further cartographic design guidelines were sought, specifically those which had evolved in response to the possibilities offered by digital computing and distributed computer networks for the representation of cartographic information (in particular interactivity, multimedia/multimodality, dynamism/animation and real-time data delivery). Augmenting the comprehensive rule set presented above, the following briefly summarises a selection of 'digital' cartographic design recommendations considered relevant to the current research, many of which are directly related to visual, map-based representations, while others can be applied more broadly within true multimedia representations (based on Miller 2007; van den Worm 2001; Brown *et al.* 2001; Cartwright 2003; Buziek 1999; Köbben & Yaman 1995; Krygier 1994):

8. **Create 'scale-sets' within a scale range** – for maps, to ensure that they are optimised for display (in terms of content, accuracy, generalisation and symbolisation) at each possible scale; requires a default or reference scale at the default display size (van den Worm 2001, p.93); enables dynamic zooming.
9. **Viewable vs. complete content** – the information able to be visually displayed at any one time will generally be more limited than the total extent of the information communicated by the representation, generating a need to minimise the resulting "lack of synopticity" (Miller 2007, p.95); this may be achieved through the use of a coverage 'map', among other things.
10. **Employ self-explanatory and self-describing symbols** – whereby information identifying a symbol is contained within the symbol itself and/or can be displayed on-demand (e.g. activated by 'mouseover'); removes the need for such symbols to appear in a fixed legend (requiring visual comparison and decoding), whilst enabling legend content that is both

geospatially and thematically specific; note, however, that "some kind of legend is always needed" (van den Worm 2001, p.94).

11. **Employ (visual) dynamism** – to call, control or increase the user's attention (i.e. as notification stimuli) and/or depict dynamic geospatial phenomena; may be achieved through the manipulation of conventional (static) visual variables (see cartographic principle 3) and/or the dynamic visual variables[19]: moment/display date, duration, order, rate of change, frequency and synchronisation (DiBiase *et al.* 1992; MacEachren 1995a).
12. **Consider incorporating sound** – where appropriate, on its own or together with 2D or 3D abstract space, visual variables, time and interactivity to reduce visual distraction, provide feedback/alerting cues and add a non-visual dimension to geospatial data (among other things); involves realistic (e.g. vocal narration, earcons) and abstract sounds, the latter relying on the set of sound variables[20]: location, loudness, pitch, register, timbre, duration, rate of change and order attack/decay (Krygier 1994).
13. **Colour** – minimum colour configurations and settings should be assumed for the end user (e.g. use of a Web Safe colour palette); furthermore, image file formats should be carefully selected to avoid compression techniques resulting in undesirable colour reproduction and poor image quality.
14. **Symbol design** – point (pictorial, geometric and alphanumeric), line and area symbols should be carefully (and collectively) designed with consideration of: size, clarity, effectiveness of different visual variables, figure-ground relationship, type of data being represented (qualitative or quantitative), need for explanation in a legend, animation, interactivity and aesthetics.
15. **Typography** – the readability of text within the representation should be optimised through simultaneous consideration of font type/variation/size/orientation, text placement (horizontal, inclined or curved), figure-ground relation (contrast) and amount of anti-aliasing; this should be done in conjunction with related symbol design.
16. **Extension of marginalia** – *spatial marginalia* (e.g. scale, direction, location, legend) should be dynamically, seamlessly and actively linked to the representation, for example changing with the scale or coverage; *manipulation marginalia* (e.g. zoom, pan, layer and search controls) should enable direct interaction with the representation's attributes/display; *navigation marginalia* should be made available for changing attributes such as coverage, theme and timeframe.

[19] The dynamic visual variables were briefly introduced in Section 3.2.2.3.
[20] The sound variables were briefly introduced in Section 3.2.2.2.

17. **Maximise delivery speed** – by minimising file sizes and file transfer (e.g. through limiting the amount of information in the representation), and employing streaming and data compression/decompression techniques, among other things.

As discussed in Chapters 2 and 3 the delivery of geospatial information via mLBS is still a relatively new phenomenon with a great deal of research being undertaken into various design issues – the current study being no exception. Thus there were no comprehensive (digital) 'mobile' cartographic guidelines/principles available for use by the research (Voller *et al.* 2005; Gartner & Uhlirz 2005), beyond limited results from isolated studies such as those discussed in Sections 3.2.2 and 3.3. Indeed, the lack of tested and accepted cartographic design rules for the mobile medium was a major driving force behind the study. Consequently the above principles were used only as a foundation for the cartographic components of the preliminary design – particularly the design of maps – each being carefully considered and adapted to suit the mobile medium where applied (designated throughout Section 7.4 by the notation **CP*n***). In conjunction with this, pertinent results from external research projects were consulted – covering a much broader range of cartographic representation forms (Chapter 3) – while all design decisions remained mindful of addressing the established target user requirements and context of use.

7.4 Design and Development

As identified above, the decision was made to generate and specify the preliminary design through the development of a low-fidelity, evolutionary prototype (Sections 7.3.3), built using the XHTML-MP v1.1 for implementation within the Internet Explorer Mobile browser of an i-mate™ SP5 (Section 7.3.4). In this way an integrated approach could be taken, combining the design of the application flow with that of the UI and, more specifically, the selection and design of the component cartographic representations and access techniques to be compared. The following sections detail this process, including the *rationale* behind each of the design decisions made. Being intended as a limited functionality simulation, the final prototype incorporated only simulated functionality and data covering the scope defined in Section 7.3.2. Note that, despite its necessarily linear presentation here, the process comprising the preliminary design was much more complex and iterative, with attempts made to illustrate this wherever possible.

7.4.1 System structure

The first stage of the physical design process was, necessarily, the determination of an overall structure for the DHR travel mLBS. The completion of this would further formalise the conceptual models and provide a framework for the more detailed design, including alternative cartographic representation forms for specific user tasks. Although the scope of the preliminary design was set to cover only three of the four remaining action-based goals[21] – 'Obtain overview of location(s)', 'Find things to do / of interest' and 'Determine route' – it was considered appropriate to take a holistic approach to the system structure (thus catering to all five scenarios) and so 'Find suitable accommodation' was also incorporated at this stage, albeit only at a superficial level.

7.4.1.1 Initial structure

The first iteration of the system structure was derived by revisiting the AND/OR graphs in Figure 6.6 to Figure 6.9 and elaborating these into interlinked 'Modules' – shown in Table 7.3 – each representing information and functionality relevant to a specific user goal (**DP26**, **DP1**). While it was initially expected that each action-based goal would comprise a single Module, it soon became evident that a number of additional Modules were required. In particular, the goal 'Obtain overview of location(s)' was split into two based on its high-level tasks – 'Find out local-level detail about the location' and 'Determine what's in the immediate area' – which were considered sufficiently distinct to warrant individual treatment (e.g. the latter required access to more immediate and localised information than the former). Furthermore, two additional Modules were created to manage cross-goal information in the form of itinerary-related data (e.g. destinations, timings, etc.) and user profile information (e.g. display preferences, interests, etc.).

Table 7.3 First iteration of the major Modules for the design, including inter-linkages.

MODULE 1. View my current location	**MODULE 2. Get info about a location**
(Determine what's in the immediate area) Links to: M2. Get info about a location M7. Manage my profile Information • Current location and orientation • Indicators	*(Find out local-level detail about the location)* Links to: M3. Find somewhere to stay M4. Find things to do M7. Manage my profile Information • Local knowledge • Physical attributes • Locations and proximities • Facilities and services*
MODULE 3. Find somewhere to stay	**MODULE 4. Find things to do**
(Find suitable accommodation) Links to: M7. Manage my profile Information • Potential accommodation • Local knowledge • Location and proximity • Availability • Restrictions • Facilities and features, costs involved, contact details*	*(Find things to do / of interest)* Links to: M7. Manage my profile Information • Potential attractions, activities, events • Local knowledge • Location and proximity • Restrictions • Costs involved, contact details, requirements*

[21] Recall that 'Select destination(s)' was excluded from the research.

Table 7.3 (cont.) First iteration of the major Modules for the design, including inter-linkages.

MODULE 5. Reach my destination	**MODULE 6. Manage my holiday plan**
(Determine route) Links to: M7. Manage my profile Information • Potential routes • Local knowledge • Length estimate • Route qualities • Locations and proximities • Transportation mode(s), costs involved, contact details, requirements*	Links to: M2. Get info about a location M3. Find somewhere to stay M4. Find things to do M5. Reach my destination M7. Manage my profile Information • Holiday itineraries **MODULE 7. Manage my profile** Information • Personal preferences • Saved locations, accommodation, routes, etc.

* Non-geospatial information

Translating this modular approach directly into a design solution, a Main Menu page was created for the prototype system[22], comprising direct entry points to each of the seven Modules, along with an option to exit the service (**DP6**). As shown in Figure 7.3[23], the menu items were written from the user's perspective in a conversational, question and answer format, using language familiar to the target user population, and thus ensuring that they were easily comprehensible (**ugH**, **DP2**). Furthermore, the items were visually categorised, with items deemed of similar importance grouped together (**DP1 –** gestalt rules)[24]:

- 'View my current location' was placed at the top of the list since it implied more immediacy in the need for information and was therefore made the most easily accessible.
- 'Get info about a location', 'Find somewhere to stay', 'Find things to do' and 'Reach my destination' comprised the second grouping, with each expected to experience similar, moderate use during a holiday. The ordering within this group was based on the general structure of the users' holidays.
- 'Manage my holiday plan' and 'Manage my profile' formed the third group of menu items, with both likely to be used infrequently during a holiday (e.g. for checking the next day's schedule of activities or for updating activity category preferences), thus they were placed at the bottom of the list.

[22] Originally referred to as the 'Holiday Assistant', was renamed 'Holiday Helper'.

[23] Note that all of the prototype screenshots in this Chapter were taken using a desktop browser, which renders some screen components differently to the SmartPhone browser.

[24] The hierarchical structure of the Main Menu (and similar lists elsewhere in the design) was based on the researcher's own reasoning with respect to the user data, in the knowledge that a single optimal arrangement is unlikely to exist due to varying user preferences and contexts of use. Since the focus here is on the cartographic aspects of the interface, menu/list structuring was not tested during the evaluation.

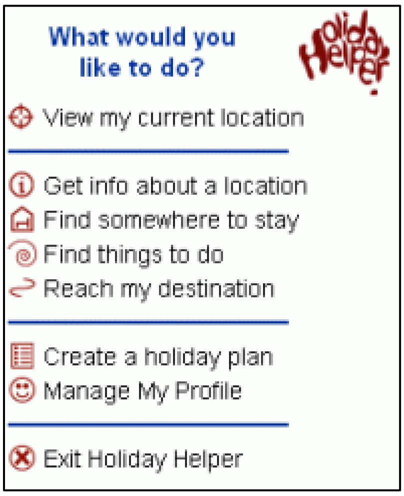

Figure 7.3 Initial Main Menu for the service, providing access to the seven Modules comprising the design.

Pictorial icons were included within the Main Menu to enhance users' understanding of the menu items (**DP20**) and to assist in user localisation within the service, with each icon intended to be displayed throughout its related Module (**DP16**). Note, however, that the icon design was not considered part of the design process – being unrelated to the cartographic aspects of the interface – nor was it planned for inclusion in the design's evaluation.

7.4.1.2 Revised structure

Design is an evolving process, characterised by review and change (where necessary) to arrive at an optimal result. As such, the initial system structure developed for the DHR travel mLBS was not automatically accepted once complete, but rather reconsidered and revised in an attempt to improve its utility and usability. The end result was a restructuring of the Main Menu items (i.e. Module access), which currently offered eight options, each at a similar visual level (using identical text-based links). The concern was that, even with the application of visual grouping, the user may not know which option to choose – particularly if they do not have a specific goal in mind – and therefore it was considered necessary to provide them with more guidance (**DP3**), whilst maintaining flexibility of use (**DP14**). To this end, the structure was revisited through consultation with each of the personas and scenarios developed from the user data (Sections 6.5.3 and 6.5.6, respectively). The main finding was that physical 'locations' (either current or potential) were the basic units or drivers of the proposed service, being fundamental to each user goal. Considering this, and the personas' perceived use of each of the system Modules defined in Table 7.3, the following decisions were made:

- When searching for accommodation and/or things to do/of interest during a holiday, each persona generally does so based on a known location, as opposed to searching for a location based on a specific lodging or pursuit[25]. This indicated that, from the user's perspective, location searching (Modules 1 & 2) was a primary task, whilst accommodation and activity searches (Modules 3 & 4) were sub-tasks of this, essentially providing information about a selected location. Therefore access to Modules 3 & 4 could be confidently moved down one level in the system hierarchy (branching from Modules 1 & 2), consequently removing their direct access from the Main Menu.

- When determining a route, the personas were found to base this around two or more known locations (e.g. current/future destinations, accommodation, activities), thus this task could also be associated with Modules 1 & 2 (and indeed 3 & 4). From the user's perspective, however, routing was not considered to be readily recognisable as providing information about an individual location and so its classification as simply a 'sub-task' of Modules 1 & 2 was not appropriate. Therefore the routing functionality (Module 5) was instead classified as a separate entity, still accessible from the Main Menu, as well as being available from within the other Modules (as required).
- With most personas actively undertaking pre-trip research and/or planning (e.g. using a desktop-based version of the service), it was important for them to have ready access to any stored itineraries (Module 6) upon entering the service. Therefore access to the planning functionality from the Main Menu was maintained.
- Each persona has distinct interests, constraints, preferences, etc. which are used to personalise the content of the service, with the information managed by their personal profile (Module 7). Since this profile affects the content of every Module, it was important for its management to remain available throughout the system, including the Main Menu.

[25] Instances involving the search for a location based on a specific lodging or pursuit were considered to be pre-trip activities (e.g. a surfer searching for locations based on quality of surf would tend to do so before embarking on a trip).

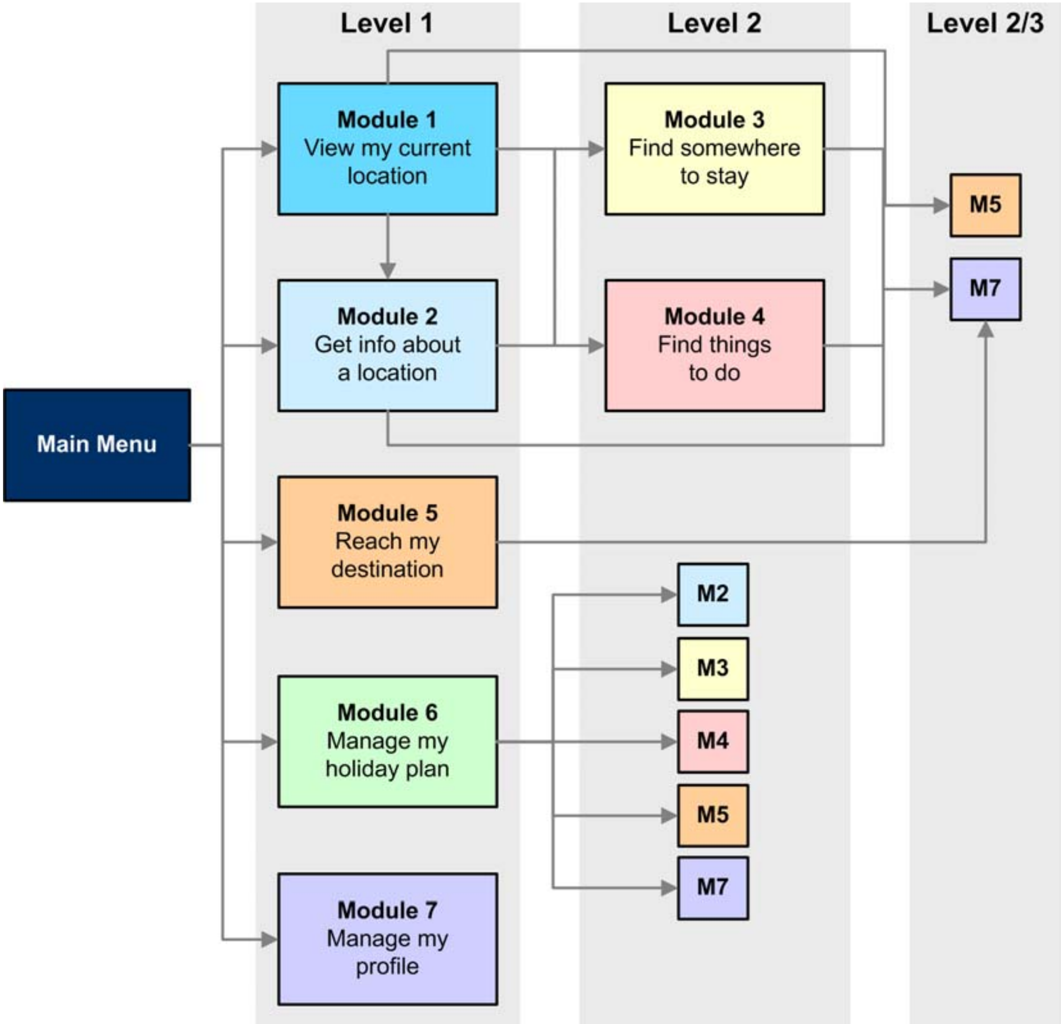

Figure 7.4 The revised structure for the system, which formalises a complete conceptual model of the users' goals, tasks and requirements.

Based on these changes, the system structure was revised from one common level of access for each Module, to between two and three hierarchical access levels – shown in Figure 7.4. Revisiting the prototype's Main Menu, appropriate adjustments were made (refer to Figure 7.5), including changes to the visual hierarchy of the menu items in order to better reflect the users' needs:

- As identified above and in Section 7.3.2, 'locations' are the drivers of the system, being a common starting point for each of the user goals identified. Therefore Module 1 (View my current location) and Module 2 (Get info about a location) were together made the focus of the Main Menu (**ugA**, **DP26**), and as such were represented by two prominent buttons (**DP19**) at the top of the screen. In order to better reflect the new system structure, these buttons were given more intuitive and representative labels than the text-based links they replaced (**ugK**), again using a conversational form associated with the page header (**ugH**,

DP2). Icons were incorporated into the button design for the same reasons of clarity and localisation as described above.

- Modules 5 (Reach my destination), 6 (Manage my holiday plan) and 7 (Manage my profile) were considered of secondary priority to Modules 1 & 2, but of similar priority to one another. To distinguish these, a visual grouping was created, organising the remaining Modules together as text-based links listed under the label 'Additional Options' (**DP1** – gestalt rules). Module 5 was placed at the top of the list since, being the only item representing a user goal, it was expected to experience greater frequency of use than the other options and was therefore made the most prominent (**ugC**). Again, the text-based link labels were revised to reflect the new structure whilst icons were incorporated for clarity and localisation.
- An option to exit the service was maintained, being visually separated from the other menu items, at the base of the list (**DP6**).

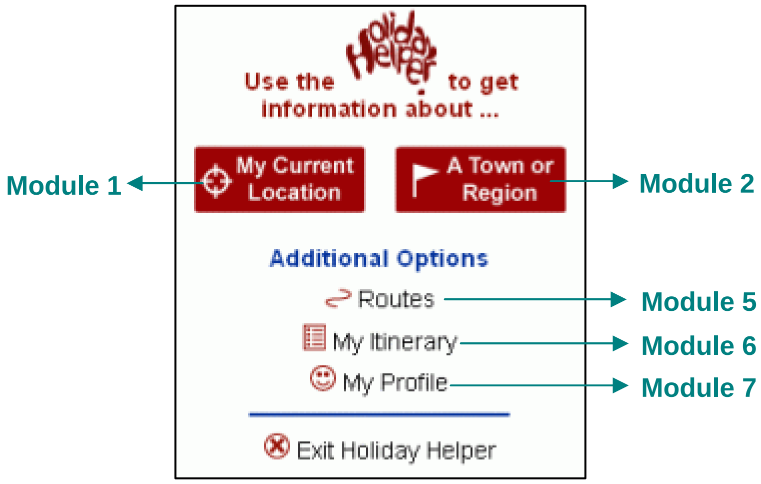

Figure 7.5 The final Main Menu for the service.

With an established system structure now in hand, the detailed design of the prototype could be undertaken.

7.4.2 System-wide design decisions

Early in the design process a number of decisions were made, establishing a foundation for ensuring consistency and simplicity across the prototype UI (**DP4**, **DP13**, **DP25**) and therefore enabling greater focus on the detailed cartographic design. Whilst the majority of these dealt with necessary system design standards (Mayhew 1999), the last two resolutions concerned the selection of (a) cartographic representation, presentation and interaction techniques for trial and comparison within the prototype, and (b) a study location about which the prototype would provide information.

- **Colour scheme** – the number of colours employed throughout the UI (excluding individual cartographic representations) was kept to a minimum of five Web Safe colours[26], used to differentiate and highlight various screen components, such as background, headings, instructions, links, etc. (**DP13**).
- **Fonts** – A single Web-supported, sans-serif font (*Arial*), along with minimum font sizes (*14pt* and *12pt*) was employed throughout the UI to optimise the readability of text (**ugJ**); font variations (e.g. bold, use of colour) were used to differentiate and highlight items such as labels and instructions (**DP13**).
- **Hyperlinks** – 'rollover' behaviours were added to linked items (e.g. text, buttons) to convey their ability to be selected (**DP19**); within the SmartPhone browser this took the form of a thin black line enclosing the selectable item (i.e. an open rectangle), which was displayed once the item came into focus (**DP16**).
- **Page header/footer** – a navigation header and footer was added to each page, providing quick access to key global shortcuts (**DP7**, **DP22**): on the far left was a link to the 'Home' page – i.e. the Main Menu which was the starting point for all system usage (**DP6**); on the far right was a link to *My Profile*, enabling users to update their personal settings at any time during use; in the centre was an optional 'Menu' link incorporating the pictorial icon associated with the current Module (**DP20**), which returned the user to the menu of that Module.
- **Page title** – at the top of each page a descriptive title was included to identify the associated content/system component (often reflecting the user's most recent action that resulted in the current page) and so providing feedback regarding the system's current 'state' (**DP5**, **DP16**); where the content related directly to a specific location, an additional title (in a different colour) was included at the top of the page reinforcing this.
- **Results lists** – all search results lists within the service included a number next to each list item, corresponding to the numbers on the device keypad; this enabled keypad-based selection of list items, in addition to joystick selection; list displays were limited to eight items per page so as to minimise scrolling (**DP22**) and reduce individual page content (**DP1**), with links included for viewing items on the next/previous screen (which were also selectable via the keypad); text was included at the bottom of each page of a given list stating the total number of list items and thus providing an indicator as to whether additional results were available for viewing.
- **Cartographic representation techniques** – with the current design phase having a largely exploratory focus, only a small set of alternative representation techniques were chosen for inclusion within the prototype in order to determine their suitability for various users and

[26] White, dark red, dark blue, black and pale orange.

geospatial tasks; drawn from those discussed in Section 3.2.2, the number and form of these was based upon minimising the complexity of the system (considering its preliminary design status) and trialling representation forms which were commonly employed within existing mLBS, namely: conventional 2D maps (incorporating map signs & symbols), photographs, natural language, sound, touch (in the form of key presses and joystick movement), animation, interactivity, hypermedia, multimodality and adaptation/personalisation; when selecting specific cartographic technique(s) to be evaluated for a given design component, the ultimate decision was informed by the pre-design research, researcher experience and simple logic (i.e. which techniques do/do not lend themselves to the task at hand).

- **Study location** – when selecting a location upon which the prototype would be based, a number of requirements were identified, such as somewhere that had a high potential of being unfamiliar to members of the target user group, and a place that possessed a reasonable number of touristic and other features distributed over a relatively small area coverage (which would limit the extent and thus contribute to the manageability of the prototype); with the original scenario location (Perth) deemed unsuitable, further consideration resulted in the nearby historic port town of Fremantle being chosen to fill this role.

7.4.3 The cartographic user interface

As discussed in Section 7.3.2, a scenario-based approach was taken to produce the detailed cartographic design for the prototype, essentially using the *preliminary design scenario* to drive the entire design process. At the same time, the various pre-design input materials were consulted, in keeping with the UCD objective of maximising a design's usefulness from the outset:

- User Profile – comprising user characteristics, context of use and user preferences (Chapter 5);
- user goal and task models – including AND/OR graphs, personas, scenarios, current information sources/tools, geospatially-related travel problems; future information requirements and the environment of use (Chapter 6);
- qualitative usability goals – P1 and potentially P2 (Table 7.1);
- platform capabilities and constraints (Section 7.3.4); and
- UI and cartographic design guidelines and principles (Section 7.3.5).

Upon revisiting the preliminary design scenario it was established that three of the defined system Modules (depicted in Figure 7.4) were required for the initial prototype, along with methods of access to a fourth (i.e. Module 5):

> "*… You start by using the Holiday Helper to find out as much detail as possible about Fremantle, starting with a general summary and then moving onto the layout of the area* (**Module 2 – Get information about a**

> **location**) *as well as nearby activities that you think your family would enjoy doing* (**Module 4 – Find things to do**) … *You pull out the Holiday Helper which tells you your current location with respect to a number of recognisable landmarks* (**Module 1 – View my current location**). *You then ask the service to guide you back to your hotel* (**Module 5 – Reach my destination**).*"*

The remainder of this section describes the detailed cartographic design of these Modules. It must first be reiterated, however, that despite its necessarily linear presentation here, the design process was one of continual, integrated revision aimed at producing a seamless result.

7.4.3.1 Module 2 – location search (inputs)

Beginning with Module 2, the purpose of this (according to Table 7.3) was to communicate local-level detail about a given location. However, as opposed to Module 1, which assumed that the system had some knowledge of where the device was located (i.e. 'my current location'), Module 2 required the user to specify a location of interest via a geospatial query. This was therefore the initial focus of the design. With the pre-design activities not having considered users' preferred methods for searching for a location, the choice of input techniques was driven by the design aim of trialling and comparing a selection of alternative representation forms. The final selection, based on those considered most suited to the location input task, comprised: text entry (natural language, touch), voice recognition (natural language, sound, multimodality), map-based selection (base maps, map signs & symbols, touch, hypermedia), list-based selection (natural language, touch, personalisation, hypermedia) – all involving some degree of interactivity.

Appearing upon selection of the 'A Town or Region' button on the Main Menu, a search menu was formulated (Figure 7.6), providing access to the aforementioned location input techniques. Again written from the user's perspective and employing language familiar to the target user population (**ugH**, **DP2**), the menu enabled users to query a location using:

- the location (town or region) name;
- a map; or
- a list of pre-saved locations (My Destinations).

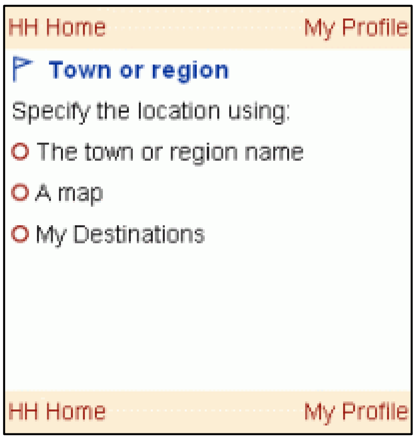

Figure 7.6 The 'town or region' search menu.

Beginning with the first menu option, searching for a location via its name incorporated two main input techniques: text entry and voice recognition. As shown in Figure 7.7a, a common criteria also accompanied the two, enabling the optional filtering of search results by a specific state – implemented as a 'dropdown' list[27] (**DP12**). The text entry input technique required the user to type in the name of the location of interest (using a minimum of three characters) via the device's keypad and then scroll to and select the 'Go' button to initiate the (simulated) search. This then produced a text-based list of towns/regions matching the search string (and state, where specified) – Figure 7.7b – from which the user could physically select the desired location about which to access information (**ugA**), or else choose to conduct a new 'name' search (e.g. if the location of interest was not on the list – **DP6**, **DP17**).

The voice recognition input technique required the user to select the 'Voice Input' button upon which an abstract sound was played (**CP12**), prompting them to speak aloud the name of the location of interest thus forming a spatial query. A (simulated) search was then initiated with the user given animated feedback of its progress (**DP5**, **DP28**) – Figure 7.7c – and resulting in a text-based list of towns/regions matching the voice input (and state, where specified) – Figure 7.7d. From here, again the user could physically select the desired location about which to access information (**ugA**), or else choose to conduct a new 'name' search (**DP6**, **DP17**). Note that within the 'Town or region name' search page (Figure 7.7a), user help was also incorporated (**DP10**, **ugM**) to assist the user with their interaction (**DP9**) – e.g. instructions for the 'voice input'. This took the form of text, differentiated from that on the rest of the page using the visual variables size and colour.

[27] Note, the implementation of dropdown lists within the SmartPhone browser was different to that within a desktop Web browser, with a new page opened containing the list items for selection.

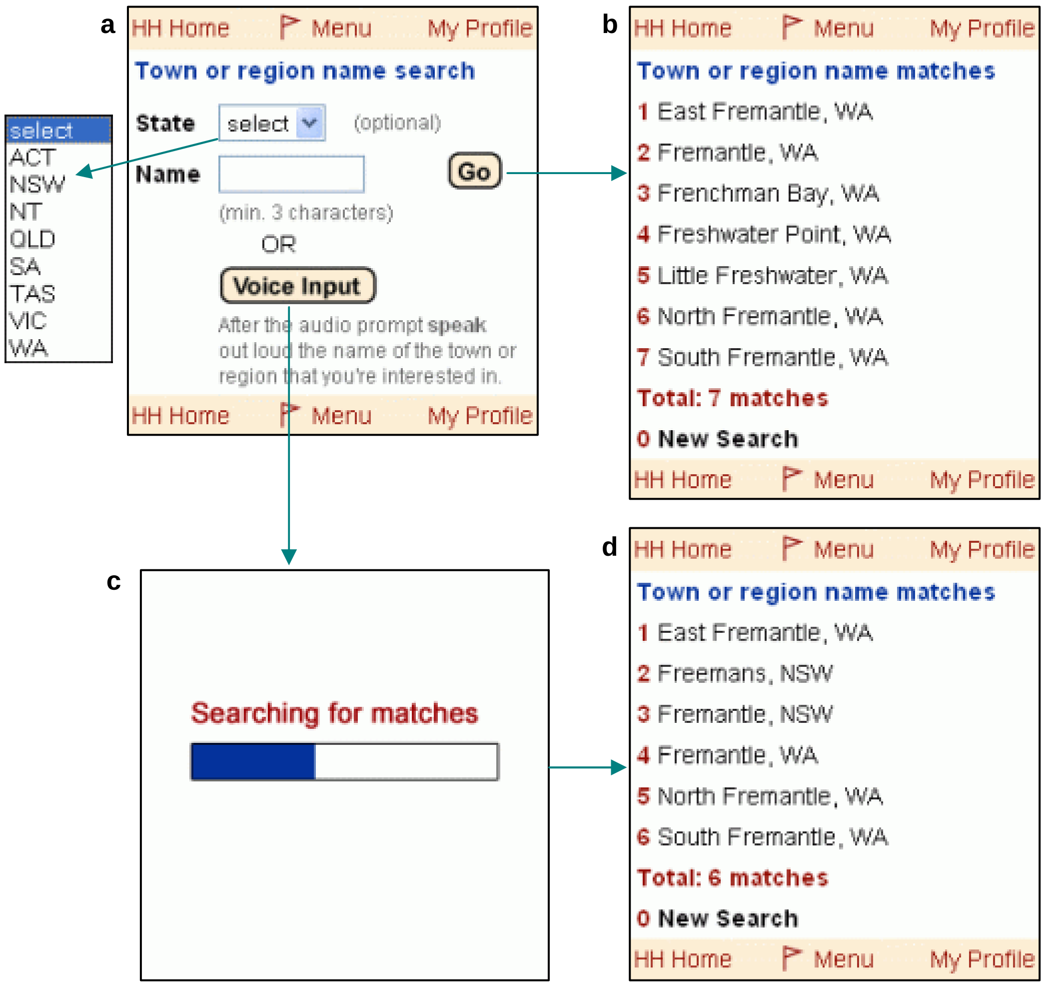

Figure 7.7 Searching for a location using (a) text input, (c) voice recognition and (b & d) list-based selection.

Looking to the second option on the 'town or region' search menu, this input technique required a location to be specified by physically clicking through a series of maps (Figure 7.8). The basic operation of this involved the user 'drilling down' to the location of interest by first selecting a state or capital city from the initial map, then selecting a region (where applicable) and eventually a location about which to receive information (**ugA**)[28]. This was accomplished through the definition of 'hotspots' within each map, linking to the appropriate map/information upon selection by the user. During implementation of this functionality it was deemed necessary to include 'Help' links to instructional information (tailored to the current map view – **DP27**) describing how the user may select locations using the maps (**DP10**, **ugM**) – also shown in Figure 7.8. The main reason for this was the non-intuitive technique by which the SmartPhone browser enabled map clicking (compared with desktop Web browsers which have the benefit of a pointing device), requiring that the map itself first be selected using the joystick, upon which

[28] Note, the user was also able to select a link below Map 3 (Figure 7.8c) in order to retrieve information at the region level.

scrollable 'crosshairs' were displayed. Only then could the user employ the joystick to move the centre of the crosshairs to the part of the map they were interested in before making a selection.

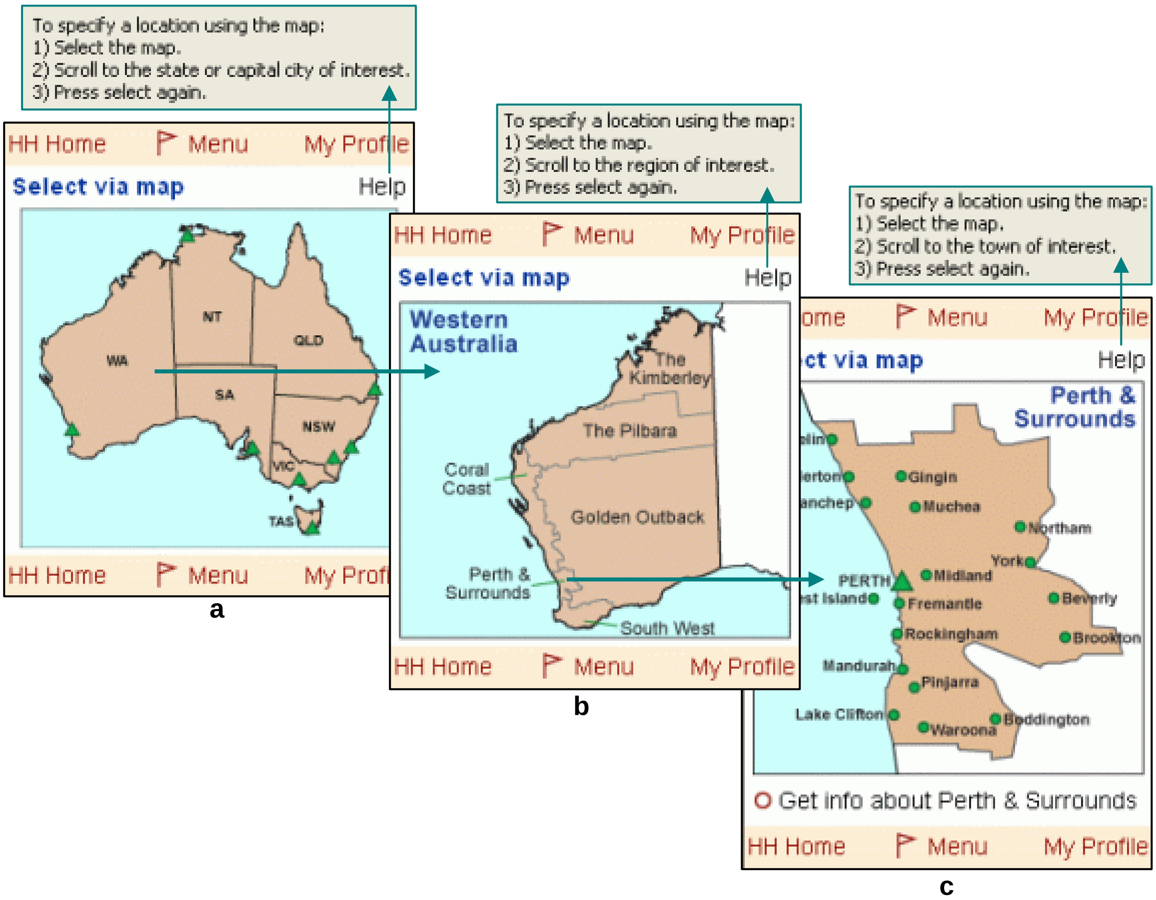

Figure 7.8 Searching for a location using map-based selection.

Moving onto the cartographic design of the maps, since their purpose was to convey general geospatial relationships (i.e. states within a country, regions within a state and towns/cities within a region) for use as an input technique – as opposed to enabling sophisticated interpretation – the design was somewhat simplistic (particularly compared with other maps in the prototype):

- **Abstraction** – the decision was made to produce three maps, each at a larger scale (and therefore smaller area coverage) than the last (**CP1**): Map 1 – country level (Figure 7.8a), Map 2 – state level (Figure 7.8b), Map 3 – region level (Figure 7.8c); furthermore, in line with Reichenbacher's (2004) mobile map design recommendations (see Section 3.3.2), only minimal map features were deemed relevant (i.e. coastlines, state and regional boundaries, capital city and town/region locations), each of which was substantially generalised (particularly through simplification and refinement, **CP2**) – although arguably the coastline and regional boundaries in Maps 1 and 2 remained too detailed, particularly considering the small-screen presentation format.

- **Symbolisation** – the majority of the maps' symbol design concerned point symbols representing cities/towns and line symbols denoting state/region boundaries; whilst the line symbols made use of the visual variable 'hue' (colour) – e.g. to distinguish regions – the point symbols exploited the variables 'shape' (triangles and circles), 'size' and 'colour' (specifically hue, contrast and visual efficiency) to represent the qualitative difference between capital cities and other towns (**CP3**, **CP14**); typography was employed for the map titles and to identify map features (states, regions, capital cities, towns), with the legibility, placement and spacing of all text optimised (**CP3**, **CP15**)[29].
- **Marginalia construction** – it was considered unnecessary to provide scale, orientation and legend information (**CP5**) and a coverage map (**CP9**) as part of the map marginalia, due to the maps' simplistic (input) purpose, as well as the minimal number of features incorporated (each of which was considered sufficiently self-describing – **CP10**); similarly, controls for map manipulation (e.g. zoom, pan) were not required (**CP16**); map titles were seen as necessary, however (for Maps 2 and 3 only) in order to provide feedback on the previous selection made (**DP16**), since this was not necessarily evident from the map content.
- **Structural design** – Gestalt principles, brightness and colour were exploited to achieve appropriate figure-ground organisation (**CP6**), providing distinctions between water vs. land, state vs. regions and land/regions vs. towns/cities; similarly visual separation of the map content (**CP7**) was achieved through visual contrast and graphical depth cues (specifically overlay); note that the use of few, highly contrasting Web Safe colours throughout the maps' design was a deliberate decision, not only to satisfy cartographic requirements (**CP13**), but also to simplify the UI in general (**DP1**).

The final option on the 'town or region' search menu – My Destinations – required list-based selection and at the same time introduced the idea of users having access to their own personal settings, referred to as *My Profile*. Similar to the personalisation features trialled by Chincholle *et al.* (2002), *My Profile's* (conceptual) purpose within the design was, among other things, to centrally store and maintain various 'favourites/shortcuts' lists for the user, which would be made available each time they used the service (**ugL**, **ugN**). 'My Destinations' was one such list, comprising references to locations (town/cities and regions) that the user had purposefully saved during previous usage of the service. Input via My Destinations (Figure 7.9) therefore required the user to find and select, from within their saved list, the location about which they sought information (**ugA**).

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[29] Unfortunately the text sizes and weights were not kept consistent between the maps, an oversight which was only detected after the evaluation (**CP3**, **CP15**).

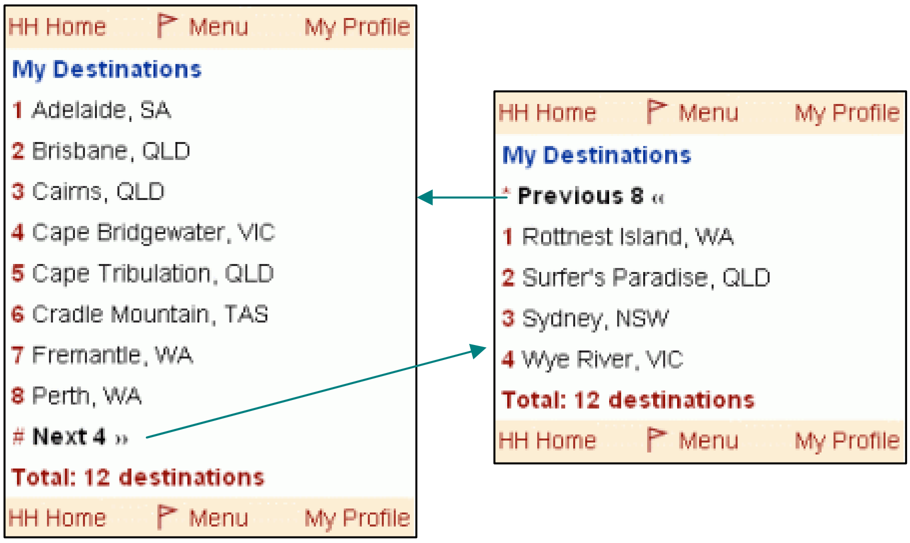

Figure 7.9 Searching for a location using list-based selection.

7.4.3.2 Module 2 – general location summary and layout (outputs)

According to the user profiling and task analysis results, upon searching for and selecting a location, users seek a variety of local-level geospatial and non-geospatial information, including: physical attributes, facilities and services, locations/proximities (within and around the location), accommodation and activities. After consulting a number of tourist Websites[30] for examples of the arrangement of similar information (recognising that none of these could necessarily be regarded as ideal), and considering the amount of information that could be usefully displayed on a single page of the service, the decision was made to provide hierarchical access to the location data from a single point (**DP1**, **DP22**, **DP26**). To this end, an initial 'location summary' page was planned (representing the top level in the hierarchy and satisfying the first output requirement of the preliminary design scenario), which would contain a brief introduction to the location, plus a means of enabling users to view more detailed location information (i.e. at the secondary level) – **ugA**, **ugE**. In total, two versions of the summary page were designed to enable comparison of alternative output techniques during the evaluation: the first comprised text (natural language, hypermedia), while the second incorporated text, voice *and* image outputs (natural language, photographs, multimodality, hypermedia) – refer to Figure 7.10a and b, respectively.

[30] Including: www.australia.com, www.rottnestisland.com, www.countrywide.com.au and www.fremantle.org.au.

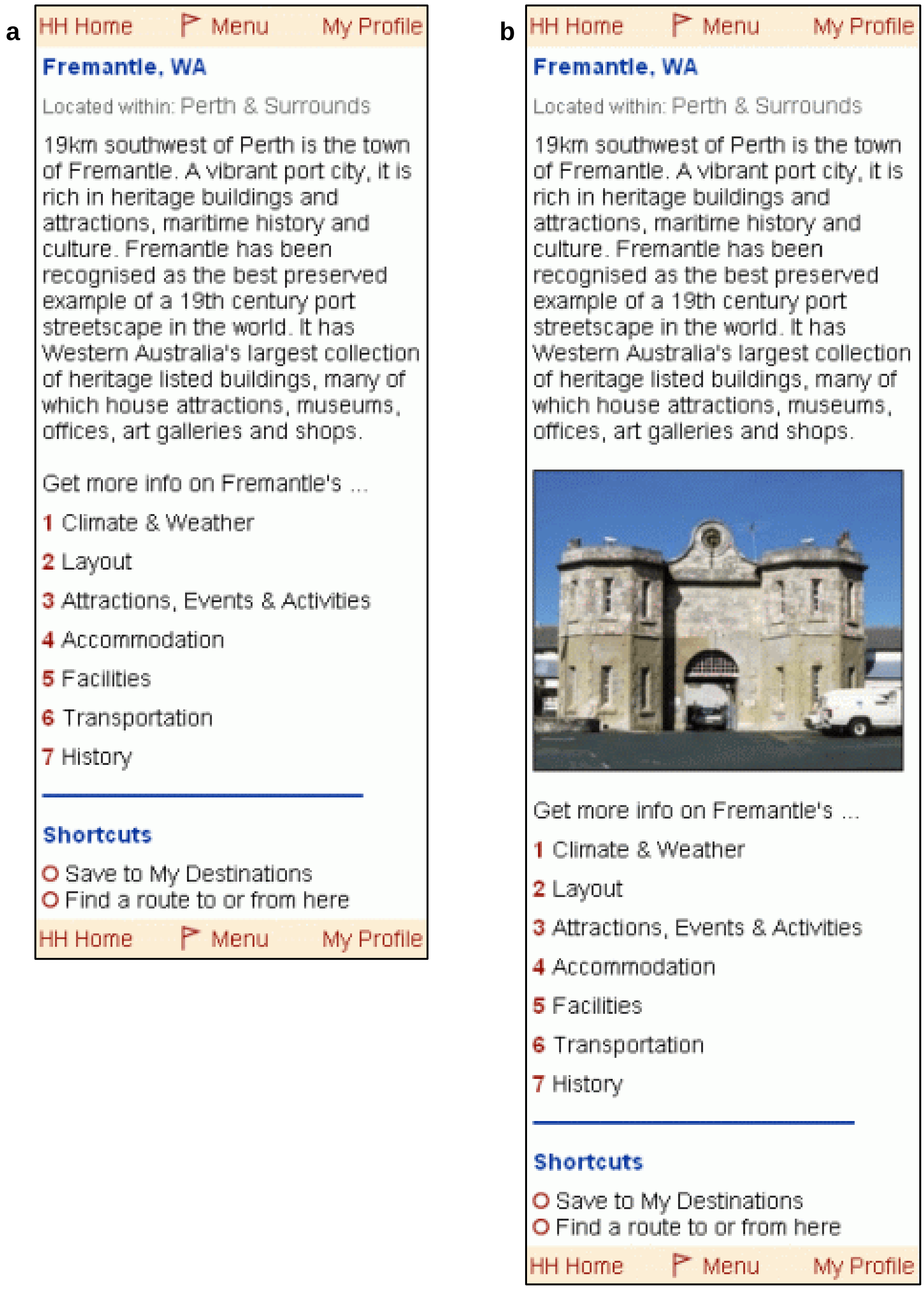

Figure 7.10 The location summary page for a town/city incorporating (a) text and (b) text, image and voice (not shown) outputs.

The text on both versions of the location summary page was identical, providing a paragraph summarising the main features of the location, below which were a series of text-based hypermedia links providing pathways to more detailed information on various aspects of the location (using a similar browser metaphor to those employed by Cheverst *et al.* (2000) and Pospischil *et al.* (2002) – **DP18**). The segmentation of the content represented by these links was accomplished through reflection on the user tasks and information requirements gathered during the user profiling and task analysis activities. Specifically, effort was made to organise the information in such a way that addressed known user intentions when seeking local-level detail about a location (**DP21**, **DP26**). The links' labels were designed to be largely self-describing (**ugK**) and were written in the user's own terminology (**DP2**, **ugH**):

1. *Climate & Weather* – local weather information.
2. *Layout* – e.g. orientation, distances, proximities, features.
3. *Attractions, Events & Activities* – Module 4.
4. *Accommodation* (non-functional) – Module 3.
5. *Facilities* (non-functional) – e.g. food options, public toilets, supermarkets, banks.
6. *Transportation* (non-functional) – e.g. roads, buses, trains.
7 *History* (non-functional) – non-geospatial, included for product completeness only.

Figure 7.11 The location summary page for a region incorporating text and voice only.

At the base of the page were two shortcuts (**DP7**, **ugL**), neither of which was functional in the preliminary design prototype. The first, 'Save to My Destinations', was intended to allow the user to save the location they were currently viewing to My Destinations – i.e. a list of their 'favourite' locations stored and maintained within *My Profile*. The second, 'Find a route to or from here,' was included to provide quick access to Module 5, thus enabling the user to determine a route involving the location they were currently viewing (**ugC**). A final, optional text component was that placed at the top of the page, above the summary, which informed the user when there was a wider region within which the current location was situated (**ugE**). Where present, this text linked to an identical summary page for the region in question (**DP4**, **DP13**, **DP25**) – for the purposes of the prototype, this incorporated text-based and voice outputs only (refer to Figure 7.11). The second version of the location summary page (Figure 7.10b) additionally incorporated voice and image outputs, with the former providing vocal narration of the page's text output (**ugG**, **CP12**): as soon as the page loaded, a voice automatically read aloud both the summary paragraph and the hyperlinked options, including the keypad numbers that could be used to select each – such multimodal output is widely recommended within the field of VNS (refer to Section 3.3.3) and for mLBS applications (Hurtig 2006). The image output comprised a photograph of a popular landmark found at the location, included for aesthetic purposes.

Revisiting the preliminary design scenario, the final component of Module 2 to be addressed within the prototype was the provision of information regarding the 'layout' of a location of interest (**ugA**). Recalling that the location summary page was designed to incorporate text-based links to more-detailed location information, including one entitled 'Layout', this was considered the natural and most direct entry point for the functionality in question (**DP21**).

In an effort to maintain consistency with the location summary page (**DP4**, **DP13**, **DP25**, **ugO**), the decision was made to also present an initial 'summary' page upon entry into the layout component, from which the user could then access further layout information, should they require it. Again, two alternative versions of the summary page were designed for the comparison of outputs, with one comprising only text (natural language, hypermedia), whilst the other incorporated both text *and* voice (natural language, multimodality, hypermedia). Figure 7.12 shows the information conveyed by the layout summary page (note, the voice output again narrated the text – **ugG**, **CP12**), incorporating a brief description of the geospatial arrangement of major features/landmarks within the location, as well as a text-based link ('View map') to more detailed information (**ugE**). As with the location summary, a number of shortcuts were included at the base of this page (**DP7**, **ugL**):

- **Return to <location> summary** – took the user directly to the location summary page.
- **Save to My Destinations** – (non-functional) allowed the user to save the location they were currently viewing to *My Profile*.
- **Find accommodation here** – (non-functional) provided quick access to Module 3, thus enabling the user to find accommodation in and around the location they were currently viewing.

- **Find things to do here** – provided quick access to Module 4, thus enabling the user to find attractions, events and activities in and around the location they were currently viewing (**ugB**).

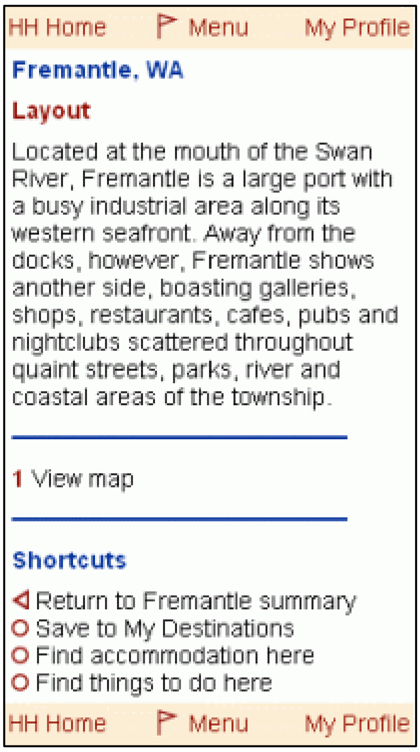

Figure 7.12 The layout summary page incorporating text and voice (not shown) outputs.

Selecting the 'View map' link from the layout summary page resulted in the display of map-based output (base/thematic/navigational maps, map signs & symbols, adaptation, interactivity) communicating the location's layout – note, numerous researchers advocate maps as the optimal technique for providing users with an overview and understanding of geospatially distributed entities (e.g. Chincholle *et al.* 2002; Kraak & Ormeling 2003; Gartner & Radoczky 2007). Here, two alternative maps were included for comparison, differing primarily in their graphic and structural design, with some differences in their levels of abstraction. The first alternative – sourced through Webraska and generated using the Whereis® API – was based on a map which had been independently designed for use within WAP-based applications unconnected with the research (Figure 7.13). No changes were made to this representation prior to its inclusion within the prototype. The second alternative comprised a custom-made map specifically designed for the research (Figure 7.14). Before discussing the maps in detail, it is pertinent to describe the design of a number of features common to both:

- **Scale and area coverage** – For the purposes of the (simulated) low-fidelity prototype, only four inter-linked raster images were created for each map, representing a pre-determined scale set (**CP8**). The four map scales – identical between the two representations – were selected in such a way as to provide adequate geographical coverage, ranging from suburb to street level (**CP1**, **ugE**). The initial scale selected for each map display was the smallest – i.e. covering the largest geographic extent, centred on the location of interest – so as to provide broad, immediate context for the location (**ugA**, **ugF**).

- **Marginalia –** The page title additionally filled the role of map title, providing sufficient description of the map coverage and theme (**DP5**). Below the map, a set of tools was included enabling direct manipulation (**CP16**):
  - *Map Pan* – Whilst not functional in the prototype, this tool (conceptually) enabled users to move the map's centre-point in any of the cardinal directions, and thus change the map view, using either the joystick or the keypad. The design of this tool endeavoured to self-describe its operation (**ugK**, **CP10**), comprising eight triangular icons each 'pointing' in the direction of the resulting centre-point movement, and a single circular icon which re-centred the map on its original position. Importantly, each of the icons incorporated a number which corresponded to the device's numbered keypad, with the spatial arrangement of numbers within the tool matching that on the keypad, thus reducing the interpretive load on the user (**DP3**).
  - *Map Zoom* – This (functional) tool allowed users to switch between the four available scales by either directly selecting a scale icon (represented as rectangles), or by selecting the '+' or '–' icon (located above and below the scale icons, respectively) to zoom in or out one scale level at a time. Again, the tool was designed to be self-explanatory (**ugK**, **CP10**), incorporating: highlighting (using colour) of the icon corresponding to the current scale (**DP5**, **DP16**, **DP28**); and intuitive labels for the smallest and largest scale icons – 'suburb' and 'street', respectively (**DP2**, **DP10**).
- **Shortcuts** – A number of shortcuts (**DP7**, **ugL**), identical to those present on the layout summary page (**DP4**, **DP25**), were included at the base of the page.

Looking first to the 'sourced' layout map (Figure 7.13), it is important to reiterate that this representation was not designed or modified in any way for the research, being included simply as an example of 'typical' maps employed within mLBS, against which other representations could be compared and evaluated (note, a map legend was omitted for the same reasons). A cartographic review of the 'sourced' map understandably identified a number of issues with its design, particularly with respect to the map's effectiveness within the prototype[31]. The results of this, which were considered during the design of the 'custom' map, are summarised below:

- Line-work (**CP2**, **CP3**, **CP14**) – coastlines were not sufficiently simplified; individual road categories employed varying line thicknesses at small scales (most likely a merging issue) but not at larger scales; ferry route symbolisation was irregular (inconsistent application of texture).
- Visual organisation (**CP6**, **CP7**) – water bodies visually dominated the display, largely due to the application of colour; visual levels were indistinct at smaller scales due to minimal visual contrast between, and 'cluttering' of, map features (e.g. land, minor roads, buildings).
- Levels of detail (**CP1**, **CP2**, **CP4**) – cluttered and messy displays manifested from the inclusion of detail beyond that required at the two smallest map scales (e.g. minor roads, land use types, buildings); insufficient detail at the largest scale rendered the map virtually useless (e.g. for user orientation, location overview, wayfinding, etc.); note, the level of detail employed at a given map scale should match its purpose.
- Typography (**CP3**, **CP15**) – reduced legibility resulted from the use of capital letters for road labels and the placement of text over the top of line features; although most likely done to increase legibility, the use of a white outline around lettering had the opposite effect in some cases (e.g. road labels at the smallest scale); the use of consistent text sizes across all map scales was commendable.
- Symbol design (**CP3**, **CP14**) – large, complex areal patterns such as the 'honeycomb' symbol used to represent malls/walkways, are unsuitable for the mLBS presentation format; symbol sizes were not always consistent between the different map scales (e.g. minor roads, malls); familiar colour conventions were not consistently applied across the map scales (e.g. whilst blue is usually reserved for hydrographic features, it was additionally used within the map to represent minor roads).

[31] Maps such as this are generally affected by real-world constraints such as data availability and inadequate resources being allocated to their production – often leading to the use of default configurations imposed by underlying GIS software and/or non-cartographers being responsible for the map design.

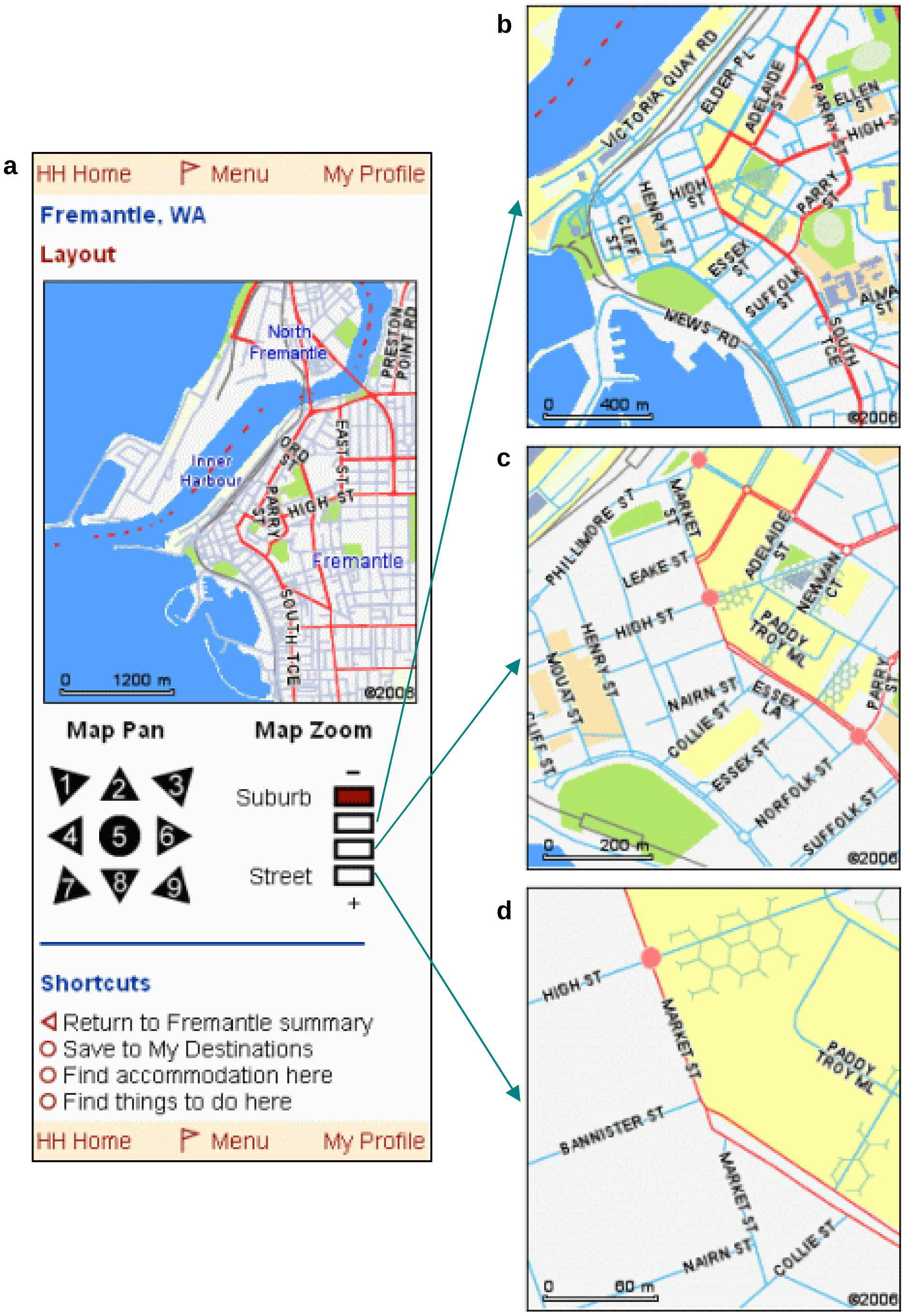

Figure 7.13 The map-based layout page employing a 'sourced' map, with all four scales shown (a – d).

The design of the 'custom' layout map (Figure 7.14) was an extensive process, addressing the goal of providing users with local-level information regarding a location's arrangement (i.e. physical attributes, facilities and services, locations/proximities). Undertaken with the use of graphic design software, the design benefited from an ability to optimise the clarity of individual map features (**ugF**). In spite of this, however, the final product was not considered beyond what could be achieved through the use of automated map generation and rendering tools – a more realistic technique for producing maps within mLBS.

Figure 7.14 The map-based layout page employing a 'custom' map, with all four scales shown (a – d).

Whilst a full discussion is beyond the scope of the research, the following provides a high-level summary of the major cartographic design decisions made while creating the 'custom' map (note, these decisions were mindful of the mobile map design recommendations provided by other researchers - e.g. Brunner-Friedrich & Nothegger 2002; Reichenbacher 2004; Wintges 2003):

- **Selection and refinement** – based on the map's purpose, information availability and known user requirements, a range of relevant map features was selected for inclusion on the map (**CP1**, **CP2**, **ugF**), comprising: land, water, transportation networks, tourism-appropriate land use types, relevant POIs and labelling of important features. Specific decisions were then made regarding which variables would be displayed at each map scale in the range (**CP8**), being particularly mindful of the limited presentation format and the resulting need to reduce visual complexity, particularly at smaller scales:

- *Scale 1* (Figure 7.14a) – was intended to provide a high-level overview of the location's position within the wider region (**ugF**) and as such incorporated minimal features: land and water (coastlines), land-use types (parkland), transportation networks (major roads, railway lines, ferry routes) and labelling (prominent water bodies, major roads, suburbs).
- *Scale 2* (Figure 7.14b) – was intended to provide a more detailed view of the location itself, thus comprising: land and water (coastlines), land-use types (parkland), transportation networks (major and minor roads, malls/walkways, railway lines and stations, ferry routes and terminals) and labelling (water bodies, major and some minor roads[32]).
- *Scales 3 & 4* (Figure 7.14c and d) – were intended to convey maximum detail for increasingly smaller and more localised areas within the location and so comprised: land and water (coastlines), land-use types (parkland, commercial/shopping), transportation networks (major and minor roads, roundabouts, malls/walkways, railway lines and stations, ferry routes and terminals), POIs (tourist information, public toilets, public parking, police stations, accommodation) and labelling (water bodies, major and most/all minor roads[32]).

- **Generalisation** – numerous line features were included on the map, all of which were simplified according to the map scale at which they appeared (i.e. greater simplification was generally applied to a line feature at the smallest scale compared with the same feature at larger scales). The simplification process particularly affected coastlines and, to a lesser extent, transportation networks. Additionally, at all but the largest scale some combination of line features was performed. This affected all roads consisting of dual carriageways, which were thus merged into single lines at the smaller scales, whilst being rendered as 'double' lines at Scale 4. Minimal displacement of overlapping point features was also required to ensure that each was clearly visible. Note that throughout the generalisation process, care was taken to maintain those geospatial characteristics and relationships of/between affected features which contributed to the purpose of conveying the location's layout (**CP2**, **ugF**).
- **Graphic and structural design** – the symbolisation of the (qualitative) map features endeavoured to convey their individual meanings in accordance with the overall map purpose, using colour as the main design element (Reichenbacher 2004). Here emphasis was placed on producing a clear, functional and aesthetically pleasing visual composition that adhered to

[32] The selection of minor roads to be labelled at Scales 2 and 3 did not follow a formula, but was instead governed by the need to maintain balance, clarity and legibility within the map (**CP4**). Whilst real-world map generation and rendering tools would require some sort of automated process for such intermittent labelling, this was not considered important within the scope of the research.

graphic design principles (**CP3**, **CP4**, **ugF**)[33], while at the same time ensuring appropriate figure-ground and hierarchical organisation within the map itself (**CP6**, **CP7**, **CP14**). Note, all colours used within the map were considered Web Safe (**CP13**), with the total number of hues used falling below the recommended maximum.

- *Water & land* – the pale blue used to denote water bodies not only followed colour conventions, but also utilised (low) colour value and intensity to place it at the lowest visual level (constituting the map's 'ground'). Considered to hold greater importance to the user, but needing to remain at a low visual level, land was coloured a higher value pale yellow. The line symbol delineating the two – i.e. the coastline – was coloured a high contrast dark grey to aid in their visual separation.
- *Roads* – the three road categories selected for the map were represented by line symbols, visually distinguished from one another through the use of hue and, to a lesser extent, size. Specifically, major roads were coloured red and minor roads brown – each in keeping with colour conventions and in high contrast to the 'land' they overlaid – with the major road symbols using a slightly thicker line weight, reinforcing their hierarchical dominance. While traditional conventions may dictate the use of texture to distinguish 'roads not fully trafficable' (i.e. malls/walkways), the decision was made to instead differentiate these features using a contrasting colour: purple. This was done to convey greater visual importance than would be accomplished through texture, thus better catering to the intended users and map purpose (i.e. tourists familiarising themselves with a location, including how to move around within it).
- *Land uses* – the two types of land use considered relevant for inclusion on the layout map – parkland and commercial/shopping – were represented by non-bordered area symbols (conventionally) coloured green and orange, respectively. The specific hues chosen were intended to place the land use types on a higher visual level than the underlying land, whilst keeping them at a lower visual level than all other land-based features (i.e. transportation networks and POIs), which were considered of higher relative importance to tourists.
- *Rail & ferries* – the railway lines and ferry routes were distinguished from the features they overlaid (land, water, parkland) using contrasting line colours: grey and orange, respectively. This also served to differentiate them from the various road symbols and each other, as did the use of texture (i.e. dashed lines). The area features associated with these line symbols, namely railway stations and ferry terminals, were rendered in the same

[33] Unfortunately line symbol weights, point symbol sizes and some text label sizes were not kept consistent for individual features across the different map scales (**CP3**, **CP14**, **CP15**). This oversight was detected only after the evaluation.

colours (respectively) and bordered by a thin black line, helping to increase their visual importance.

- *POIs* – effort was made to design POI point symbols that were familiar to users (and therefore self-describing – **CP10**, **ugK**), while at the same time being of low complexity so as to maximise their clarity for small screen viewing. The symbols were also intended to sit together at the highest visual level, being considered of greatest importance to users at the scales where they appeared. These goals were achieved through adherence to convention (where possible) and careful selection of symbol shape, size and hue. In particular, all of the POI symbols except one were represented by a small filled square. The exception was the tourist information symbol which used a filled circle (of similar dimensions) with a familiar white *i* in its centre, designed as such to make it slightly more visible/important than the rest. Most of the square symbols also incorporated a white letter in their centre, with 'T' used for public toilets, 'P' for public parking and 'H' for hotels/accommodation, whilst a white 'shield' was used in the symbol denoting police stations. The high intensity colours employed for the symbols were: dark blues for tourist information and police stations, green for toilets, brown for parking and pink for accommodation.
- *Labelling* – the three text label types were differentiated and their legibility optimised through colour, size, orientation and placement (**CP15**, **ugJ**), each employing the established sans-serif system font. The water body labels, centred on the visible part of the associated feature, were coloured mid-blue, utilised two sizes – *12pt* for oceans/rivers and *9pt* for bays/quays – and were oriented horizontally, except for river-based labels which followed the orientation of the associated river segment. The suburb labels (*12pt*) were coloured darker blue and also oriented horizontally, with their placement being as close as possible to the centre of the suburb they represented. Finally, while all road labels were of the same size (*11pt*) and coloured black, each was centred to and oriented in the direction of the associated road, being placed thus: roads with a bearing between 0° and 90° (or 180° and 270°) were labelled directly *above* the line symbol; roads with a bearing between 90° and 180° (or 270° and 0°) were labelled directly *below* the line symbol (**ugF**).

- **Marginalia** – in addition to the aforementioned map title and zoom and pan tools, a number of marginalia components were included in the map design (**CP5**, **CP16**). The map display itself (always oriented 'north-up'), incorporated a north point in the upper left corner as well as a dynamic scale bar in the lower left corner (**ugF**), each of which was rendered over the top of other map features. Accessed via a text-based link located above the map, a legend was also included to explain the map symbols (excluding land and water) and opened in a new page (**ugF**, **ugM**). To reduce the load on the user's memory caused by the map and legend not being viewable within the same page (**DP3**), the legend itself was designed to be 'contextual', with its content adapted to include only those map features displayed at the scale from which it was accessed (Figure 7.15).

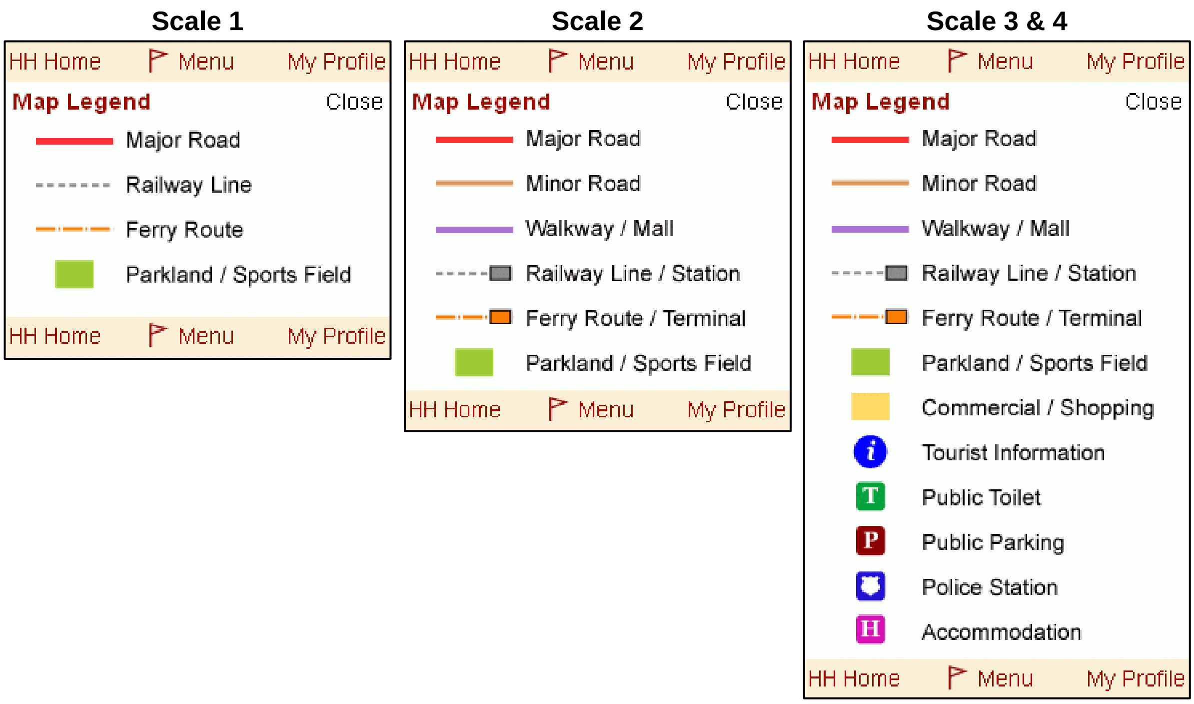

Figure 7.15 The contextual legend for the 'custom' map at each scale.

Having been a constant consideration during the map design process, upon its completion the use and combination of colours within the map display were tested to ensure that the representation was equally effective for colour blind and plain-sighted users (**ugJ**). To this end, an online tool named *Vischeck* (www.vischeck.com/vischeck) was employed to test how the map would look to humans with a range of colour vision deficiencies. A related tool – *Daltonize* (www.vischeck.com/daltonize) – then enabled various corrections to be made, accommodating certain colour vision deficiencies. The results of running *Vischeck* on the map design (see Figure 7.16 for examples) showed that the map's functionality and aesthetic appeal were not seriously degraded for people with Deuteranopia (a form of red/green colour blindness), Protanopia (another form of red/green colour blindness) or Tritanopia (a very rare blue/yellow colour blindness). Furthermore, corrections performed using *Daltonize* did not appear to produce significant improvement for colour blind users (example shown in Figure 7.17) – particularly when the associated loss of aesthetic appeal was considered. Therefore no changes to the map colours were deemed necessary.

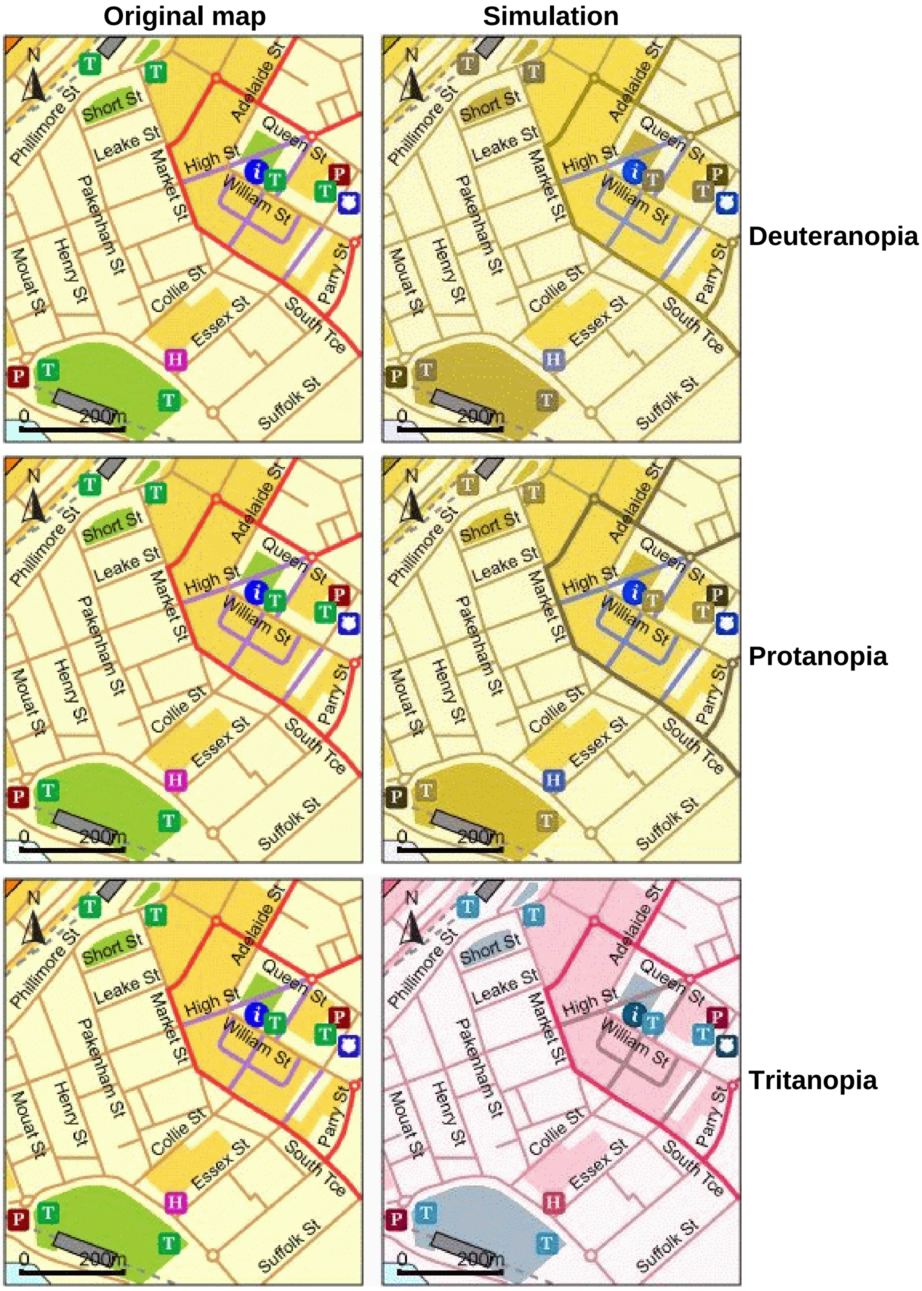

Figure 7.16 The appearance of the map display (Scale 3) for users with various colour vision deficiencies.

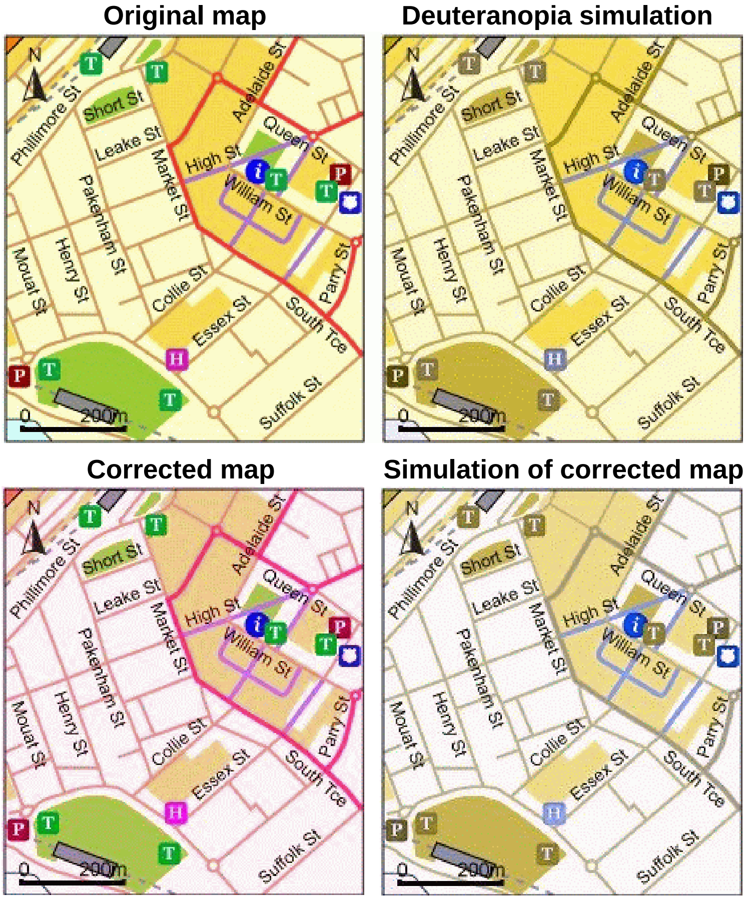

Figure 7.17 Medium-level correction and simulation of the map display (Scale 3) for users with Deuteranopia.

7.4.3.3 Module 4 – activity search (inputs)

Revisiting the preliminary design scenario, it was now time to focus the design activities on Module 4 which, according to Table 7.3, should enable users to search for and access information about 'things to do' in and around a location of interest. As with location searching, no specific information had been collected during the pre-design activities in terms of users' preferred methods for identifying things to do – apart from the need to relate pursuits to a particular location (**DP27**). The choice of input techniques was therefore again driven by the design aim of trialling and comparing a selection of alternative representation forms, with the final selection comprising: hierarchical list-based selection (natural language, touch, personalisation, hypermedia) and text entry (natural language, touch, personalisation) and a degree of interactivity.

The design of Module 2 had already provided for access to Module 4, in the form of a text-based link on the location summary page entitled 'Attractions, Events & Activities'. A search menu was thus formulated to appear upon selecting this link (Figure 7.18), incorporating access to the aforementioned location input techniques, along with two additional options and several shortcuts:

- *Browse by category* – hierarchical list-based querying of attractions, events & activities related to the current location;
- *Search by name* (originally called *Advanced search*, but renamed during the evaluation – see Section 8.2.2.3) – text entry for querying attractions, events & activities;
- *Local tips* (non-functional) – recommendations from local residents, operators and other tourists providing lesser known and/or fine-grained information about attractions, events & activities in and around the current location; and
- *View and compare shortlist* (discussed in the next section) – a list of attractions, events & activities (for the location of interest) saved by the user and managed within *My Profile*, allowing quick access and comparison.
- *Shortcuts* (**DP7**, **ugL**) – identical to those on the layout summary page (**DP4**, **DP25**), omitting 'Find things to do here'. Note, these shortcuts appeared throughout the attraction search pages.

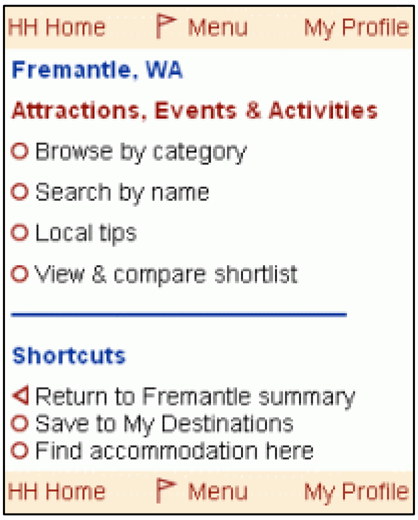

Figure 7.18 The 'attractions, events & activities' search menu.

The 'Browse by category' page (Figure 7.19a) listed eight categories, which was not the total number available, but rather a subset based on the current user's selection and storage of preferred 'attraction' categories within *My Profile* (**DP27**, **ugN**). Being a limited functionality simulation, the list was pre-populated (i.e. as if the user had configured it during a previous usage session), to include those categories considered to best match the persona upon which the preliminary design scenario was based. Below the initial category list was a text-based link to 'See more categories', thereby enabling users to expand their search as required (**DP1**, **DP14**) – this was incorporated in response to Cheverst *et al.* (2000)'s warning not to constrain the accessible information too rigidly. Selecting this link opened a new page containing the remaining categories, any number of which could be selected via their associated checkboxes (Figure 7.19b)

– note, the total category list was based on the main holiday activities of the target user group, which were identified during the user profiling and user task analysis. Once the desired categories were 'checked', the user could 'Continue' to the initial category list, which now additionally incorporated the specified categories.

Figure 7.19 The first level in the hierarchy when searching for an attraction/event/activity using list-based selection. The initial category list (a) is tailored to the user's preferences, while additional categories (b) are accessible.

Selecting a given category from the 'Browse by category' page opened a new list, this time comprising all of the attractions, events and activities related to the current location, that were classified under that category. Figure 7.20 shows the listing of 'Historic Sites' for Fremantle, covering three interlinked pages. From here, the user could select the desired attraction/event/activity about which to access information (**ugB**), or else choose to conduct a new attractions, events & activities search (e.g. if none of the listings were of interest – **DP6, DP17**).

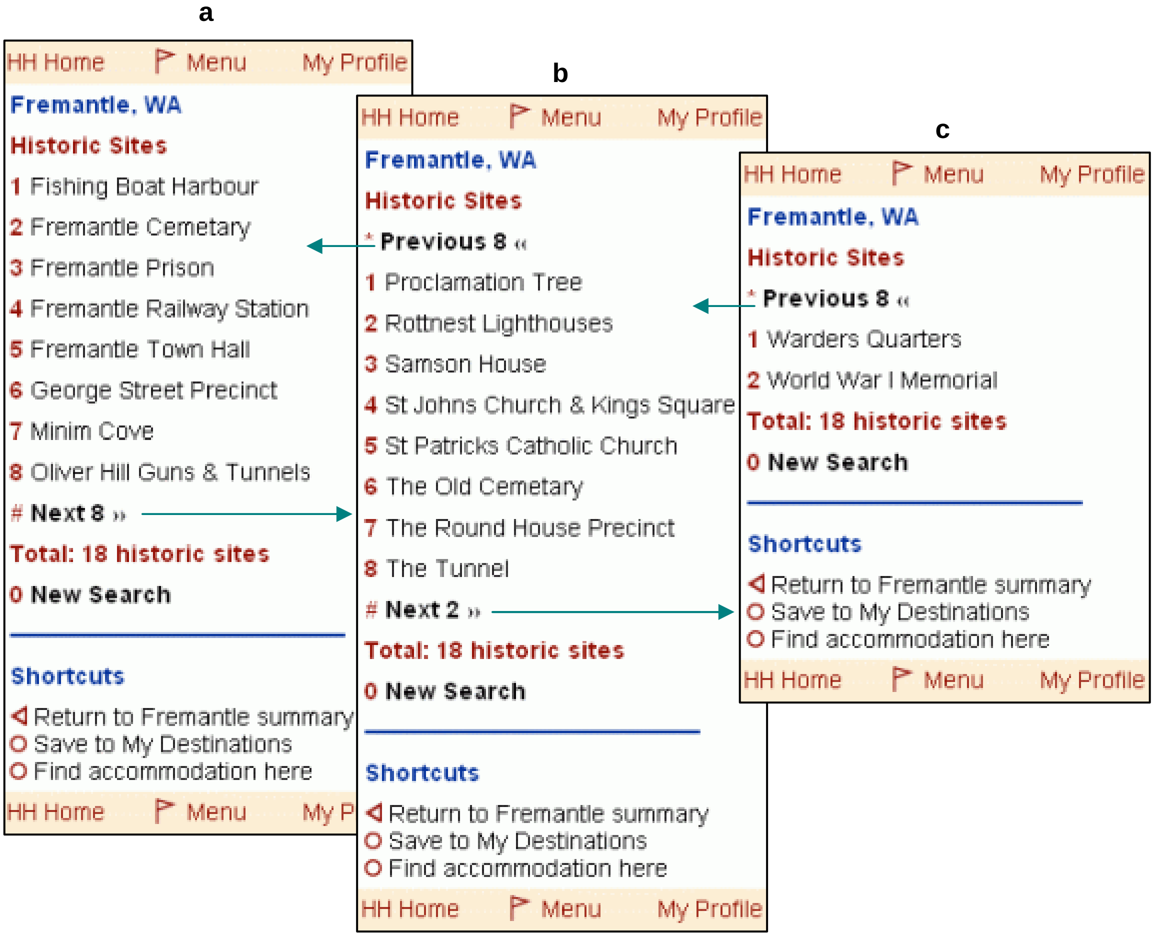

Figure 7.20 The second level in the hierarchy when searching for an attraction/event/activity using list-based selection: 'Historic Sites' in and around Fremantle.

The 'Search by name' page (Figure 7.21a) required the user to type in the name of an attraction/event/activity of interest (using a minimum of three characters) via the device's keypad. A further screen component – implemented as a 'dropdown' list (**DP12**) – additionally required the user to specify the category or categories to which the search would be limited[34], defaulting to those stored within *My Profile* (i.e. their personalised list). Selecting the 'Go' button then initiated a (simulated) search, producing a list of attractions, events and activities matching the text string and category/categories specified – Figure 7.21b – from which the user could physically select the desired attraction/event/activity about which to access information (**ugB**), or else choose to conduct a new attractions, events & activities search (e.g. if none of the listings were of interest – **DP6**, **DP17**).

[34] The available categories were limited to either 'All – unlimited' or one/all of those stored within My Profile. The user was also able to access additional categories on an individual basis via the 'See more categories' link.

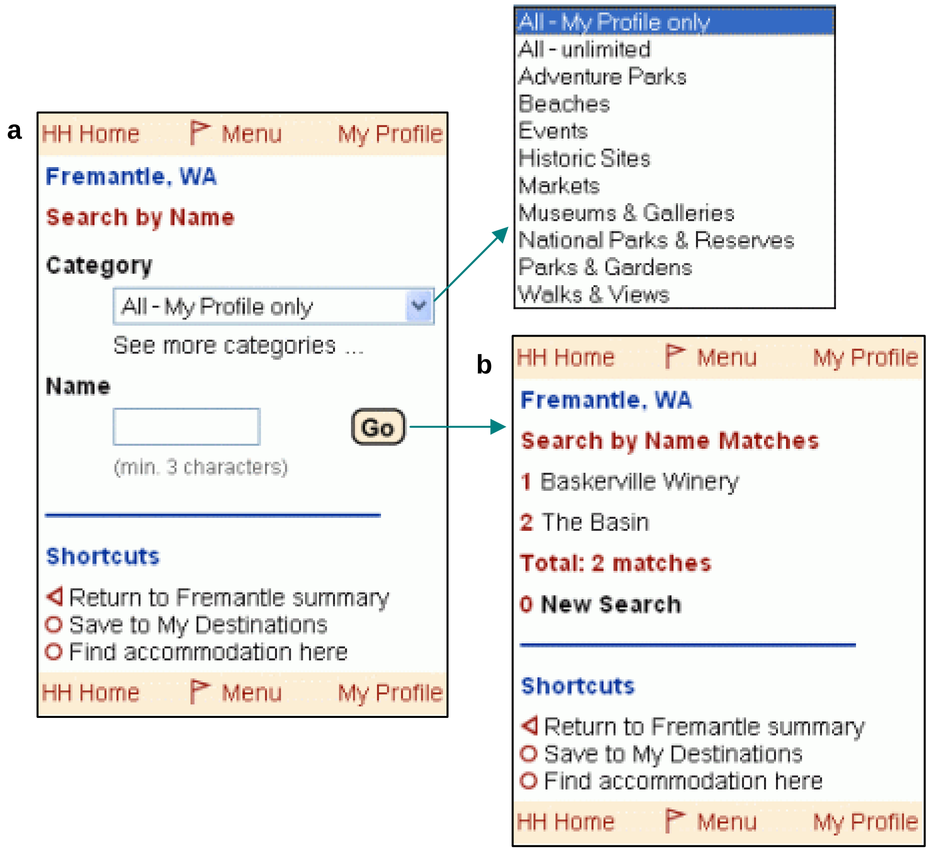

Figure 7.21 Searching for an attraction/event/activity using text input.

7.4.3.4 Module 4 – activities (outputs)

When approaching the design for Module 4's output, the user task analysis was consulted, highlighting a range of information (both geospatial and non-geospatial) required by target users in order to identify attractions/events/activities of personal interest and determine their accessibility – see Figure 6.9. The list comprised: the features of the pursuit; its location/ proximity (with respect to the location of interest and specific objects in the environment); the costs involved; relevant contact details; restrictions/limitations (e.g. operating hours); and requirements (e.g. bookings). Since Module 4 effectively formed a low level of the hierarchy providing information about a specific location (Module 2), it was preferable to keep each attraction/event/activity to a single page, where possible. This was intended not only to minimise the interaction required to access information of interest, but also to avoid users becoming 'lost' in the system, having already navigated through multiple search pages to reach this point (**DP1**, **DP23**). Similar to the location summary page, two different attraction/event/activity pages were designed, with the first comprising text and map-based outputs (natural language, base/ thematic/navigational maps), and the second incorporating text, map, voice *and* image outputs (natural language, base/thematic/navigational maps, map signs & symbols, photographs, multimodality) – refer to Figure 7.22a and b, respectively.

a


b


Figure 7.22 The attraction/event/activity page incorporating (a) text and map outputs and (b) text, map, image and voice outputs (note, maps and voice not shown).

The text on both versions of the attraction/event/activity page followed an identical format, beginning at the top of the page with a summary providing a high-level description of the pursuit, below which was a set of structured 'reference' information addressing the aforementioned requirements (**ugB**), written using language familiar to the target user population (**ugH**, **DP2**):

- **Location** – The address of the attraction/event/activity, incorporating a link to a map of its location.
- **Contact** – A phone number (or other method of contact) for finding out more information about the attraction/event/activity.

- **Facilities** – Pertinent features and services provided by/at the attraction/event/activity.
- **Entry** – Any costs that are involved in the attraction/event/activity.
- **Open** – Opening hours, including restrictions to such.

Next were a series of interactive text-based links providing a number of options, most of which were contextual (**DP27**) – i.e. their inclusion depended on the type of search that had been performed to arrive at the current attraction/event/activity:

- 'Add to shortlist' – allowed the user to save the attraction/event/activity they were currently viewing to *My Profile* for later reference (**DP3**); appeared only when the attraction/event/activity was not on the shortlist.
- 'Remove from shortlist' – allowed the user to remove the attraction/event/activity they were currently viewing from *My Profile*; appeared only when the attraction/event/activity was already on the shortlist.
- 'Browse <current category>' – returned the user to the category page from which the current attraction/event/activity was selected; appeared only when the attraction/event/activity was found via a 'category' search.
- 'Browse all categories' – returned the user to the 'browse by category' page listing the user's preferred category list (including any recently made additions); appeared only when the attraction/event/activity was found via a 'category' search.
- 'Edit Search' – returned the user to the 'Search by name' page (with the most recent criteria maintained); appeared only when the attraction/event/activity was found via a 'name' search.
- 'New Search' – returned the user to the 'attractions, events & activities' search menu; this link was always present.

Finally, at the base of the page were two shortcuts (**DP7**, **ugL**): the first – Return to <location> summary – took the user directly to the current location's summary page; while the second – Find a route to or from here – provided quick access to Module 5, enabling the user to determine a route involving the attraction/event/activity they were currently viewing (**ugC**).

The second version of the attraction/event/activity page (Figure 7.22b) additionally incorporated voice and image outputs, with the former narrating the page's text output (**ugG**, **CP12**): as soon as the page loaded, a voice automatically read aloud both the descriptive paragraph and the linked options (excluding the structured information in the middle of the page). The image output comprised a photograph of the attraction/event/activity, intended to provide additional, multimedia information about the potential pursuit (Almer *et al.* 2004; Gartner 2003). As mentioned previously, a text-based link on both versions of the page enabled the user to view an overview map for the current attraction/event/activity – this representation was included as an alternative to the text-based address for reasons similar to inclusion of the location layout map (Section 7.4.3.2). Clicking on this link opened a new page containing the map, a link to return to the attraction/event/activity page and the same shortcuts present on the attraction/event/activity page (Figure 7.23a).

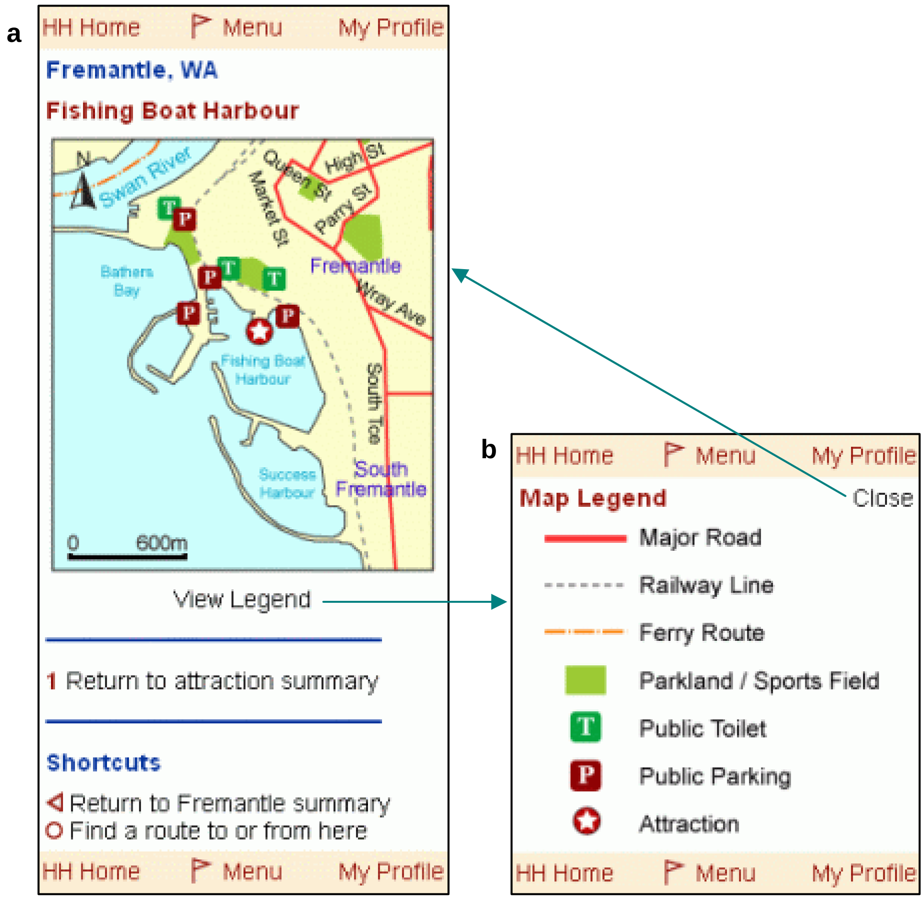

Figure 7.23 (a) Map-based output showing the location of an attraction/event/activity and (b) the accompanying legend.

While the map design was directly based on the 'custom' map created for Module 2, there were a number of minor deviations, resulting primarily from the different map purposes, but also a wish to vary certain aspects for comparison during the evaluation. The following describes the individual cartographic decisions made when designing the attraction/event/activity map for inclusion within the prototype:

- **Scale and area coverage** – since the intention of this map was to convey the location of the attraction/event/activity relative to the location of interest (and the proximity of other features in its immediate environment), the decision was made to design it as a static, non-interactive 'map image' of limited extent – i.e. the view could not be changed by panning, zooming or other manipulations. Each instance of the map would therefore require a fixed scale and area coverage that, while centred on the attraction/event/activity of interest, covered enough of the relevant location (i.e. town/city, region) in order that it could be readily identified (**CP1**).

- **Selection and refinement** – a sub-set of the 'custom' layout map features was selected for the attraction/event/activity map, based on what were considered to be most relevant to the map purpose and what could be feasibly included without overcomplicating the visual display (**CP1**, **CP2**, **ugF**):
  - land and water comprised the map 'ground';
  - major roads, railway lines and ferry routes gave a general picture of transport access methods to/from the attraction/event/activity (minor roads, railway stations and ferry terminals were omitted to simplify the display, which was not intended to aid navigation);
  - parkland, water bodies and road names provided recognisable landmark-type context for the attraction/event/activity within its surrounding area (commercial land use was not considered to be as readily apparent in the real world and would have only served to clutter the map); and
  - public toilets and parking were the only point symbols included (apart from a new symbol representing the attraction/event/activity itself – see *Symbolisation*), informing on the location of 'essential' nearby facilities (tourist information, police stations and accommodation were considered superfluous to the map purpose).
- **Symbolisation** – the design of a new point symbol representing the attraction/event/activity upon which the map was based, had similar aims to the POI design for the layout map – i.e. familiarity/self-description (**CP10**, **ugK**) and low complexity, whilst remaining at the highest visual level (**CP6**, **CP7**, **CP14**). Again this was achieved through careful selection of symbol shape, size and hue, with the ultimate goal being to design a 'focal' symbol that was more visually important than all others within the map display. The final attraction/event/activity symbol comprised a small filled circle (the same size as that used to represent tourist information on the layout map), which was coloured dark red with a black border, and had a large white star in its centre.
- **Marginalia** – as identified earlier, pan and zoom tools were intentionally omitted from the map marginalia. Whilst a legend was included (Figure 7.23b), incorporating only those features included on the attraction/event/activity map (**CP3**, **CP5**, **ugF**, **ugM**), the text-based link via which it was accessed was placed in a different position here compared with the layout map: where the 'View Legend' link was located above the top right corner of the layout map display, that for the attraction/event/activity map was centred on the page directly below it.

Although not explicitly part of the preliminary design scenario (nor a specific user requirement), an initiative was taken by the research to provide users with the ability to directly compare various features of different attractions, events and activities (**ugO**), thus facilitating the decision-making process when scheduling and/or choosing between different pursuits (**DP3**, **ugB**). This led to the design of a final set of outputs for Module 4, centred on the 'shortlist' concept introduced earlier – i.e. a list of attractions, events and activities saved by the user for later reference. The 'View and compare shortlist' option on the 'Attractions, Events & Activities' search menu (Figure 7.18) was the pre-determined entry point for this new functionality, providing access to a page listing each of the shortlisted items, along with an option to 'Compare' them (**DP26**) – refer to Figure 7.24a. Further down the page (and throughout the rest of the comparison pages) was a 'New Search' link, which returned the user to the 'attractions, events & activities' search menu, as well as three shortcuts, all of which have been described elsewhere.

Figure 7.24 The attraction/event/activity shortlist menu (a) and the shortlist comparison menu (b).

While each item on the shortlist was linked to its own version of the attraction/event/activity page, the 'Compare attractions' option opened a menu page offering five alternative comparison types (Figure 7.24b). Three of these options – Location, Proximity and Cost – were based on the two personal criteria constraints affecting users' selection of pursuits while on holidays, which were identified within the AND/OR graph corresponding to Module 4 (Figure 6.9). While 'Minimise monetary costs' naturally gave rise to the concept of *Cost* comparison, 'Maximise time available for travel' yielded *Location* and *Proximity* as comparison methods to support the optimal scheduling of attractions/events/activities (i.e. by enabling users to order/group pursuits), with the two differentiated as follows:

- Location – comparison of the relative location of each attraction/event/activity.
- Proximity – comparison of the absolute distance (linear or time-based) between each attraction/event/activity and a specified location.

The two remaining comparison options were conceptually based on additional information conveyed by each attraction/event/activity page: *Facilities* enabled the features and services of different pursuits to be contrasted, while *Availability* provided for a time-based comparison relating to when each attraction/event/activity could be visited.

For the purposes of the preliminary design, only one comparison type was required for inclusion within the prototype, with the choice falling to those having geospatial relevance – i.e. Location, Proximity and Availability. Ultimately *Location* was selected, for no other reason than that it was expected to be the simplest in terms of comparing information, requiring nothing beyond the location of each attraction, event and activity on the shortlist (simplicity was a key aim for the prototype, especially at this early stage – **DP1**). Two alternative output techniques were then selected for the location comparison: text-based (natural language, interactivity) and map-based outputs (base maps, map signs & symbols, adaptation, interactivity).

Upon selecting the *Location* comparison option, the user was presented with text-based output (Figure 7.25), comprising the names of the shortlisted attractions/events/activities, along with their addresses (to street level, where available) – note, the shortlist numbering was consistent with that on the 'shortlist' menu (**DP4**, **DP13**, **DP25**). Two options were included below the names and addresses: the first – 'View map' – provided access to the map-based location comparison output; while the second – 'Change comparison' – returned the user to the 'shortlist' comparison menu, thus allowing them to easily select a different comparison type (**DP6**, **DP7**, **DP14**, **DP17**).

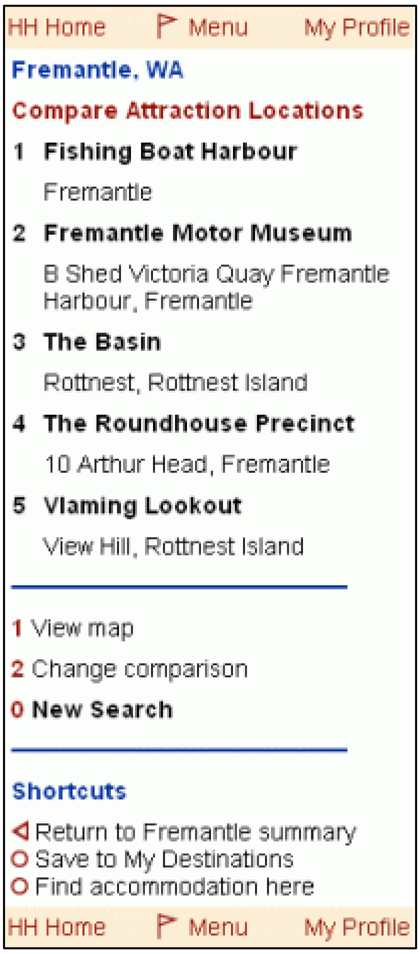

Figure 7.25 The text-based location comparison.

Selecting 'View map' presented the user with a page containing a simplistic overview map showing the location of each attraction/event/activity on the shortlist (Figure 7.26a) – note, this map was also considered *egocentric* (Reichenbacher 2005a, p.152; Meng 2005b) due to its design being directly tied to the immediate task at hand (i.e. comparing locations). Below the map was a quasi-legend, incorporating checkboxes allowing users to select which shortlist items to show on the map (with all 'checked' for display by default). Clicking on the 'Reload map' link refreshed the map, taking into account the quasi-legend selections (Figure 7.26b). Finally, two options included below the map and quasi-legend provided access to the text-based location comparison output ('View text') and the 'shortlist' comparison menu ('Change comparison').

Again, the map design was based on the 'custom' map created for Module 2, however in this case very little detail was required, based on the map's simple purpose of conveying relative locations between selected attractions/events/activities. Specific cartographic decisions made during the map's design involved the following:

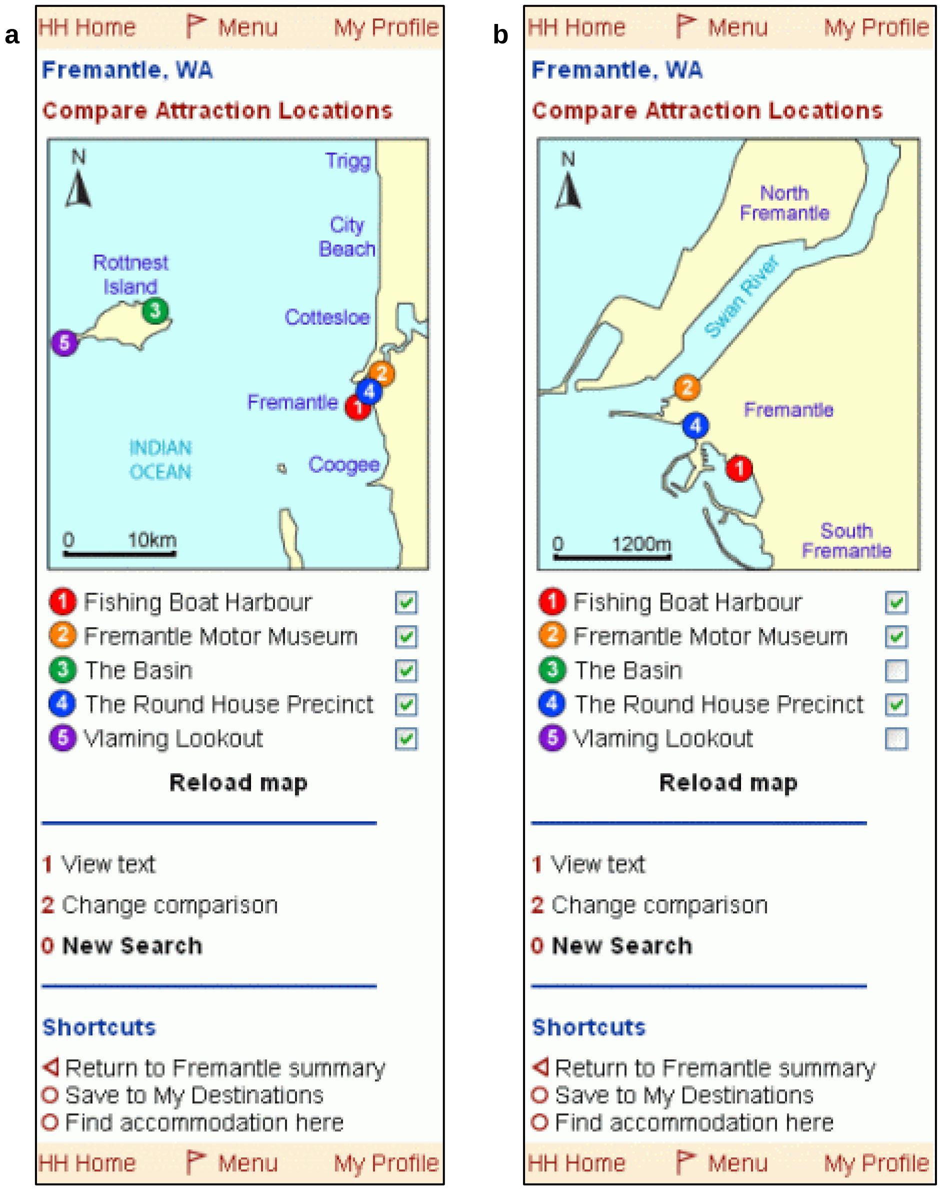

Figure 7.26 The map-based location comparison showing (a) all attractions/events/activities and (b) only selected attractions/events/activities.

- **Scale and area coverage** – since the user could select any combination of attractions/events/activities for display on the map, its scale and area coverage had to be dynamic, adapting to 'fit' all selected items within the display each time the map was reloaded (**CP1**). The decision was made to also decrease the scale once calculated – i.e. beyond the best fit to selected attractions/events/activities – in order to provide slightly more context for the displayed locations. This is illustrated (in hindsight, using too small a scale) by Figure 7.26b.
- **Selection and refinement** – again the map purpose required only minimal features to be included within the design (**CP1**, **CP2**), comprising: land and water (as the map 'ground'), point symbols representing the selected attractions/events/activities (satisfying the map's aim – **ugB**), and labelling of towns/cities and water bodies (to provide locational context).

- **Generalisation** – some displacement of overlapping point features (i.e. attractions/events/activities) was required to ensure that each was clearly visible (**CP2**).
- **Symbolisation** – the point symbols representing each attraction/event/activity were again designed with the aims of familiarity/self-description (**CP10**, **ugK**) and low complexity. The general simplicity of the map, however, meant that little effort was required to ensure that these features were at the highest visual level (**CP6**, **CP7**, **CP14**). Since the purpose of these symbols was simply to represent the location of a specific entity, with no other qualitative or quantitative information conveyed, it was important that they each had a similar appearance while being distinguishable from one another. This was achieved through keeping a constant symbol size and shape (a small filled circle) but varying the hue using contrasting colours[35] (**CP3**). To further aid in their differentiation (while supporting colour blind users – **ugJ**), each symbol additionally included a white number in its centre, corresponding to the attraction/event/activity numbering on the 'shortlist' menu (**DP4**, **DP13**, **DP25**).
- **Marginalia** – the decision was made not to provide explicit interaction tools for panning or zooming the map, which was intended for the comparison of locations and not for navigation or other geospatial activities requiring its manipulation. In fact, the inclusion of a quasi-legend below the map enabled a degree of pan and zoom functionality, with the scale and centre point adapted each time the map was reloaded following one or more attractions/events/activities being checked/unchecked (**CP16**). The quasi-legend itself comprised only the symbols representing attractions/events/activities, with the simplicity of the map content negating the need for a more formal legend (**CP5**). It is important to note that the quasi-legend was designed to list **all** of the attractions/events/activities on the shortlist, regardless of those currently displayed. This was done so that the user could easily see what was on their shortlist and/or change the map display without having to return to a previous menu (**DP6**, **DP17**).

✧ ✧ ✧ ✧

At this point, the scope of the design and development efforts was re-assessed, partly to address time constraints, but also to ensure that the prototype was not too extensive to allow for sufficiently in-depth evaluation. The result of this was a decision to defer the outstanding design of Module 1 until the next design iteration, with the expectation that doing so would enable greater focus on the existing design components during the evaluation and thus the potential to

[35] The Web Safe colours used to differentiate the five attractions/events/activities in the prototype were: red, orange, green, blue and purple.

generate richer, more detailed evaluation results. Furthermore, in terms of addressing the design aims, it was considered that the prototype in its current state:

- possessed sufficient content and functionality to support the evaluation of (qualitative) conceptual models of users' goals, tasks and requirements – specifically those relating to the goals 'Obtain overview of location(s)' and 'Find things to do / of interest';
- utilised all but one of the alternative cartographic representation, presentation and interaction techniques initially selected for trial and comparison through the preliminary design; and
- supported an initial specification of cartographic UI design models for a DHR travel mLBS.

In terms of the existing design components, this decision had little impact – mostly resulting in prototype links being omitted (e.g. an option to search for a location in Module 2 based on the user's current location) or remaining non-functional (e.g. the 'My Current Location' button on the Main Menu). Changes to the preliminary design scenario were required, however, with only the first three sentences retained for the evaluation (refer to Section 8.2.2.2)[36].

7.4.3.5 Module 2 – location weather (outputs)

As mentioned above, limiting the design scope to the prototype's current state meant that a single cartographic representation technique from the initial selection had been omitted: *animation*. Although this could have potentially been incorporated into the design of Modules 1 and/or 5, that was not an option for the reasons given above. A simple solution was found by extending the design of Module 2 to utilise animation in the communication of geospatial information relating to a location's weather (**CP11**). Since this was only a small addition to the prototype, serving to provide extra information about the location of interest (**ugA**), it was not expected to adversely impact on the effectiveness of the evaluation. The preliminary design scenario did require some minor editing, however, to cater to this change (refer to Section 8.2.2.2).

Referring back to the location summary page (Figure 7.10), this was designed to incorporate text-based links to more-detailed location information, including one entitled 'Climate & Weather' – a logical entry point for the prototype's final functionality (**DP21**). To again maintain consistency with other pages in the system (**DP4**, **DP13**, **DP25**, **ugO**), the decision was made to present an initial 'summary' page upon entry into the weather and forecast component, from which the user could then access further weather-related information, should they require it. A single version of the summary page was designed (Figure 7.27), incorporating a brief, text-based overview of the

[36] Note, the final sentence of the scenario – "*You then ask the service to guide you back to your hotel*" – was also removed at this time based on the scope decision detailed in Section 7.3.2 which excluded route guidance from the research.

location's climate/weather, below which were a series interactive text-based links providing pathways to more detailed information on various aspects of the weather (**ugE**):

1. *Weather & forecast* – current and forecasted weather conditions.
2. *Current Warnings* (non-functional) – any weather warnings currently being broadcasted.
3. *General climate* (non-functional) – general weather patterns (e.g. annual temperature, rainfall) for the region.
4. *Local tips* (non-functional) – lesser known and/or fine-grained information provided by local residents, operators and other tourists pertaining to the local weather and climate (e.g. months during which 'The Fremantle Doctor' blows).

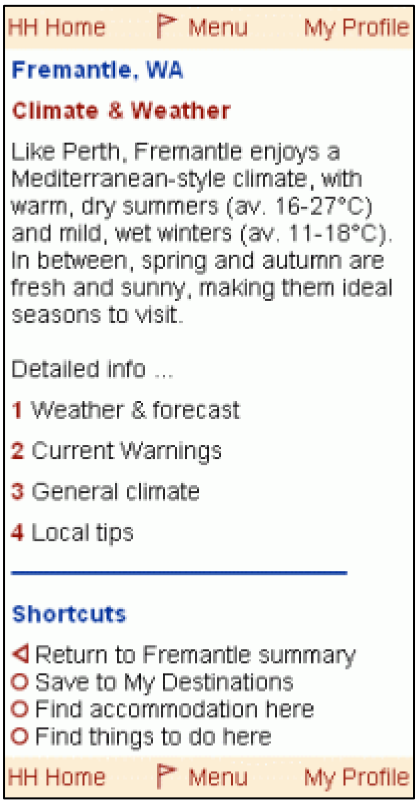

Figure 7.27 The climate & weather summary page.

At the base of the page (and throughout the rest of the weather information) were four shortcuts, all of which have been described elsewhere.

The focus of this part of the design was primarily to trial animation as part of a cartographic representation, with the decision made to do so using an animated map of rainfall observations covering a recent time period. To this end, the content for the 'weather & forecast' option was designed, with the end result comprising two versions of a page informing on current weather measurements – temperature, humidity, wind and rainfall – as well as the weather outlook for the next five days – conditions and temperature. While each version incorporated largely text-based output and a number of recognisable weather diagrams/icons (**DP20**, **CP10**), the main distinguishing factor concerned the rainfall information: where one version (Figure 7.28a) comprised a text-based description of the current rainfall situation, in clear, non-technical language (**ugH**), the other (Figure 7.28b) provided a link to the animated map-based output.

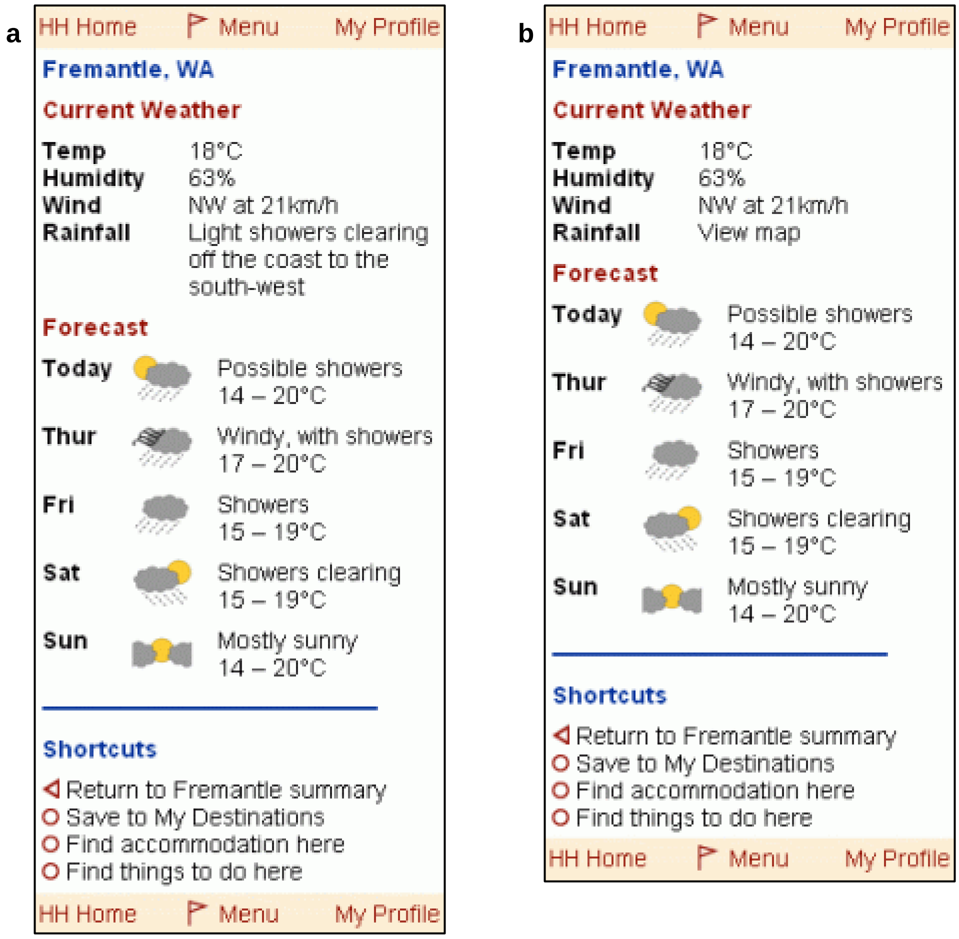

Figure 7.28 The weather & forecast page incorporating text-based and diagrammatic outputs.

The animated rainfall map shown upon selection of the 'View map' link (Figure 7.29) was not designed for or by the research, being sourced from the Bureau of Meteorology website[37] (therefore it was potentially familiar to members of the target user group). Specifically it comprised a looping sequence of four sequential map images conveying rainfall radar observations made within a 50km radius of Perth, over a 30 minute period (**CP11**). Below this was a legend enabling interpretation of the rainfall symbols. As with the 'sourced' layout map this representation was not modified in any way for the research, with its cartographic design considered sufficient for the purpose of evaluating the animation's effectiveness. A brief cartographic review, however, uncovered a number of issues with the map's design:

[37] Under the conditions of the original copyright (www.bom.gov.au/other/copyright.shtml) and disclaimer (www.bom.gov.au/other/disclaimer.shtml) relating to the use of Bureau of Meteorology materials.

- Level of detail (**CP1**, **CP2**, **CP4**) – the scale was too small, and the area coverage too wide for the map's purpose and presentation medium, leading to potential difficulties in identifying rainfall symbols; the inclusion of topography was superfluous and distracting, with respect to the map's purpose, while being largely ineffective when viewed on a small screen (mainly due to insufficient contrast between the colours representing higher elevations).
- Colour (**CP3**, **CP6**) – some of the colours used to represent rainfall were overly similar to those employed for topography, having the potential to cause confusion during the map's interpretation (note, topography was not included in the legend).
- Typography (**CP3**, **CP15**) – the font used to label towns/cities resulted in poor legibility, while the text size was too small for the presentation medium.
- Marginalia (**CP5**, **CP16**) – the 'target-like' scale spread across the map display was difficult to see on a small screen, mainly due to its colour (the same as that used to represent the coastline and similar to that used for topography) and its obscurement by several town/city labels.

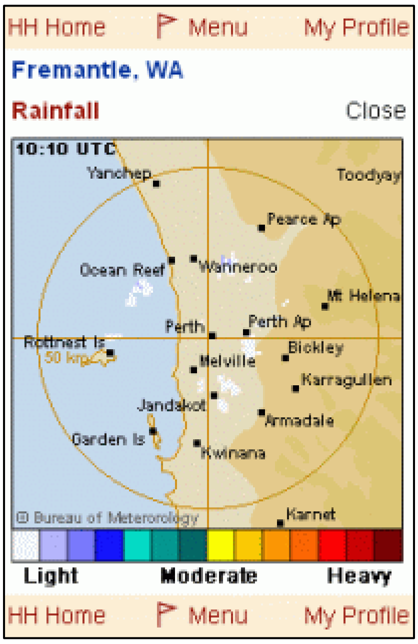

Figure 7.29 The rainfall page incorporating animated map-based output.

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This completed the cartographic UI design for the prototype which, along with the overall system structure and design, comprised an initial specification of cartographic UI design models for a DHR mLBS application. Note, the preliminary design prototype is included in its entirety on the attached CD (go to \Preliminary Design\index.html).

7.5 Preliminary Cartographic UI Design Models

Whilst the previous sections describe the preliminary design in detail, it was considered useful to additionally develop a more manageable high-level summary, particularly for the purposes of communicating the research results. To this end, flow diagrams were created to demonstrate the design's structure including the complete system flow and, most importantly, the alternative cartographic representation techniques included for comparison. Once complete, the flow diagrams embodied the preliminary cartographic UI design models for the research – presented in Figure 7.30 and Figure 7.31.

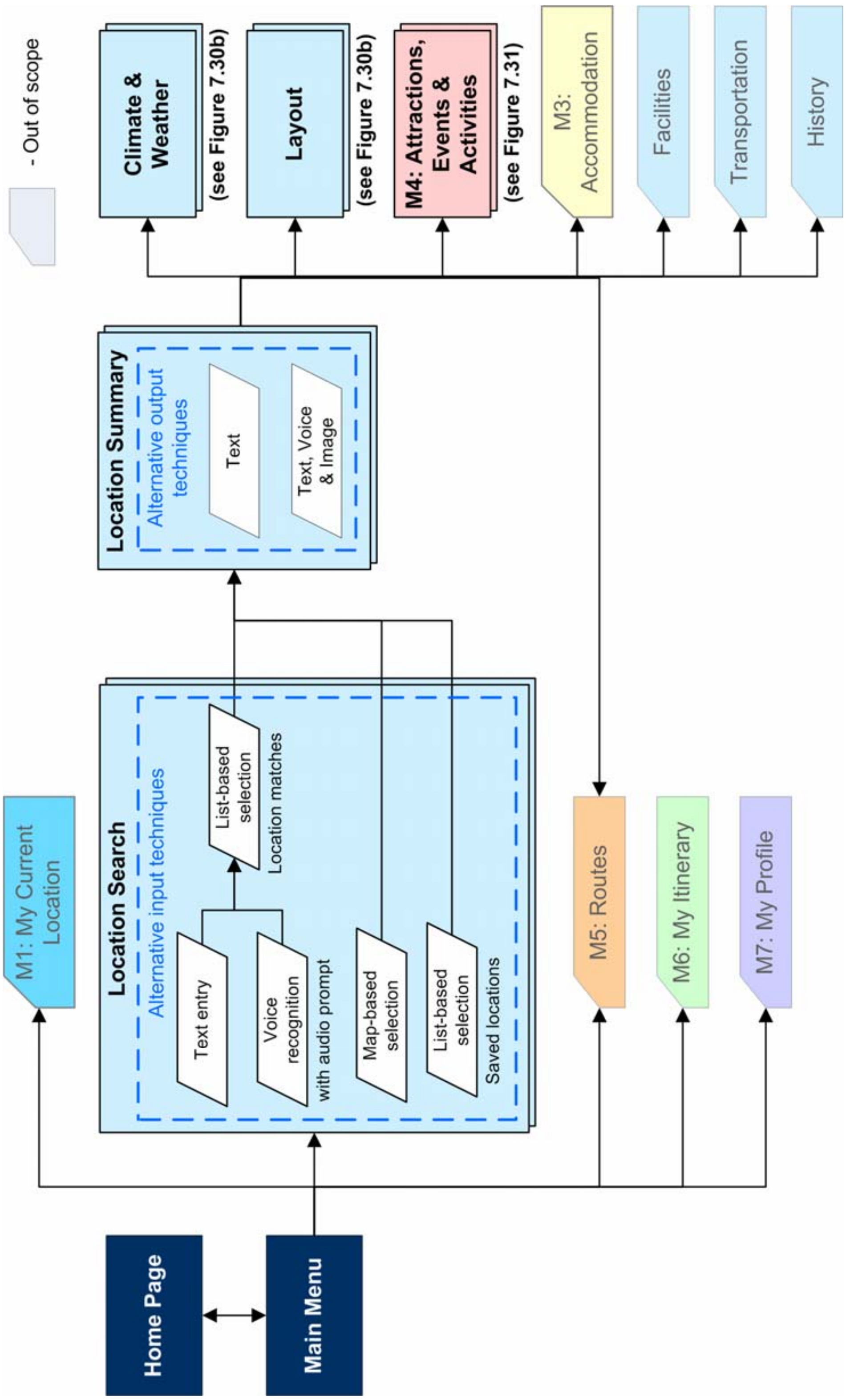

Figure 7.30(a) Segment of the preliminary design models showing the structure of the Main Menu and the highest level within the Module 2 information hierarchy (note, universal links to *My Profile* and the Main Menu are not shown).

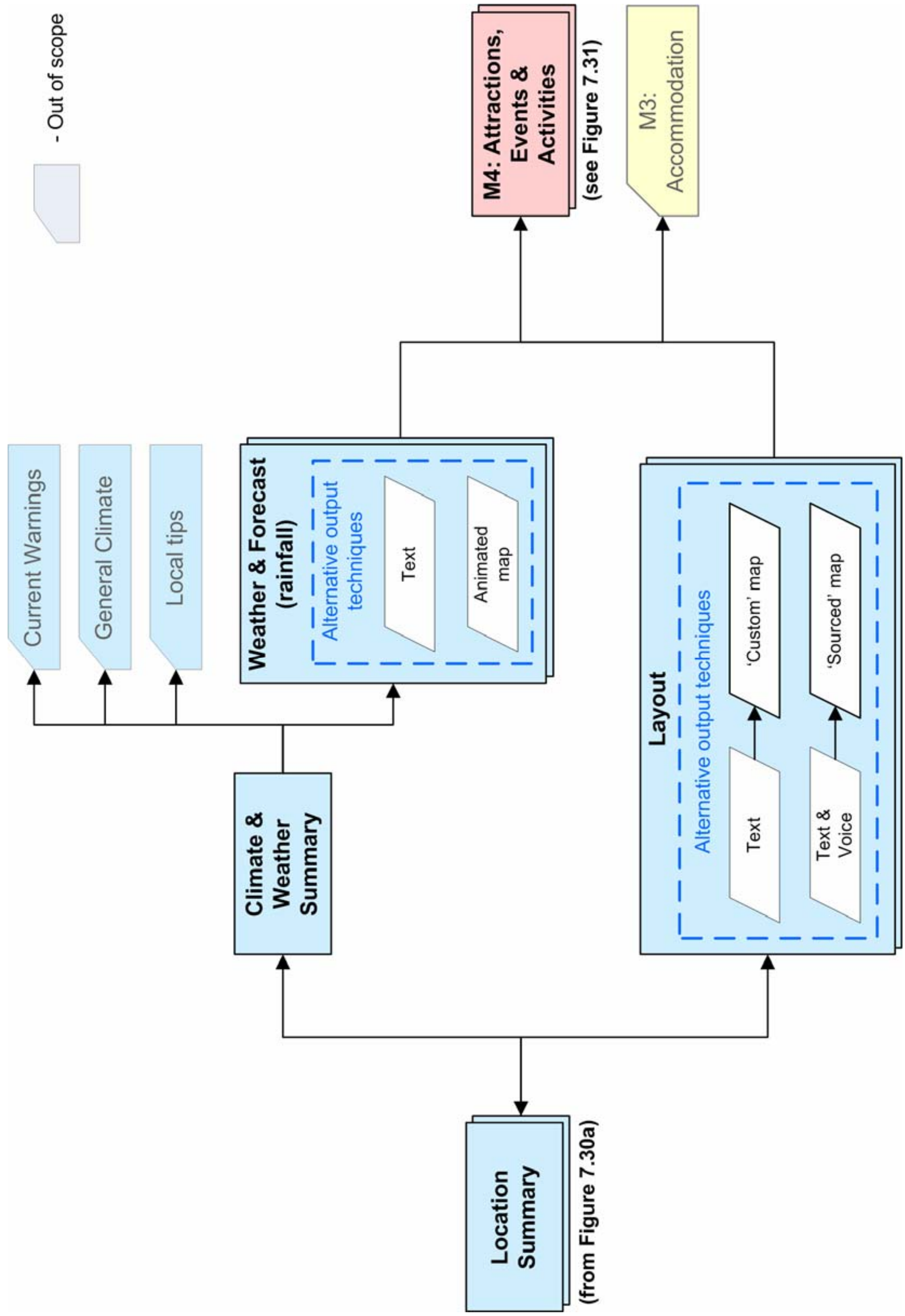

Figure 7.30(b) Segment of the preliminary design models showing the structure of the lower levels within the Module 2 information hierarchy (note, universal links to *My Profile* and the Main Menu are not shown).

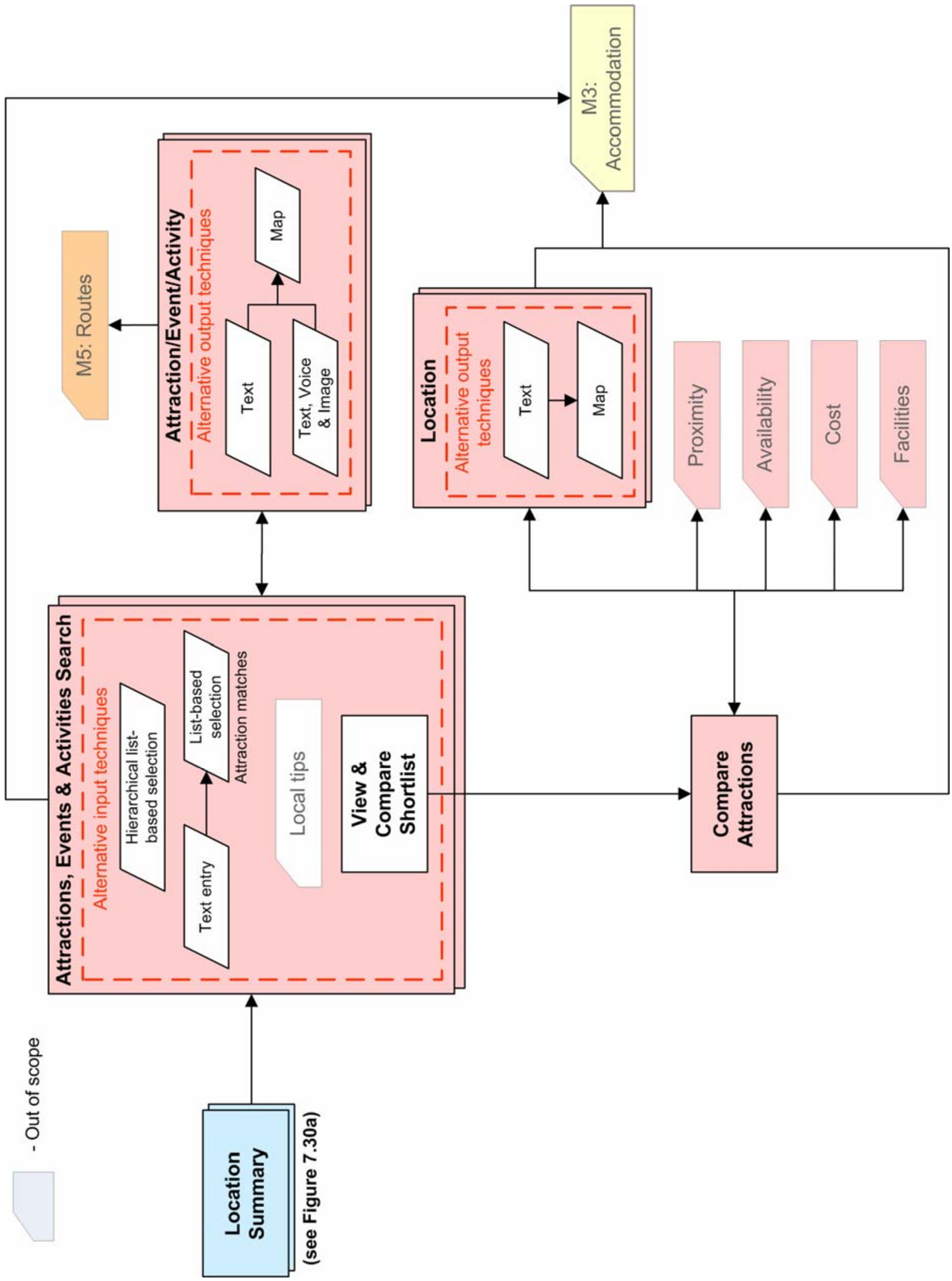

Figure 7.31 Segment of the preliminary design models showing the structure of Module 4 (note, universal links to *My Profile* and the Main Menu are not shown).

7.6 Discussion

With the preliminary design now complete, it was ready to be evaluated. Before the evaluation process is described, however, it is useful to briefly reflect on the design process with particular emphasis on the effectiveness of the procedures involved.

UI design is considered a largely creative and inherently difficult process (Myers 1994). Indeed, developing the preliminary design for the research was a process of exploration and discovery, having no real 'rules' to follow in the translation of complex pre-design outcomes into design specifications. In this respect, advice was taken from Hackos & Redish (1998) who recommend "immers[ing] yourselves in the information, generating design ideas, prototyping, testing, and iterating the process until you meet your usability and quality goals for the product" (p.345). The ultimate approach was not entirely free-form, however, with several specific techniques employed to assist in the design's evolution, while adding structure and credibility to the results.

The first of these was the design's basis on a realistic scenario of use, which was generated by the user task analysis. Some of the advantages of this approach specifically encountered during the design process included the scenario's ability to: fix the design problem and so raise questions for the design to address; encourage reflection throughout the design activities; and be easily revised/elaborated, to allow for changing requirements (Carroll 2000). A weakness often attributed to using scenarios as a driver for design is that "they are not engaging" (Grudin & Pruitt 2002). This was the justification behind involving personas in the preliminary design process, since these serve to augment a further benefit of scenario-based design – evoking empathy for users in a realistic situation of use. Despite the preliminary design scenario having been 'neutralised' prior to the design activities, each of the research personas (including the one on which it was based) were 'consulted' throughout the design process to ensure that their individual goals and needs were being met. This was of particularly value during the design of the system structure (Section 7.4.1).

Second, was the focusing of design efforts through the development and guidance of a set of qualitative usability goals. While it is usual to set both qualitative *and* quantitative usability goals prior to most design activities (Mayhew 1999), with the latter used as acceptance criteria during the design's evaluation, the exploratory aims for this stage of the research dismissed the need for setting objective and/or measurable goals. Instead, the emphasis was placed on using qualitative usability goals drawn from the user profile and user task analysis to drive and assess all cartographic UI design decisions, thereby addressing the use context and requirements of the target user population. Prioritising these goals was of additional benefit, enabling greater concentration on those considered most vital to achieving the design aims, with each of the second-priority goals also variably addressed in the final preliminary design. Augmenting the qualitative usability goals, a third technique employed during the design process was an adherence to established design principles, which involved collecting and applying fundamental guidelines for the design of: (a) UIs in general; (b) mobile interfaces; (c) traditional cartographic products (i.e. conventional paper maps); and (d) digital maps incorporating interactivity, dynamism, multimedia and real-time data delivery. This was approached with the knowledge that while following established usability principles would not guarantee the design's success – since such theories and guidelines can only ever cover limited aspects of a design – it would aid in making deliberate and conscious decisions rather than producing designs based on opinion and personal preference (Myers 1994; Liu 1997; Constantine 2000).

Fourth, was the creation and documentation of a design rationale (Section 7.4), providing a detailed account of the decisions underlying the UI design, in particular the contributions made by the aforementioned preliminary design scenario, research personas, qualitative usability goals and design principles and guidelines. Effectively representing an "audit trail", the design rationale was included to make transparent the reasoning behind various aspects of the preliminary design – including the investigation of/choices between different alternatives and the context within which specific decisions were made – which was important should its foundations ever be questioned or clarification required, such as during subsequent design iterations (Nielsen 1992, p.19; Dix *et al.* 1998). Furthermore, an additional benefit resulted from the very act of producing the design rationale, which encouraged greater reflection and more careful deliberation over every decision made (Dix *et al.* 1998).

The fifth and final technique of note was the exploration of design ideas through a limited functionality prototype, which also served as the design specification medium. The decision to define the design in this way was based on consideration of both the design aims and the resources available, with the result being a 'working' application that embodied each of the preliminary design decisions. An additional benefit of this close association was the prototype's subsequent value in the ensuing evaluation as a tool that allowed representative users "to interact with, visualize and comment on the future design" (Maguire 2001, p.604). While the prototype's simulation status meant that it was constrained by a lack of real data and therefore provided for only limited paths of interaction with the system (Nielsen 1993), it was considered sufficiently detailed and functional to achieve the preliminary design and evaluation aims, at the same time being a fast and simple tool for generating the design. Moreover, it was able to be designed such that it would be easily modified during redesign activities (Liu 1997).

7.7 Chapter Summary

This chapter has described the process by which preliminary design models for representing, presenting and interacting with geospatial information via a DHR travel mLBS were produced. The box below summarises the major steps involved, in addition to the outcomes. Overall, the design process was considered a success, commencing the specification of cartographic UI design models for a DHR travel mLBS – preliminary design aim (c) – in a form that could be evaluated by real users. The inherent difficulties of designing a UI were recognised, however, leading to the knowledge that the preliminary design models may not be beneficial for all users (Myers 1994). This was the primary reason behind employing a process of iterative design and evaluation as part of the overall UCD process – i.e. to assess the effectiveness of the design for different users, and improve on it as required. The next chapter describes the process by which the preliminary design was evaluated through empirical usability testing involving representative users.

- A set of qualitative usability goals were derived from the results of the user profiling and user task analysis phases, for use in focusing and assessing all design decisions.
- The aims for the preliminary design and its subsequent evaluation were established to be:
  - **(a)** evaluate initial (qualitative) conceptual models of the users' goals, tasks and requirements;
  - **(b)** trial and compare a preliminary selection of alternative design techniques for representing, presenting and interacting with geospatial information; and
  - **(c)** commence the specification of cartographic design models for a domestic holiday-related travel mobile Location-Based Services.
- A scenario-driven approach for the preliminary design process was chosen to provide guidance in achieving the largely exploratory design aims, while addressing the goals and requirements of the research personas.
- A limited functionality prototype was chosen to both specify the design and enable its evaluation. The development environment selected for this was the XHTML Mobile Profile v1.1, implemented within the Internet Explorer Mobile browser of an i-mate™ SP5. The capabilities and constraints of this platform were defined prior to beginning the design.
- The design process was conducted in accordance with the prioritised qualitative usability goals, as well as established UI and cartographic design guidelines and principles, with all decisions documented in the design rationale.
- The end result comprised a set of preliminary design models and a semi-functional prototype embodying the design in a form that could be evaluated.

8 Evaluating the Preliminary Design

8.1 Introduction

> *"a true understanding of a tool can only come through usage, in part because new tools change the system, thereby changing both needs and requirements"* Donald Norman (quoted in Myers 1994, p.76).

With the preliminary design now generated and embodied within a prototype, the next step was its empirical evaluation by real users to ensure that their requirements, where still applicable, had been met (Nielsen 1992). Being the fourth major component of UCD (Figure 4.1), the primary aim of this was to collect valuable feedback on the cartographic design for use in its refinement and improvement, towards the ultimate goal of optimising its usefulness for the target user group. This chapter describes the evaluation of the preliminary design, beginning with the selection of an evaluation technique (Section 8.2), before moving onto its preparation and conduct (Section 8.2.2) and a comprehensive analysis of the evaluation findings (Section 8.3). The remainder of the chapter presents the major outcomes, in the form of a set of design recommendations (Section 8.4), before discussing the effectiveness of the evaluation and the implications of its results (Section 8.5) in preparation for the next design iteration.

8.2 Data Collection

8.2.1 Evaluation techniques

To evaluate the preliminary design, a number of UCD techniques were available, categorised as either empirical usability testing or usability inspection methods (Butler 1996). *Empirical usability testing* – "the most fundamental usability method" (Nielsen 1993, p.165) – involves the collection of data relating to a set of usability parameters during observations of target users interacting with the design (i.e. via a prototype) to perform representative tasks (Butler 1996; Rubin 1994). *Usability inspection methods*, on the other hand, are less formal techniques involving 'inspection' of the design by various evaluators, including usability specialists, human factors experts, designers, developers and (occasionally) users, to identify usability problems (Nielsen & Mack 1994)[1].

[1] There are eight usability inspection methods: heuristic evaluation, guideline reviews, cognitive walkthroughs, pluralistic walkthroughs, feature inspections, consistency inspections, standards inspections and formal usability inspections (Nielsen & Mack 1994).

Whilst research has shown that usability testing can uncover problems that are overlooked by inspection methods and vice versa (Jeffries *et al.* 1991) – implying that optimal results may be achieved through a combination of both, at various stages of the development process (Nielsen & Mack 1994; Butler 1996) – only empirical usability testing methods were selected for the purposes of the study. This decision was made based on the fact that inspection methods largely entail the evaluation of a design by *project team members* and/or *usability expects*, with minimal user involvement (indeed, this only occurs with pluralistic walkthroughs). Conversely, usability testing involves a design's evaluation by *representative users*, and since the aim of the research is to produce cartographic UI design models that are considered useful by the target users, based on their evaluation of alternative representation techniques, empirical usability testing was deemed most appropriate. Furthermore, usability inspection methods rely heavily on the assessment of a design with respect to established usability principles and standards. But as Section 7.3.5.1 identifies, despite the availability of abundant desktop Web and software design guidelines, there are few widely-accepted standards available for the design of mobile services, in particular the design of UIs for the mobile medium. This suggests that any inspection methods employed would be based on guidelines established for other mediums, which is undesirable.

8.2.2 Empirical usability testing

There are various approaches to usability testing, generally distinguished by the stage at which they are conducted during the design and development process. Two different classifications were consulted for the research. Table 8.1 provides a summary of these and the correlation between them.

Referring back to the aims for this phase of the research (Section 7.3.1), and based on the early stage of the design and development cycle, a combination of *exploratory testing* and *formative evaluation* was considered the most appropriate approach. Specifically, exploratory testing was selected due to both the preliminary nature of the design, which was intended to evaluate conceptual models of the users' goals, tasks and requirements, and the fact that it had not undergone any previous evaluation. Closely associated with this, formative evaluation was also deemed applicable since only certain aspects of the UI were being tested (i.e. cartographic representations and limited system components) – as opposed to the overall quality of the interface – while information was sought concerning ways of improving the still-evolving design. Additionally, the evaluation was also planned to involve an element of *comparison testing*, due to the aim of trialling and comparing the usefulness of alternative cartographic design techniques. Indeed, according to Rubin (1994), exploratory and comparison tests are commonly combined –

mainly to avoid early commitment to a single design which may be later found to have "serious flaws and liabilities" (p.36).

Table 8.1 Classifications of usability testing.

Rubin (1994)	Nielsen (1992; 1997) and Liu (1997)
Exploratory test Conducted early in the development cycle to explore the effectiveness of preliminary design concepts and to verify assumptions about the users; participants may attempt to perform representative tasks with a prototype and/or 'walk through' it; involves a high level of interaction with the facilitator.	**Formative evaluation** Conducted iteratively while a product is still being designed to assess the usability of detailed aspects of the interface and generate requirements for the design's improvement; involves largely qualitative measurement and representative tasks.
Assessment test Conducted early to midway into the development cycle to expand the findings of previous exploratory testing; participants attempt to perform representative tasks with a prototype; involves less interaction with the facilitator.	
Validation (or Verification) test Conducted late in the development cycle to certify a product's usability through comparison against some predetermined usability standard or benchmark; participants perform representative tasks with the product; involves very little to no interaction with the facilitator.	**Summative evaluation** Conducted after a product has been developed to assess the overall functionality and usability of the interface with respect to established usability goals; may be used to compare alternative designs; involves quantitative measurement and representative tasks.
Comparison test Conducted at various stages of the development cycle, in conjunction with other usability tests, to compare two or more alternative designs, e.g. in terms of which is easier to use or learn and/or to understand the benefits and limitations of different designs.	

For both exploratory tests and formative evaluation, it is recommended that the data collection and analysis employ qualitative rather than quantitative techniques (Rubin 1994; Nielsen 1992; Mayhew 1999), corresponding well with the qualitative usability goals set for this stage of the research. In particular, it is advised that during the data collection participants should "solicited for their ideas about how to improve confusing areas", with the researcher striving "to understand *why* the user performs as he or she does", as opposed to "measuring *how well* the user is able to perform" (Rubin 1994, p.34-5). The following sections describe the planning and conduct of the qualitative preliminary design evaluation.

8.2.2.1 Initial preparations

A great deal of planning is required prior to conducting any type of usability evaluation, beginning with the definition of test goals which in turn impact on the level of formality and the testing processes required. As established earlier, the initial evaluation was intended to explore users' impressions of the preliminary design, in particular the effectiveness of the underlying conceptual models and the alternative cartographic representations embodied within it.

Furthermore, information was sought concerning ways to improve the design's usability. These goals indicated the need for a relatively informal study, comprising a largely *participatory* approach – as opposed to a *controlled* user test, which is more suited to summative/validation testing. Here, the importance of understanding participants' thought processes called for active questioning (by the facilitator) with respect to their intentions and expectations while they employed the prototype to work through a set of tasks. Moreover, the evaluation was also planned to be *assisted*, with participants asked to complete the tasks without help while the evaluator prompted them when they could proceed no further (Maguire 2001).

The key to the entire process was the application of a 'think aloud' protocol, which involved asking each participant to verbalise their thoughts as they used the prototype, so that they effectively provided a commentary on what they were doing, experiencing and thinking as they completed each task. Nielsen (1997) credits this technique with facilitating the identification of participants' major misconceptions: "One gets a very direct understanding of what parts of the dialogue cause the most problems, because the thinking-aloud method shows how users interpret each individual interface item" (p.1557). While this technique is inappropriate for performance measurement (such as collecting timing data during a validation test) and can influence a user's problem solving behaviour, it is extremely useful for collecting an abundance of qualitative data from a limited number of participants, often also aiding user focus and concentration (Nielsen 1997; Rubin 1994; Mayhew 1999). Special care must be taken in the interpretation of 'think aloud' results, however, due to the danger of placing too much weight on participant theories relating to the causes of certain issues and ways to resolve them. For this reason, emphasis should be placed on observing and interpreting actual behaviours, rather than relying on participants' rationalisations for such (Nielsen 1993).

Another major planning consideration was choosing a setting for the evaluation, including the length of each test session. Looking first at the setting, two options were considered for this: in the field vs. a usability laboratory. Whilst the former offered an ideal situation, emulating the system's natural usage environment as closely as possible (i.e. mobility and a dynamically changing context - Kjeldskov & Graham 2003b), the controlled atmosphere of a laboratory was ultimately chosen for two reasons. First, the system's purpose, along with limitations on location, time and cost, presented immense difficulties for designing and conducting a field-based test that placed representatives of the target user group within an unfamiliar environment. And second, the goals of the evaluation did not require the environmental context of the preliminary design to be tested, with such factors considered of greater relevance at a later stage in the iterative design and evaluation process (although the design was already mindful of these – Section 6.5.8).

Following this decision access to appropriate facilities was obtained, again through Sensis who offered the use of their Melbourne office's specialist usability laboratory. After an orientation of the laboratory, it was planned that, in addition to being observed from behind the one-way mirror, each evaluation session would be videotaped (and its sound recorded) for later analysis using two cameras – one capturing the participant's interaction with the prototype and the second providing an overhead view to capture any larger movements made by the participant. Figure 8.1 shows an example of the visual output from the session recordings. In terms of the evaluation timing, the decision was made to limit each session to two hours, which was considered to be a sufficient period for testing all existing aspects of the design without participants becoming too tired or bored with the process (Holleran 1991).

Figure 8.1 Screenshot from an evaluation session video recording. Participant interaction with the device/service was captured in the main picture, with an overhead 'picture-in-picture' view capturing any larger movements.

8.2.2.2 Test tasks and data collection

The next step involved creating a series of tasks for participants to complete during the evaluation sessions. In particular it was important for the tasks "to be as representative as possible of the uses to which the system [would] eventually be put in the field", while providing "reasonable coverage of the most important parts of the user interface" (Nielsen 1997, p.1552). Two further requirements – more specific to the research at hand – were to structure the tasks in such a way that they: (a) demonstrated and thus facilitated evaluation of the conceptual models upon which the design was based; and (b) enabled participants to compare and evaluate the various cartographic representations incorporated. To this end, the logical starting point for the task creation was deemed to be the preliminary design scenario, the final version of which is included below.

Evaluation Scenario

You have been sent to Fremantle by your company for a couple of weeks and it's somewhere you've never been before. You're thinking of taking your family along on your next, inevitable visit and making it into a holiday for them, so you maximise your non-work time to get to know the town and surrounding area in preparation.

You start by using Holiday Helper to find out about Fremantle and the surrounding area, specifically its layout, and nearby activities that you think your family would enjoy.

After this you decide it would be good to explore the area on foot. Just before heading out though, you use the Holiday Helper to check whether it is going to rain.

Below are the tasks employed during the evaluation, including a brief description of what each was designed to test. Note that all but one of the tasks comprised two or more sub-tasks, for the purpose of evaluating alternative design techniques. The tasks' final form resulted from a process of iteration and refinement, which was aimed at satisfying the aforementioned requirements while producing realistic tasks which were neither too long to be completed within the two-hour timeframe, nor too short as to become trivial (Nielsen 1997). It should be highlighted that some of the task wording was highly specific (i.e. providing interaction cues) which is generally inappropriate in formal usability testing, but was considered necessary here – and entirely acceptable based on the evaluation's exploratory nature – to ensure that alternative representations of the same geospatial information would be comprehensively compared and evaluated.

Task 1: Find out local level detail about the location (overview)

As its title suggests, this task was designed to contribute towards evaluating the conceptual model underlying the user goal 'Obtain overview of location(s)' (**ugA**). To this end, participants were required to use the prototype to find general information about the study location. The separation of the task into four sub-tasks was undertaken to test participants' reactions to and interactions with each of the different input techniques built into the design: text entry, voice recognition, map-based selection and list-based selection. Furthermore, the achievement of all sub-tasks exposed them to each of the alternative output techniques incorporated: text, voice and image. Being the first task for each participant, the starting point was also the initial system state – i.e. the Holiday Helper Home Page. The task was considered complete once all of the input and output representation forms had been encountered.

Task 1

(a) Search for information on Fremantle using its name, entered via the keypad (enter the text "fre"). Since you already know that Fremantle is located in Western Australia, specify this in the search criteria.

(b) Search for information on Fremantle using its name, via voice input. Don't specify the state.

(c) Search for information on Fremantle using a map.

(d) Search for information on Fremantle using your previously saved list, making sure you look at the whole list.

NB: This list is likely to have been saved during your pre-trip preparation.

Task 2: Find out local level detail about the location (layout)

This task extended the conceptual model evaluation begun in task 1 (**ugA**), additionally enabling participants to interact with and compare the different representation forms used to convey the location layout: text, voice, 'custom' map and 'sourced' map. The inclusion of two sub-tasks served to ensure that all alternative output techniques were encountered, the achievement of which signalled the task's completion.

Task 2

(a) Navigate to the Fremantle summary page by searching using your previously saved list. From here, learn about the general layout of Fremantle. Visualise its layout using a map. NB: Map pan is not functional.

(b) Navigate to the Fremantle summary page by searching using a map. From here, learn about the general layout of Fremantle. Visualise its layout using a map.

NB: Map pan is not functional.

Task 3: Identify & select pursuits / find out the characteristics of each pursuit

Task 3 was designed to contribute towards evaluating the conceptual model underlying the user goal 'Find things to do / of interest' (**ugB**). Here, participants were required to use the prototype to find information about a number of attractions in and around the location of interest. The separation of the task into two sub-tasks was undertaken to test participants' reactions to and interactions with each of the different input techniques built into the design: text entry and hierarchical list-based selection. Furthermore, the achievement of each sub-task exposed them to all of the alternative output techniques incorporated: text, voice, image and map. The task was considered complete as soon as each of the input and output representation forms had been encountered and all attractions had been 'added' to the shortlist (in preparation for the next task).

Task 3

(a) Search for detail on the following attractions in Fremantle, finding them via their categories:

→ Fishing Boat Harbour (Category = Historic Sites).

NB: View its location on a map.

→ The Round House Precinct (**Category = Historic Sites**).

NB. Location map is not available.

→ Vlaming Lookout (**Category = Walks & Views**).

NB. Location map is not available.

Add each attraction to your shortlist.

(b) Search for detail on the following attraction, finding it via its name and making sure the category list is unrestricted:

→ The Basin (enter the text “bas”).

Add this attraction to your shortlist.

Task 4: Determine the accessibility of each pursuit

This task extended and completed the conceptual model evaluation begun in task 3 (**ugB**), additionally enabling participants to interact with and compare the different representation forms used to compare the location of different attractions: text and map. No sub-tasks were required since the output techniques were directly linked to one another. The task was considered complete when each of the outputs had been encountered.

Task 4

- View and compare the items on your shortlist. Note that there is an extra attraction that was saved during a previous session – view its details and then return to your shortlist.
- Compare the location of each attraction on your shortlist.
- View this on a map.
- Then map only the attractions located in Fremantle (i.e. on the mainland).

Task 5: Find out local level detail about the location (weather)

Task 5 extended and completed the conceptual model evaluation begun in tasks 1 and 2 (**ugA**), additionally enabling participants to trial and compare the different output techniques built into the design: text and animated map. The inclusion of two sub-tasks served to ensure that all alternative representation forms were encountered, the achievement of which signalled the task’s completion.

Task 5

(a) Navigate to the Fremantle summary page by searching using your previously saved list. From here, check the current weather forecast, in particular the rainfall situation.

(b) Navigate to the Fremantle summary page by searching using a map. From here, check the current weather forecast, in particular the rainfall map.

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Following on from the tasks, another major set of preparations involved determining what data would be collected during the evaluation and procedures for doing so. It was established earlier that *qualitative* data collection and analysis was of most relevance to the preliminary design, with quantitative measurements therefore ruled out. As such, the decision was made to gather largely behavioural and opinion data, through a combination of observation and active questioning. Specifically, participants would be observed both by the facilitator and an assistant/observer, with notes taken regarding their experiences with the prototype. Here the focus of the data collection (based on the evaluation aims, as well as recommendations from Rubin 1994) would be on participants':

- impressions of alternative representations and design aspects (Which is easier to use/learn? Advantages/disadvantages of each? Preferences? Why?);
- main stumbling blocks in initiating and/or completing tasks;
- understanding of the underlying conceptual models and their relationships; and
- needs for prerequisite or additional information;

with some attention also paid to:

- navigation within and between pages;
- the ability to manipulate objects (e.g. text entry, hyperlink selection);
- opinions on the value of functionality provided; and
- overall impressions of the system use.

Supplementing the observational data would be comments made by the participants as they worked through tasks using the prototype. This consisted of verbalised thoughts, intentions and expectations (i.e. thinking aloud), as well as subjective answers to a set of questions developed to gather the required information while allowing for some systematic data collection (thereby simplifying the data analysis later on). The list of questions – asked at the completion of each sub-task – was as follows:

1. How easy was it to find the information that you were looking for?
2. Was the information you found satisfactory? Was any of it unnecessary? What else could have been included?
3. Can you comment on the suitability, usability and utility of the input / interaction method(s) that was/were required? Examples:
   - Hyperlinks – navigate/select with joystick
   - Hyperlinks – select with numbered keypad
   - Selection from a list, dropdown list
   - Checkbox selection
   - Text entry – typing
   - Audio prompt
   - Voice recognition
   - Map-based selection
4. (*optional*) Can you compare the differences between these input / interaction techniques and the last/others? Can you suggest any other input / interaction techniques that you think could be useful for this task?
5. Can you comment on the suitability, usability and utility of the output techniques used? Examples:
   - Text-based lists
   - Text-based summaries
   - Voice-based summaries
   - Images
   - Maps – scale, detail, clarity, text, symbols, zooming, legend
   - Animation
6. (*optional*) Can you compare the differences between these output techniques and the last/others? Can you suggest any other output techniques that you think could be useful in this situation?

Additional to the above, three final questions were created to gather further subjective information about the design/prototype as a whole. These were to be asked at the conclusion of the evaluation session:

1. What was your overall impression of the Holiday Helper (keeping in mind its prototype status and currently limited functionality)?
2. Looking to the future, would you find a fully functional version of this system useful while travelling within Australia? Why/Why not?
3. What other functionality would you like to see included in the system?

Usability experts recommend that before undertaking an evaluation it should be pilot tested with one or more participants who are representative of the end users, to ensure the effectiveness of the test procedure and any supporting materials. In this way, instructions can be clarified and the accuracy of the data collection increased, before the actual evaluation sessions begin (Mayhew 1999; Nielsen 1997; Rubin 1994). Given the exploratory nature of the evaluation, and the high level of interaction planned between the facilitator and each participant (i.e. with misunderstandings clarified during task completion), it was decided to forego formal pilot testing with the first participant instead acting as a single pilot test subject. While pilot test data would normally be excluded from an evaluation's analysis, this was not deemed necessary for the initial (pilot) session. Indeed the few minor issues in the procedure and materials that were uncovered during the first evaluation session – i.e. a need to lengthen the backlight timeout on the device and slight clarifications within the wording of tasks 3(a) and 4 – were not considered to have affected the outcomes in any way.

8.2.2.3 Sampling and conduct

The final preparation before conducting the evaluation sessions was sourcing and scheduling test participants. It is an accepted rule that studies such as this should involve participants who are "as representative as possible of the intended users of the system", with most (if not all) of whom comprising "novice users" (Nielsen 1997, p.1547-8). With a target user group in hand and a new system at the centre of the evaluation, sourcing such participants was not an issue. Determining the sample size was more problematic, however, with no clear direction in the literature as to how many participants should be employed for usability testing. Recalling the sampling discussion in Section 6.3.2.3, expert recommendations range from a minimum of four or five participants (Nielsen 2000; Virzi 1992; Nielsen & Landauer 1993) to upwards of 15 evaluation sessions per test in order to identify all major design problems (Spool & Schroeder 2001; Woolrych & Cockton 2001). The qualitative inquiry literature, on the other hand, does not put a figure on the size of a sample, instead stating that the decision rests on an individual study's purpose (Patton 2002). Ultimately guidance was taken from Nielsen (2000) and Rubin (1994) who purport that, where statistically significant results are not required, and multiple evaluations are to be conducted, the involvement of four or five participants is adequate. The key to this is in running multiple small tests, with the majority of usability problems (~85%) found and fixed after the first test, enabling subsequent tests to "probe deeper into the usability of the fundamental structure of the [design]" (Nielsen 2000). With an iteration of redesign and evaluation already planned for the research, it was thus considered acceptable to set the sample size for this evaluation at five participants.

Unlike the previous research phases, which employed criterion sampling to select participants, in this case a different technique was required, with *purposeful random sampling* selected whereby members of the target user group were randomly selected for participation. It is important to note that this method does not yield a generalisable sample (as in probability sampling), but rather is intended to add credibility to participant selection process (Patton 2002). To this end, random numbers were assigned to all members of the target user group who: (a) had previously indicated a willingness to participate further in the research; (b) resided in Victoria – since the evaluation sessions were being conducted in Melbourne; (c) were over the age of 25 – a requirement established during the user profiling; and (d) were not involved in the user task analysis – it was preferable to involve a fresh set of users. Following the random number sequence, individuals were then contacted until five had been scheduled. At the time of contact (conducted by telephone), users were provided with background information before being asked to participate in the evaluation sessions. These conversations followed a script, a copy of which is included in Appendix D, Section D.1. As users were recruited, a schedule was updated, incorporating the evaluation session time, contact details and user characteristics. A representation of the final schedule is shown in Table 6.3, indicating a diverse and comprehensive coverage of pertinent user characteristics within the sample[2]. At the conclusion of this process, all five participants were sent an email to confirm their session date and time, provide instructions for their arrival at the interview and supply them with the Plain Language Statement (PLS) and Consent Form in advance of the evaluation session (refer to Appendix D, Sections D.2, D.3 and D.4).

Table 8.2 The final evaluation schedule.

Characteristics	Day 1	Day 2	Day 3
Session 1			
gender	Male	Female	
age	31-40	25-30	
holiday frequency	2	4-6+	
holiday distance	Inter/Intrastate	Inter/Intrastate	
holiday length	Too variable	Too variable	
mLBS opinion	Definitely	Probably	
Session 3			
gender	Female	Male	Female
age	31-40	31-40	31-40
holiday frequency	2	3-4	12 or more
holiday distance	Interstate	Inter/Intrastate	Inter/Intrastate
holiday length	3 days	1 week	4 days
mLBS opinion	Probably	Probably	Probably

During the evaluation sessions there were three people in attendance: the facilitator, the participant and an assistant/observer (seated behind a one-way mirror), who was responsible for taking notes and recording the session. At the beginning of each session, the participant was

[2] Note that each participant was later asked, via email, which persona(s) they most closely identified with in terms of their travel-related goals and behaviours (as opposed to gender, age, etc.). At this time they were provided with the persona descriptions, not their likenesses (which were not considered relevant). All but one participant responded, with each persona covered to some extent: P1 = Kevin, P3 = Daniel/Lisa, P4 = Linda, P5 = Daniel/Linda.

asked to read and sign both the PLS and Consent Form, in acknowledgement of having been informed of the research, the evaluation's purpose and other pertinent details (e.g. privacy). Following this, they were given a cash voucher to thank them for their time and effort, and asked to sign another form which stated that they had received the gratuity and were willing to be videotaped during the session.

Before beginning the actual evaluation, each participant was given instructions on 'thinking aloud', as well as a brief orientation on the use of the device they would be using to test the design (this was the same i-mate SP5 SmartPhone on which the prototype was built). They were also informed of the structure of the evaluation session, including the presence and purpose of multiple sub-tasks for evaluating alternative representations of the same geospatial information)[3]. A copy of the evaluation session script is provided in Appendix D, Section D.5. The conduct of the evaluation itself began by asking the user to read aloud the Evaluation Scenario. After this, they were asked to work through each task/sub-task, reading it aloud before attempting to complete it using the prototype. At the end of a task, any of the evaluation questions not yet addressed were asked by the facilitator. Beyond the scenario and task descriptions and a guide to the SmartPhone's operation (Appendix D, Section D.6), no other supporting materials were provided to the user. At this early stage of the design it was not deemed necessary to provide documentation on the operation of the system beyond the help cues embedded within the interface. Furthermore, should the participant require additional help during the session, a 'technical expert' (i.e. the facilitator/designer) was present throughout "to reveal limited but crucial information needed to use the product" (Rubin 1994, p.43).

Throughout each session, the facilitator encouraged the participant to think aloud using techniques such as: neutral prompting; echoing (repeating the participant's own words/phrases as a question); 'conversational disequilibrium' (beginning a trailing sentence that encourages the participant to complete the statement); and summarising at key junctions (Ramey 2005). In doing so special care was taken not to bias the participant in any way, express personal opinions, or indicate whether the participant was doing well or poorly (Nielsen 1997). Participants were generally encouraged to complete each task without assistance from the facilitator, except where they clearly could not progress any further, in which case sufficient help was provided to allow them to continue. In a few cases participants had to be 'led' to a task's completion which, while

[3] Note that the order of sub-tasks within a given task was randomised for each participant to control the effects resulting from user familiarity with components increasing after each initial sub-task (Nielsen 1997; Holleran 1991).

not recommended, was deemed necessary to elicit feedback regarding all of the cartographic representations included (a major aim of the evaluation).

At the conclusion of each evaluation session the participant was asked the final three questions prepared to collect subjective opinions about their overall experience with the prototype, while being invited to make any additional comments they had about the prototype and/or the evaluation process.

✧ ✧ ✧ ✧

Before proceeding to the analysis of the evaluation results, it is worth noting that in between participants a limited amount of rapid prototyping was undertaken, which involved making changes to the prototype prior to the next session, in order to correct observed issues (Medlock *et al.* 2002). Here, however, the decision was made to only fix problems that distracted participants from satisfying the aims of the evaluation (i.e. the cartographic design was never altered). Specifically, the following issues were rectified between sessions three and four:

- Missing display of a 'shortlisted' symbol upon saving one of the attractions (Task 3a);
- An incorrect link destination upon saving one of the attractions (Task 3a);
- Display of an incorrect value for the total number of attractions on the 'shortlist' (Task 4); and
- Renaming of the 'Advanced search' option on the Attractions, Events and Activities search menu to 'Search by name'.

8.3 Analysis of Results

> *"Qualitative analysis transforms data into findings. No formula exists for that transformation … the final destination remains unique for each inquirer, known only when – and if – arrived at." (Patton 2002, p.42)*

There is no agreed or 'correct' way to conduct a qualitative analysis of evaluation data such as that presented here (Patton 2002; Creswell 1998). Guidance comes, however, from the initial aims of the evaluation process – in this case equating to the preliminary design aims – upon which the data analysis should be focused. Regardless of the approach, it is important that any qualitative analysis is founded upon thick, rich, detailed, concrete descriptions of the phenomena uncovered within the data (Geertz 1973; Patton 2002; Myers 1997a). Only in this way may patterns and themes be properly identified and findings accurately interpreted.

8.3.1 Qualitative analysis and interpretation

The first stage in the analysis was to organise the raw evaluation data into a more accessible form. This was accomplished by creating descriptive transcripts of each evaluation session from the video recordings, supplemented by the observer's and facilitator's session notes. When producing the transcripts (see example in Table 8.3), every effort was made to describe in detail not only those thoughts that each participant expressed aloud, but also their behaviours/interactions with the device[4] and the prototype service, as well as any larger movements that they made (e.g. leaning closer to the device). Additional descriptive comments were also included (where pertinent), to enhance the richness of the data and aid in their later interpretation.

Table 8.3 Extract from an evaluation session transcript.

Time	Task	Quote / Interaction / Movement	Comment / Inference
3:08	1c	Deciding between all 3 menu options; scrolls to and selects 'search using a map'	Correct navigation option
3:25	1c	Leans towards the screen; "little triangles on every capital city"	Slight viewing difficulty?
3:30	1c	"We need to go to WA … somehow"; reads aloud the top navigation bar links and the help link; scrolls onto the map and off again	Doesn't know how to use the map – looks at the page options for clues; doesn't use 'help'
3:45	1c	"There's something down the bottom there we can't see"; facilitator instructs participant to scroll down to see the bottom of the page	Doesn't see the vertical scroll bar, nor try to scroll down
4:05	1c	Scrolling through the bottom menu bar links "HH Home, don't know what that means"; shakes head	Doesn't understand the link label

With the transcripts in hand, the next step was to uncover patterns (descriptive findings) and themes (more categorical or topical in form) within the evaluation data through an *inductive analysis* process – i.e. "deriving concepts, their properties, and dimensions" (Patton 2002, p.454). This was accomplished by collectively analysing the participant data with respect to the aims of the preliminary design and evaluation, and the focus of the data collection (Section 8.2.2.2), thereby specifically concentrating on:

1. Participants' understanding/non-understanding of the conceptual models embodied by the UI and the effectiveness of the UI's communication of such, including:
    - their ability to achieve goals/tasks;
    - the main stumbling blocks/points of confusion; and
    - where help or prerequisite information was required.
2. The comparison of alternative representation forms, including:
    - which were easier to use and/or learn;

[4] With most interactions involving the joystick, only the participants' use of the device's back button and keypad were specifically recorded.

- the advantages and disadvantages of each; and
- participants' preferences.

3. Information concerning any of the P1 qualitative usability goals.

Concurrently, a process of interpretation was undertaken for the descriptive observational data, which involved making sense of the findings, offering explanations, drawing conclusions and making inferences with respect to the aims of the study (Patton 2002). Particular care was taken here in striving to understand the reasons behind identified problems, rather than just detecting and reporting on the symptoms (Dix *et al.* 1998). The end result, presented in Section 8.4, was a set of recommendations for changes and additions to the prototype (and therefore the design models) which would be incorporated into the next design iteration. The following section describes the outcomes and chain of reasoning behind the inductive analysis and interpretation that produced the design recommendations. Conducted on a task-by-task basis, this was included here in an attempt to address questions of credibility and 'observer bias' that may be raised due to the unavoidable subjectivity that characterises interpretations of observational data (Nayak *et al.* 1995). Note, throughout the detailed findings, the following references are used to denote relevance to particular research concepts:

- **ug*L*** – a qualitative usability goal (defined in Section 7.3.2);
- **DP*n*** – a UI design principle (defined in Section 7.3.5.1); and
- **CP*n*** – a cartographic design principle (defined in Section 7.3.5.2).

8.3.2 Findings

8.3.2.1 Task 1: Find out local level detail about the location (overview)

Being the first task set for each evaluation session, Task 1 led to participants' first exposure to the prototype. Regardless of their initial sub-task, each participant had to make a selection from the Main Menu (upon entering the service from the Home Page) to begin their quest for geospatial information, with varying results. After reading the scenario and task ('Search for information on Fremantle …'), each participant was observed to look/read through the options on the page before making their selection. Where two participants then chose the *A Town or Region* button, the other three felt that the scenario/task directed them to the *My Current Location* button – "because I am in Fremantle, I should probably go to My Current Location". While an understandable choice, the latter was considered the 'incorrect' option of the two, with the 'current location' functionality (Module 1) designed to provide users only with immediate geospatial information – such as their current location and orientation, and indicators for what is around them (e.g. landmarks) – while the 'town or region' functionality (Module 2 – accessible from Module 1) provided more general location information. This was interpreted to indicate two things: (a) the button labelling did not sufficiently support the user goal 'Obtain overview of location(s)' (**ugK**); and/or (b) the design's interpretation of the associated task model required adaptation so as to better match the observed user needs (**ugA**, **DP1**). Recommendations 1 and 2 addressed both issues, augmenting the existing Module functionality whilst endeavouring to make clearer the options available to users.

Interestingly, while deciding which option to select from the Main Menu, two participants uncovered additional issues with the main buttons, which had the potential to confuse users. The first of these related to the *A Town or Region* button, with one participant seeming to have difficulty with the wording – "I guess Fremantle's a town" – implying that this terminology may be unclear (**ugH**, **DP2**). Since she then selected the correct option without further comment, and no other participants appeared to have similar issues, no specific design changes were recommended. The second issue related to the *My Current Location* button, with another participant looking for a hardware key that matched the button's icon – presumably wishing to use this to select the button when the joystick click did nothing[5]. The implication was that the icon did not clarify the button's functionality as intended (**DP20**), but instead implied non-existent behaviour. If the button had been functional, however, the participant would likely not have looked for other ways to select it, and thus may never have attached additional meaning to the icon. Therefore, no specific design changes were recommended.

Returning to the task itself, Task 1 was primarily concerned with the comparison of alternative input techniques for accessing information about a specific location. To begin, **Task 1a** involved searching for the location using text-based input, entered via the device's keypad. Overall, participants experienced few problems with this technique – considering it "quite easy" and "easier than I thought" – with all five readily recognising the correct option on the *Town or region* menu, easily typing the required text in the text entry field, initiating the search and understanding/selecting from the list of *Town or region name matches*. Minor issues were experienced by three participants, however, with respect to specifying the state. The first did not recognise the behaviour of the State dropdown list which, when selected, opened a page listing each state and allowing the user to select one. She instead interpreted the list's right-pointing arrow to mean that scrolling the joystick to the right would incrementally change the state displayed. A second participant instinctively tried to type the state into the text field after the town name, having admittedly not noticed the dropdown list. A third participant, while having no trouble specifying

[5] The *My Current Location* button was not operational for the evaluation.

the state, commented that he would prefer "the state [field] under the city [field]", apparently not recognising that it related to both the town/region (i.e. city) text entry field *and* the voice input button. Whilst each participant progressed easily once finding or being directed to the correct functionality, their difficulties implied a need for support information relating to the state specification (**ugM**, **DP10**) – reflected within Recommendation 3.

Task 1b involved searching for the location using voice input (i.e. voice recognition), spoken into the device's microphone. This technique appeared to be slightly less intuitive than the text-based input, although most participants still considered it relatively straightforward: "once you've used it more than once, it'd be quite easy". Again, participants encountered no problems in recognising the correct option on the *Town or region* menu, or in understanding/selecting from the list of *Town or region name matches*. Issues arose, however, when actually inputting their voice. While all five participants readily recognised how to initiate the process, only three correctly completed the voice input procedure. Of the others, one expected some form of audible instruction[6] ("I was waiting for it to actually tell me to say what I had to say"), while another did not understand the audible prompt ("oops, what was that?"). Additionally, one of the successful participants commented that she'd expected a more familiar audible prompt ("a tone, like on a phone") – **CP12**. The initial implication from this was that the visual instructions and audio prompt were together inadequate for supporting the voice input task – indeed only two participants clearly read the instructions, one having to look at the screen more closely to do so (**ugJ**). It should be noted, however, that the participants' difficulties with the voice input were exacerbated by the simulation status of the functionality – if the voice recognition technique had been fully functional, it is possible that the participants would have been able to rectify their errors, based on either a message informing them to repeat the process (e.g. if no sound was detected) or else unexpected/erroneous *Town or region name matches*. Regardless, Recommendation 4 endeavours to overcome the observed voice input issues by changing the initial provision of support (**ugM**, **DP10**).

Task 1c involved searching for the location using a series of simple, 'clickable' maps ranging from small to large scale. Participants had mixed reactions to this input technique, ranging from "easier than I thought it would be" to "a little more difficult I'd say" and "horrendous … really time consuming". These differences related largely to varying experiences with initiating the map-based selection and scrolling around/selecting the map using the crosshairs, with no issues encountered in recognising the correct option on the *Town or region* menu. Principally, it was

[6] Note, it was later discovered that the device's volume was set to 'low' at this time.

evident that the initiation of the map-based selection was not intuitive to participants, with none managing to do so straight away. After viewing the map and other page items, the participants took varying actions: while one consulted the online help and was eventually able to progress with the task, two others initially selected the *Town or region* menu shortcut – hoping that it would provide assistance and/or enable them "to select an area to look at" – then scrolled around the page, eventually noticing when the map was highlighted for selection (this being the initial approach taken by the remaining two participants). Once selected, the difficulties continued for two participants, with both having trouble scrolling and positioning the crosshairs over the map 'hotspots' (some of which were very small) and each finding the map scrolling slow in general (**DP22**). These results implied that the map-based functionality was not optimal and that design changes were required to make it more intuitive to initiate and simpler to use (**ugK**, **DP1**). Notably, at least three of the participants reported an expectation (and preference) that individual states on the initial map would be highlighted sequentially as the joystick was scrolled left and right, negating the need for the crosshairs. This suggestion was viewed as a potential solution to the issues identified and thus formed the basis of Recommendation 5.

In general, the clarity and detail of the input maps was considered satisfactory ("very clear", "they're quite good", "I imagine if you had … an eyesight problem it might be a bit hard, but for me it's fine"). Despite this, at least four of the participants leaned in closer to the device when viewing the maps, presumably because some details – in particular state and town labels – were too small for optimal viewing (**ugJ**, **ugF**). Recommendation 6 addresses the implications of this, as well as some inconsistencies that were found in text and symbol sizes between the different maps (**CP3**, **CP14**, **CP15**).

Task 1d involved searching for the location using a pre-saved list called *My Destinations*. This was arguably the most difficult sub-task for participants, largely because the concept of *My Profile* (and *My Destinations* in particular) had not been explained in advance. Therefore they were essentially required to guess at functionality that they would normally have already been exposed to if the data were real and the prototype fully functional. This situation was the most likely explanation for why several of the participants had great difficulty determining which option to select from the *Town or region* menu – for example, one wanted to access the browser's 'Favourites' button, while another went looking "for a history or a saved list" on the *town or region name* search page, even trying to select the (non-functional) *My Profile* link. Furthermore, two of the three participants for whom this was the final sub-task admitted they had used a process of elimination to select the correct option, having already used each of the other options during the previous sub-tasks. Interestingly, two participants had no trouble at all selecting the correct menu option, seemingly due to its labelling: "if I've saved something, it's usually headed with *My*". After having its functionality explained by the facilitator, each participant demonstrated an understanding and appreciation of *My Destinations*, with one even correctly guessing at its behaviour before being informed. Another participant had initially expected that the *My Destinations* list was built from their previous location searches (i.e. without explicitly saving locations), suggesting additional tailored functionality which may be considered useful (**ugN**, **DP27**) – see Recommendation 7. Furthermore, two other participants implied that they would use My Destinations as a form of itinerary or a "reminder" of where they'd planned to visit, boding well for the proposed itinerary functionality. None of the participants experienced problems understanding or selecting from the list of *My Destinations*.

Inputs

At the end of each sub-task, participants were asked to comment on and compare the various input techniques employed. Here there were four methods used: *text entry*, *voice recognition*, *map-based selection* and *list-based selection*. Whilst the participants' opinions of the input methods were mixed, the data overwhelmingly indicated that having access to multiple options was seen as beneficial for this task: "I think all of them work quite well 'cos [*sic*] everyone would do it a different way. I think options are good".

Visiting each technique in turn, text entry was generally accepted as a useful input method by all participants, being considered "quiet and easy" (compared with voice recognition), and of particular value (along with voice) when little is known about a desired location's whereabouts (e.g. its state or region within Australia). Notably, two participants attributed one shortcoming to text entry when comparing it to voice recognition, namely the need for keypad use: "anything that uses less key punches is better" and "there's always going to be people who don't know the keypad very well". Focusing then on voice recognition input, this was also favourably accepted by the participants, although with some apprehension from each regarding its effectiveness for voice matching (without training) and in environments with ambient noise. Assuming its ultimate operation was comparable to the simulation, however, participants considered voice to be a fast and easy input technique (especially compared to text entry and map-based selection) that would be particularly useful when their primary attention was directed elsewhere (e.g. when driving) and/or to cater for "a broader range of people" (e.g. those with vision problems).

Moving onto map-based selection, participants generally found this to be slower than the other techniques (particularly voice recognition and text entry), with three participants also finding it more difficult, whilst one thought it easier (preferring "pictures" over "words"). Furthermore, participants identified the need to have prior knowledge of the desired location's whereabouts within Australia for his technique ("really you've got to have some sort of an indication of where you're going"), with the implication that map-based selection may have a different purpose to the other methods, namely finding information about a wider area, compared with searching for a specific location ("I just know an area I wanna [sic] go to, but I don't know what's in that area"). Similarly, input via list-based selection was also seen by participants to have a specific and separate purpose, being useful and convenient only when the desired location had been previously viewed and stored. There were some misgivings with this technique, however, in terms of having to set up the list and whether this would be easy to do. One participant in particular believed that "the other way[s] of accessing [the same information were] quick enough that I don't think you'd really need to do this".

These combined experiences and preferences implied that the target users did not consider any of the featured techniques to be more useful than others when searching for information about a location. In fact, each technique was variably ranked in order of preference by the various evaluation participants, often based on their assumed environment and/or underlying purpose at the time of the search, as well as their personal characteristics (**ugD**). Thus it was deemed important to retain each of the input techniques evaluated, with any new techniques considered as additions, rather than replacements. The merits of enabling users to configure the service (through *My Profile*) so as to restrict the input techniques available to them were additionally considered, however this was deemed unnecessary with the small number of options available on the *Town or region* menu. Recommendation 8 addresses these findings.

Outputs

Embodying the second focus for the task, participants were asked to comment on the various output techniques employed – i.e. *text*, *voice* and *image* – as well as the geospatial content provided. Beginning with the image output, participants were unanimous in their view that the displayed image did not add value to the location summary information. Indeed, no one considered the image as particularly representative of the location, providing such comments as: "[it's] some old building", "what relevance that building's got? I wouldn't have a clue" and "is that really in Fremantle? … I don't know what I expected … a bay with boats?". Participants' suggestions for the fate of the image ranged from removing it altogether (e.g. to save time and bandwidth), to providing it with a caption, or else placing it (and other images of the location) under one of the 'additional information' options for access, if required (**ugD**). Recommendation 9 addresses this by advocating further image-related comparisons.

Looking next to the voice output, this was met with varying opinions. Whilst two participants liked it, citing the benefits of not having to always read the information (e.g. especially when driving) – **CP12** – the three other participants were less approving. Not only was voice output considered inappropriate under certain circumstances (e.g. in public places) and an unnecessary drain on bandwidth (**CP17**), it became increasingly "off-putting" over time (**ugI**). When prompted, these participants proposed options to 'turn off' voice output for the entire service (e.g. through *My Profile*) and/or the ability to "skip" it upon loading a page. Another suggestion was for the voice to play once only for a single location – i.e. the first time that the location is visited within the service (**ugN**). Interestingly, while resistant to the voice output, one of the participants suggested that "maybe if you were with some friends or something, you'd turn it on and then … you all get the information". This suggested that it may be useful to have an option within affected pages to 'play' the voice output on demand (**ugD**). Considering this and the aforementioned solutions, the voice-related issues were addressed by Recommendation 10.

Turning finally to the text output, very little feedback was provided here (beyond two participants asserting that the font size was readable – **ugJ**), with more comment reserved for the geospatial content and its organisation within the summary page. The majority of participants believed that there was too much information within the text (and, it is assumed, voice) description, particularly with respect to historical details, with two suggesting that the 'additional information' options were of greater importance to them and therefore should be among the topmost items on the page. This implied a greater interest in information relevant to their immediate situation, rather than descriptive details about the location (**DP1**, **DP11**, **DP21**, **DP26**). One participant noted, however, that the descriptive detail may be more relevant after performing a map-based search (compared with text entry input) since the user would in that case likely have less knowledge of the location of interest (e.g. having selected it because it lay within a desired area). Recommendation 11 was created to respond to these findings and enable further evaluation of the text/voice content.

Final results concerned a desire expressed by two participants for additional geospatial information within the location summary. Here, one wished to see a map showing the location's whereabouts (and that of neighbouring suburbs) within the wider region, along with information on transportation options for getting there; whereas the other, referring specifically to wider regional information, sought more geospatial information about places surrounding the location of interest and suggested that this could be linked to the input maps employed in sub-task 1c (**ugA**, **ugE**). From these findings it appears important to some participants to view a visual representation of the location's whereabouts, in addition to (or perhaps instead of) a language-based description of such. Recommendation 12 addresses this, contingent on further evaluation.

8.3.2.2 Task 2: Find out local-level detail about the location (layout)

Still within Module 2, Task 2 focused on the comparison of alternative output techniques for representing the layout of a specific location. Comprising this were two sub-tasks, differentiated by the presence or absence of *voice output* and alternative *map displays*: where Task 2a employed a 'custom' map and contextual legend incorporating POI symbols that were specifically designed for the research, Task 2b employed a 'sourced' map with no legend or POI symbols, designed independently of the research.

A number of features were common to the sub-tasks, which are best discussed independently of the tasks themselves. To begin, none of the participants encountered problems in navigating to the textual and map-based *Layout* information from the location summary page. This may have been because the links were sufficiently self-explanatory (**ugK**), but was more likely a result of the task wording ('learn about the general <u>layout</u> of Fremantle … using a <u>map</u>'). Evidence of a reliance on task wording was demonstrated by statements such as: "I would never [use] *Layout* as a word for a map … 'layout's' more … I think of desktop publishing". This implies a need for more careful wording of task descriptions. Another common feature between the two sub-tasks were the map manipulation tools, namely *pan* and *zoom*. Beginning with the former, despite being told it was non-functional, two participants instinctively tried to pan the map east-west in order to see more information, by scrolling right and left with the joystick. Furthermore, these participants each demonstrated a lack of familiarity with the term 'map pan', suggesting that it was indeed quite technical, and not based on the users' own language (**ugH**, **DP2**). With the remaining participants also expressing an interest in map panning ("using the pan – that would certainly help"), it appeared that this feature would be considered particularly useful (**CP5**, **CP16**). Recommendation 13 addresses these issues by suggesting changes to the proposed map pan functionality.

Turning to map zoom, the availability of this functionality was generally well-received by all participants, however its operation was not always self-evident. While two participants tried to select the 'Map Zoom' header text to zoom in/out one scale at a time (note, this was the only part of the tool that was visible onscreen at the same time as the map), another expected to be able to select the map and then use crosshairs to scroll to a point at which to zoom in (similar to the procedure used in Task 1c). This indicated that the map zoom tool and its operation were not sufficiently obvious to users, with Recommendation 14 formulated to rectify this (**ugK**, **CP5**).

Furthermore, when zooming between different scales it was interesting to note the different techniques employed by the participants, with two selecting individual scales only (i.e. scrolling to Scale 1, 2, 3 or 4 and selecting), one zooming a scale at a time using the '+/–' icons, and two using a combination of these techniques. From this it appears that the provision of multiple (redundant) zoom techniques is beneficial to cater for different user preferences. Recommendation 14 was amended to address this. In terms of the suitability of the four scales offered by the prototype, participants were generally happy with these – "[the] zoom levels [are] good 'cos [*sic*] you can zoom it right into the street" – with only one suggesting that an additional, smaller scale (i.e. greater coverage), might be beneficial. These results are inconclusive, however, since without testing the different scales within real use contexts (i.e. in the field), their usefulness cannot be truly ascertained. Whilst the next evaluation endeavoured to test the zoom levels more thoroughly, field-based testing was beyond the scope of the research.

Concentrating now on the findings specific to the sub-tasks, each prompted a number of participant comments and opinions, in some cases generating ideas for additional information and functionality connected to the maps. All five participants expressed an appreciation of the 'custom' map-based representation incorporated within **Task 2a** ("I like this map"), in the process indicating that the various map scales were clear and easy to read, despite four participants leaning closer to the screen at times. Readily identifying the different levels of detail between the scales (**ugE**), most participants found the POI symbols and other map features to be adequately familiar and self-explanatory (**ugK**). More information was sought, however, with many wanting to see: (a) more POIs (both general – "the same information that's on a Melways [*sic*]", e.g. train stations, schools, shopping centres – and personal/tailored – "it depends on the individual", e.g. attractions, activities); and/or (b) more POI and feature details (e.g. POI name, POI facilities, street numbering, etc.) – available at appropriate scales, either directly on the map and/or within an 'icon rollover' textbox. Furthermore, one participant requested the ability to mark custom POIs (e.g. 'my hotel') on the map using the joystick, a second wished to see POIs representing *events* of personal interest (e.g. "where the sales for shoes are"), and a third suggested that it would be useful to view his current location on the map. A number of implications can be gained from these findings and are reflected in Recommendation 15: (1) the use of familiar map symbology is beneficial to users, lessening the need to consult a legend (**CP3**, **CP10**); (2) users want access to a wide range of mappable POIs, the selection and display of which they have the ability to personalise (**ugE**, **ugN**); (3) attractions, activities and events distributed in space are considered to be useful map POIs; (4) access to additional POI and feature information is important to users at the time the map is viewed (**CP10**); (5) users may find benefit in being able to define new POIs within the map (**ugN**); and (6) the ability to view their current location may be of value to some users (**ugA**, **ugN**).

With respect to the legend, this feature was considered beneficial by all participants ("very handy"). The positioning of the legend 'link' above the map was slightly problematic, however, with only one participant discovering it without prompting, and three of the remaining four participants instinctively looking for the link below the map, rather than above it. When questioned specifically on the contextual nature of the legend, all participants readily understood the content tailoring ("so you only see what's showing on that particular map"), and while four saw this as appropriate ("[it] hasn't got any unnecessary things on it, which is always good"), the fifth was less approving ("I'd probably keep the legends the same"), being concerned that he would need to check the legend at each scale to make sure that he didn't miss any map features. While the original purpose of implementing contextual legends was to minimise the amount of unnecessary detail displayed on the screen, this participant's concern was considered valid – for example, non-awareness of the legend's contextual nature may lead users to think that the legend for Scale 1 is indicative of the entire map content, thus hiding the presence of map features only present at Scales 2, 3 and/or 4. Based on this, it appeared important to offer users the option of accessing either standard or contextual legends, a factor that was incorporated into Recommendation 15.

The three participants for whom **Task 2b** was their initial sub-task, generally liked its map-based representation ("magnificent … it's really good"), with none of the five expressing difficulties in viewing the information, despite several leaning closer to the screen and one rotating the device 90° in a counter clockwise direction. While most participants appreciated the differences in the level of detail between the four scales – "[Scale 2] does give me far more street information" – many found the overall map detail lacking, citing a desire for the inclusion of POIs (e.g. railway stations, schools, museums, post offices, car parking, etc.) and their names/descriptions, displayed at specific scales – in particular the fourth scale within which two participants could identify nothing ("I've got no idea [where that is]"). Along a similar theme, two participants indicated a need to identify existing map features (e.g. different coloured/patterned shading), suggesting that the absence of a legend (or similar) was problematic; however two others specified that a legend was non-essential to the map (although one then admitted that she would prefer one). The implication here is that some users will always find a legend useful and thus it is important for this feature to remain available so that users have the option to view it (**CP10**).

A final opinion of note came from a single participant who saw an additional purpose for the map beyond its provision of the location's layout: wayfinding. This revolved around using the map to determine how to reach the location, as well as "a directional help facility, where you could … say 'I wanna [*sic*] get from here to here' and it would give you some sort of guidance on how to do that … not even using the map". In essence the participant was describing the proposed routing functionality (Module 5), which was not accessible from the *Layout* map page, but was instead available from the location summary page – two levels 'up' in the system's hierarchical structure. This implied that access to the routing functionality may be required from more/different parts of the system than those currently planned (**ugC**, **DP1**, **DP14**), with additional thought to be given to this during the next design iteration – Recommendation 16.

Outputs

At the end of the task, participants were asked to comment on and compare the various output techniques employed. Whilst the *map* differences were the focal point, participants' opinions on the *text* and *voice* outputs were also sought. To begin, one participant was surprised by the initial presentation of text-based output, having expected to see a map first. This implied that she attributed greater importance to the graphic representation (**ugD**, **DP1**), a preference that was also expressed by two other participants – "I would just use a map … I like to be able to see where I'm going" and "I didn't actually read it … 'cos [*sic*] I was going straight to the map". On the same theme, the *text* was also considered by some to be overly "broad", in particular providing insufficient locational context (e.g. "no street[s]"), while the map encouraged them to explore the location's layout further (**ugE**). Since not every participant dismissed the text output, however ("they're both good"), Recommendation 17 recognises the findings by integrating the two output techniques.

Looking next to the voice output, participants' reactions were again mixed. Similar to Task 1, two participants didn't mind the voice output ("if the text comes up, the voice is great"), but would appreciate the option to turn it off somewhere within the system. Conversely, two others found the voice accompanying the text output unnecessary ("[I] wouldn't worry about it"), with one of them ignoring it completely. Combining these findings with those for the text output, it would seem that the language-based outputs were not as useful to participants as the maps. To maintain consistency with the rest of the interface the voice output was not recommended to be removed but rather, together with the text output, should be given lesser prominence within the *Layout* pages – reflected by Recommendation 17.

After using each of the alternative output maps, the participants overwhelmingly expressed a preference for the 'custom' map in Task 2a, which they considered "a much better map" than that in Task 2b. The main justifications given for this were: (a) better map clarity ("cleaner", "clearer", "much easier to read"); and (b) greater detail ("it shows you where things are that you need to know about", e.g. POIs). One participant summed this up in claiming that while both maps provided a bird's-eye-view of the location, the custom map also provided "information". In terms of specific comments, two participants made note of differences in the predominant map colours, with one stating that the 'sourced' map was "harder to read than the other one … 'cos [*sic*] there's so much blue", while the other claimed that the colour of the water on the 'sourced' map made it "too busy … it just feels messy". The hierarchical display of roads was also a factor, with one participant asserting that the 'custom' map made it "a lot clearer what [*sic*] are the main roads", another stating that "it's harder to actually read where the streets are [on the 'sourced' map] … the roads stand out [on the 'custom' map]", and a third not seeing the need for the number of minor roads included on the first and second scales of the 'sourced' map ("I don't think for this kind of purpose [they're necessary]"). Based on these findings, it was evident that the 'custom' map was considered most useful by the participants and, since it encompassed all of the information presented within the 'sourced' map and more, the latter should be discarded from the design models, with improvements made to the 'custom' map only – refer to Recommendation 15. Note that this finding was not unexpected, particularly due to the fact that the 'sourced' map was not designed or altered in any way for/by the research (see Section 7.4.3.2).

Of final note was a single participant's assertion that he would use neither of the evaluated maps, preferring to "always use a [paper] road map" due to unavoidable limitations on the map extent resulting from the small screen size of a handheld device. While this had no bearing on the design of the maps themselves, it did suggest that some users may never accept and use the maps employed within mLBS applications, having major implications for existing commercial systems that are heavily reliant on map representations. From this it would seem that the key to satisfying the requirements of (at least) this user type lies in the provision of alternative, non-map representations to communicate geospatial information.

8.3.2.3 Task 3: Identify & select pursuits / find out the characteristics of each pursuit

Task 3 comprised a mixture of input and output techniques for accessing information about a number of attractions within a location, and the representation of related geospatial (and other) information. This involved two sub-tasks, each of which utilised Module 4. In general, participants encountered no problems determining and selecting the correct option for this task from the location summary page, having been exposed to the available links several times during the previous tasks. Although one participant attempted to select the *History* option at this point, this was most likely a result of the wording for Task 3a (i.e. 'Search for … Category = Historic Sites') and not a problem with the design as such.

Task 3a involved searching for three different attractions around a location by browsing and manipulating a hierarchy of lists. Participants had no notable problems initiating the browse search and selecting the first attraction, *Fremantle Boat Harbour*, from within the category 'Historic Sites'. This particular attraction was accompanied by a location map which all participants found easily, each then readily identifying the map symbol representing the attraction. Furthermore, upon adding the initial attraction to the shortlist, all participants demonstrated an immediate understanding of the 'shortlisted' icon upon first seeing it, appreciating the feedback it provided ("I think that's important"). Following on from the first attraction, there were no problems encountered in searching for the second, *The Round House Precinct* (also within the 'Historic Sites' category). In general, all participants found searching for the first two attractions "straightforward" and "easy".

When searching for the third attraction a number of issues arose, however, which made this step "a little bit more difficult" than the previous two. The problems stemmed from the fact that the category of interest, 'Walks & Views', was not part of the initial category list, which had been 'tailored' to include only those categories that the user was interested in, as specified within *My Profile*. With none of the participants pre-informed of this list composition (recalling that the specification of category preferences did not form part of the evaluation, but was instead assumed to have been done previously), three initially expected 'Walks & Views' to be a sub-category of another – 'National Parks & Reserves' ("that's where you'd find a walk"). The other two participants, however, immediately selected the *See more categories* link, openly searching for "that exact category". It can be assumed that had the participants set up the category preferences themselves, the tailored list would have been more intuitive.

The next set of issues arose with respect to the checkbox-based list of additional categories. Whilst two participants had no problems understanding and correctly manipulating the list – 'checking' the required category and then selecting *Continue* ("so that's gonna [*sic*] most likely add [that] to the categories") – three expressed confusion at the list's appearance ("[a] different layout of categories") and when their selection of the 'Walks and Views' checkbox did not take them directly to the list of attractions for that category ("oh, ok you can pick more than one?").

Furthermore, when back at the category list, one participant expected it to be filtered to include only those categories that he had checked – "that's what it looks like". Although the other four participants did not have the same misconception, this and the previous issue suggest that the appearance and behaviour of selecting additional location attraction categories was potentially confusing (**DP1**). Recommendation 18 endeavours to alleviate this by simplifying the affected functionality. In completing the task, participants had no problems selecting the attraction of interest – *Vlaming Lookout* – and adding it to the shortlist.

Task 3b involved searching for a single attraction, *The Basin*, using text-based input. As noted in Section 8.2.2.3, the label of the option on the *Attractions, Events & Activities* menu for initiating this task was changed from *Advanced search* to the more specific *Search by name* for participants four and five. This was done to better represent the underlying functionality and alleviate the confusion demonstrated by an earlier participant who was uncertain which option to select (eventually making the correct decision based on a process of elimination). No problems were encountered following this label change. Next, participants were required to unrestrict the list of categories within which to search for the attraction. Only one participant initially found this difficult, having not noticed the *Category* dropdown list and instead trying to select the *See more categories* link. The remainder of the task was completed without incident, with all participants easily typing the required text into the text entry field, initiating the search, understanding and selecting from the list of *Search by Name Matches* and adding the attraction to the shortlist. In general, all participants found this sub-task "really easy".

Inputs

At the end of each sub-task, participants were asked to comment on and compare the various input techniques employed. Here there were two main methods: *hierarchical list-based selection* and *text entry*. Beginning with the former, this was generally well-received as an input technique by all participants – "lists are really good. I like lists". In particular, all but one participant found the tailoring of the initial category list to their *My Profile* preferences beneficial ("it's required I think"), with one person citing that individual users could then easily search only the categories they were interested in, while always having the ability to view other categories should the need arise. The fifth participant, however, felt that the list tailoring would be better "as a secondary thing, as a menu option somewhere … [it] made [the task] too confusing". Again, prior knowledge of the list's composition would likely have alleviated his frustration, however it seems clear that some support information was required for this feature (**ugM**, **DP10**) – see Recommendation 19. In terms of the text entry, this was found by some to be slightly easier, and perhaps faster, than list browsing, with the ability to restrict categories within which to search being widely appreciated ("[that's] handy – I like this"). At least two participants identified different purposes for the two input methods, with one summarising it thus: "if you know what you're looking for … [text entry] is a lot easier to go straight there, rather than going through all the lists and the categories – I think [hierarchical list-based selection is] more [for] if you're not really sure what you wanna [*sic*] do, but you have an idea [that] this is the kind of thing you wanna [*sic*] do" (**DP11**, **DP21**).

The final results regarding input techniques concerned suggestions for additional methods. In this respect, one participant indicated a desire for voice recognition when searching for attractions by name – similar to that in Task 1b (**DP4**, **DP13**, **DP25**). A second participant came up with an entirely new technique altogether, comprising a "browse by image" option whereby users could search for attractions based on representative pictures – "people could look at stuff and [say] 'that looks nice, I'd like to go there'" (**ugD**). One final technique, while not explicitly suggested by any participants, was prompted by a comment on the alphabetical sorting of the category list (which was seen as beneficial). This concerned the possibility of additionally sorting/searching for attractions based on their *proximity* to the user's current location or that of another object (e.g. a hotel, train station, etc.) – **ugD**. Each of these suggestions was prioritised and recommended for incorporation into the design for the next evaluation – Recommendation 20.

Outputs

Participants were also asked to comment on the various output techniques employed for each sub-task – i.e. *text*, *voice*, *image* and/or *map* – as well as the geospatial content provided. Looking first to the text output, all participants were generally happy with the level of detail provided on the attraction summary page – "[I] never find information unnecessary". A number of concerns were raised, however, with respect to individual information items. The first related to the attraction description/summary, with one participant stating: "all the written information at the top – I'm not sure that I'd need to use that a lot … that's the sort of thing you look at once and … you never have to read it again". Instead she found the information listed below the description (i.e. location, contact details, facilities, entry fees and opening hours) far more important, anticipating a need to revisit this for later reference (**ugE**, **DP1**). Another participant expressed confusion over the presence of a contact phone number for certain attractions, which made him feel the need to book something, even when the other information did not suggest this. Recommendation 21 addresses both of these issues. Additional information sought by different participants included public transport (e.g. bus, train numbers) and/or directions to get to the attraction (note, this particular participant later noticed the *Find a route to or from here* shortcut, stating "[that's] what I was talking about earlier") and more attraction-specific information – e.g. characteristics for walks, bushwalks and hikes (grade/rating, length, weather). Whilst the former indicated a need to make the routing functionality more visible (**ugC** – covered by Recommendation 22), the latter identified further geospatial information for representation (**ugE** – refer to Recommendation 23).

Participants' opinions of the voice output were similar to those for the previous tasks, with some being quite accepting of the technique ("you can actually hear what's being said while you're looking at other things"), while others were not ("[it] puts me off and puts me out of sync with what I'm reading"). Again, suggestions were made concerning an ability to turn off the voice output and/or play it on demand. Recommendation 10 already addressed this issue. Moving on to the image output, participants were generally more accepting of this (especially compared with similar output in Task 1), with at least two participants believing that the image was particularly useful to this task: "I think photos are important … that photo of the swimming hole made me want to go there a lot more"; and "gives you an idea of what you're going to be looking for". Similarly two participants suggested it may be worthwhile having access to additional images, on another page, although a third preferred only a single image "that tells a story". Two participants, however, did not see any value in the image ("it's [just] a beach", "I'd ditch the image"). To address each of these preferences, Recommendation 24 suggests maintaining the presence of the image, but reducing its prominence.

The final output technique was a map representing the attraction's location, the presence/absence of which was compared. Without exception, participants were unanimous in their preference for having access to a location map from the attraction summary page – "maps are always good". They were also in agreement with the desire for a map zoom (and in two cases also a pan) tool. In fact, most participants sought the same level of detail and functionality as the map evaluated in Task 2a (**DP4**, **DP13**, **DP25**), additionally requesting specific map POIs: cafes, parking, toilets, food outlets and, most importantly, their own location (**ugA**, **ugE**, **ugN**). Overall, participants appeared to have no major difficulties in reading the map and map symbols ("that's easy enough to read. You can see the street names"), although two did lean slightly closer to the screen at times to view the map, while another commented that "I would perhaps find a different colour for the [attraction symbol], only because it's … very similar to the parking [symbol]; doesn't stand out as much" (**CP3**, **CP7**, **CP14**). Each of these map-related issues is addressed by Recommendation 25. Finally, three participants were concerned with using the map for navigating to the attraction, with two believing that this might be possible if they had the ability to zoom in. Upon noticing the *Find a route to or from here* shortcut at the bottom of the page, however, one of these participants commented "that's very handy … that's more what I was after for the more detailed map … the only reason you'd have it" (**ugC**) – implying that the routing functionality needed to be more visible and/or better linked to the map, a situation reflected by Recommendation 22 (**DP1**, **DP14**).

8.3.2.4 Task 4: Determine the accessibility of each pursuit

Task 4 concerned alternative representation techniques for comparing the relative locations of multiple attractions, again utilising Module 4. This involved a single (sub-)task which incorporated both *text-* and *map-based* output. Beginning at the *Attractions, Events & Activities* menu, participants experienced no notable problems in selecting the correct menu option, identifying and viewing an extra attraction on the list and then selecting *Compare attractions*. From this point on, however, a number of issues arose, beginning with two participants expressing uncertainty over which comparison type to choose: *location* or *proximity*. Although the task had asked participants to 'compare the location' of attractions, it seems that the terminology used in labelling the comparison options was confusing since these participants felt that location and proximity were the same thing ("considering we're comparing them all against each other, I would've thought that those two would've meant pretty much the same thing"). Furthermore, with the proximity comparison not functional within the prototype, it was impossible for participants to discover the difference between the two[7]. Two implications were identified for this. The first was that the comparison labels (at least 'location' and 'proximity') were too technical (**ugH**, **DP2**) and/or not sufficiently intuitive (**ugK**), and therefore required revision. The second suggested that perhaps these and other geospatial comparisons – e.g. straight-line distance, route-based distance, travel time, availability (opening hours, booking times, etc.) – would be better combined into a single option enabling multiple and potentially simultaneous geospatial comparisons to be made for different attractions, locations and times (**ugB**, **ugD**). Recommendation 26 advocates incorporating each implication into the revised design as alternative geospatial information access methods.

The next issue concerned a mismatch between two participants' expectations of the location comparison functionality and its actual behaviour. While each had expected to be able to select a sub-set of attractions and then map these (e.g. attractions on the mainland), the system instead required that all attractions on the list be mapped before providing the functionality to narrow the selection. The subsequently smooth progress of these participants, together with the fact that

[7] Recalling that 'by location' provided a method for viewing the location of each attraction relative to one another, while 'by proximity' was intended to enable a comparison of the distance (i.e. linear or time-based) to each attraction from a specified location (e.g. the user's current location, hotel, train station).

the remaining three did not share the same initial expectations, indicated that the current system functionality was acceptable, while being learnable. These participants' comments did raise a valid point, however, over the need to map all 'shortlisted' attractions when the user may at times only be interested in a subset of these (i.e. why produce the first map?). Furthermore, forcing a map to be generated before enabling the selection and mapping of a smaller subset of attractions potentially leads to unnecessary user interaction (**DP1**, **DP14**, **DP23**), system processing and network traffic, compared with allowing the selection of an attraction sub-set prior to generating a single map (i.e. two vs. one map request). Recommendation 27 advocates a change in functionality so as to evaluate the suggested alternative.

Upon viewing the location comparison map, almost all participants quickly understood and appreciated the technique for displaying only the attractions of interest – i.e. using the checkboxes in the quasi-legend (to select/de-select attractions) and the *Reload map* link – "I can eliminate the ones that aren't on the mainland … just lets me focus on the three that I am interested in", "but still with the option to re-highlight the others if we wanted to". The exception was a single participant who, upon 'unchecking' an attraction's checkbox, expected the map to immediately update, omitting the excluded attraction ("it's still on the map!"). Whilst this was his preference for the map-checkbox behaviour (**DP23**), the participant did admit that 'live updating' can be costly to the user while being intensive on system resources. Nevertheless, it was deemed important to investigate the feasibility of such a change in functionality – see Recommendation 28. Overall, despite the difficulties identified, most participants considered their completion of this task to be "good, straightforward, easy", with only one admitting that "I needed help to get there I think".

Outputs

At the conclusion of the task, participants were once more asked to comment on and compare the various output techniques employed. Beginning with the text-based output, very little was said about the list of addresses for each short listed attraction, beyond each participant recognising the information content and its relevance to the location comparison ("a list of, basically, where they are"). One participant did express a preference, however, for the list of attractions to be divided by locality – i.e. Fremantle, Rottnest Island, etc. – so as to make their spatial arrangement clearer before proceeding to the map (**ugD**). The implication of this was that it may be useful to offer users options for sorting the short listed attractions in different ways (**ugN**). This is addressed by Recommendation 29.

In comparison, the map-based output generated numerous comments concerning various aspects of the representation. First, each participant readily identified the location of each attraction on the map, easily linking their symbolic representation to the quasi-legend below the map – "it's got the listing there, of the colours and the numbers, which is handy". Second, the initial scale and clarity of the map were considered useful by most participants, enabling them to clearly see the geospatial distribution of attractions between Rottnest Island and Fremantle ("I like the different colours [for each attraction] … that works really well for me"), as well as the wider area/situational context within which the attractions were located ("it's good to have the surrounds"). Third, the change in scale between the initial map – incorporating all attractions – and the 'reloaded' map – 'zoomed in' to the extent of only the selected attractions – was seen as particularly beneficial by two of the three participants who commented on it ("[that's] what you want it to do"; "It's just giving you what information you need and eliminating what you don't need"). The third participant was concerned, however, that 'zooming in' to the extent of attractions in very close proximity to one another would cause the user to lose the wider context – "if you don't know the area, you need to see more, not less". He went on to argue that "if you knew the area, [the] scale change [would] be good", although for this particular scenario he would want the map to remain at the same scale "and possibly zoom in at my convenience". This last comment served to raise another interesting point, with this participant being the only one who sought map zoom and pan tools during the task ("[it's] a feature that you need on every map I think"). Taking this into consideration, it was deemed most appropriate to maintain the current change in scale, but additionally provide zoom and pan functionality for the map (**CP5**, **CP16**). The suitability of this decision was dependent, however, on the outcomes of Recommendation 28, which was thus adapted to address the scale change issue.

The final topic of interest was the "very simple" level of detail provided, with most participants wanting more information from the map, despite making initial comments such as "for this point, I think it's enough". Whilst noting that the map was essentially "a big overview of … general location" – which satisfied his assumption of its purpose being to enable users to "think about the possibility of [visiting] those attractions in one day" – one participant, in particular, considered the map to be more of a starting point from which to find out further information. He specifically wanted a link between this and the 'layout' map featured in Task 2 (presumably to obtain access to greater level of detail). Furthermore, three other participants requested the option to view more detail on the map itself (particularly at the larger scale), including landmarks, public transportation and major roads – all of which were expected to assist in determining "how to get there". Similar to the individual attraction location maps featured in Task 3a, it seemed that participants were seeking access to the same level of detail and functionality here as that included on the layout map (**DP4**, **DP13**, **DP25**). Recommendation 30 addresses this issue, in the process advocating new tools allowing users to add and remove map features at will (**CP16**). It is also worth noting at this point, that none of the participants leaned in closer to the screen when viewing the attraction location comparison map (whereas they did for all other maps). This was most likely a result of the low level of detail included within the map – an important implication for the redesign of any/all maps, since it suggests that at least the initial level of detail on a given map should be minimised, in accordance with the map's purpose.

When directly comparing the text and map-based output techniques, participants were unanimous in their desire to have access to both: "you always need the address … where things are"; "unless you knew the city, the text means nothing … I think they're good together"; "I don't mind having that list there … [it] re-confirms where they are and what they are before you go into the map". But while most participants were happy with the organisation of the two representation forms – "[the address list is] all you need … and then you can view your map from there … [which] confirms everything", one participant in particular expressed a preference for viewing the map first – "I like the view of the map, 'cos [*sic*] that shows you what you can achieve when you go somewhere and what is there to do … [with the address list] there was no sense of where it was … so going straight to that map would be probably better". Considering this, but recognising the existing design recommendations generated from this task, both output techniques were expected to be retained in their existing configuration.

8.3.2.5 Task 5: Find out local-level detail about the location (weather)

The final task of the evaluation, Task 5 compared *textual* and *animated map* techniques for representing current rainfall at a location, utilising Module 2 once again. Additionally, *diagrammatic* representations were trialled for the communication of forecasted weather. Beginning with commonalities between the two sub-tasks, participants encountered no problems selecting the correct option from the location summary page, admittedly having been exposed to the available links several times during the previous tasks ("I know I'd seen where to go already"). Similarly, all but one participant immediately selected the correct option from the Climate & Weather page, with the fifth instead selecting *Current Warnings* – not an unreasonable choice considering the task wording ('check the current weather forecast'). Once on the *Current Weather & Forecast* page, each participant then readily recognised the information: "this is giving me … the current weather" and "a pretty standard weather forecast".

Focusing first on **Task 5b**, as it was the initial sub-task for four out of the five participants, this involved interpreting the current rainfall situation from an animated radar map. Here, most participants encountered no issues in identifying and selecting the *View map* link which opened a page conveying the radar. One participant, however, did not see the link at first ("I didn't even notice it"), having scrolled past it initially to look at the forecast information. She admitted, though, that "knowing that that was there next time, and being familiar with the service you would know where to look". Three participants expressed familiarity with the animated map, having used similar representations before ("I use [the radar] every single day. I think it's pretty easy to understand"), while another appeared not to recognise it at all ("what the? … it looks like a game"). Each, however, seemed able to interpret the information presented to some degree, variously noting (despite misinterpreting 'rain rate' as "little white clouds" or "chance of rain"): "that's telling me that there's light to moderate showers" and "[it's] fairly fine". Notably, three participants looked more closely at the map at times, with one having difficulty determining its time period. Furthermore, two participants noted that the location of interest wasn't labelled on the map, although one of them acknowledged that Fremantle would likely have the same weather as Perth (which was labelled).

Task 5a involved determining the current rainfall situation from a text-based description. Of the four participants for whom this was their second sub-task, three immediately noticed the omission of the map: "where's the map link gone?"; "it doesn't give you the map". One, however, needed help to identify the different rainfall representation employed ("are they the same?"). Each read out the rainfall description, one leaning in closer to do so before stating that she would hold off her walk until "later in the day". Overall participants found accessing the information required by Task 5 to be "really easy" and "quite well laid out".

Outputs

At the end of the task, participants were asked to comment on and compare the various output techniques employed – i.e. *text*, *animated map* and *diagrams*. When considering the information content in general, all were satisfied with the level of detail provided on the *Current Weather & Forecast* page: "I think if you're actually looking at weather, you probably want all of that sort of stuff"; "it's got a lot more information than what I thought it might have … I think everything there's useful". They particularly liked the diagrams used to represent *Forecast* information – "easy to read", "[the] graphics are great", "they're what you'd see on the weather forecast usually … you'd wanna [*sic*] stick to … what people are used to … so, it's fine", "looks good with the pictures" (**CP10**) – however one participant sought more from the *Current Weather* information, wanting to see its age and/or update rate – "[there's no] indication of when the weather is from;

it just says 'current'" (**ugN**). Further suggestions for additional information were made later on, with one participant seeking recent changes in temperature (e.g. every hour for the past four hours) which, he claimed, together with rainfall was important to know when planning outdoor activities, while a second participant suggested a clock, "because of time differences". Recommendation 31 addresses the issues raised, focusing on the geospatial information content.

Comparing the animated radar map with the text-based rainfall information, participants were split in their preferences, with two preferring the map, three preferring the text, while four suggested that access to both might be useful. Specific arguments in favour of the map included: "you can never describe enough in a description of where the rain is and what it's doing"; "if you wanna [*sic*] do something now … outdoors … there's definitely not enough [information in the text]"; and an observation that users could interpret the map themselves, rather than being told what it means ("I would trust the map"). Note, however, that one of these participants did concede that the text may be helpful for users who aren't familiar with reading the radar and/or those who do not wish to. Conversely, when arguing in favour of the text output, participants doubted the need for the high level of detail provided by the map ("depending on your purpose"), claiming that the text (including the forecast) provided the same information – "this one's more usable, 'cos [*sic*] it just tells you". Again, however, one of these participants saw potential in the alternate representation form, conceding that the map would be good for seeing exactly where the rain was falling (**ugA**), while its animation feature could be handy for providing "more of an idea of where the rain's going" (**CP11**). It is obvious from these results that neither representation form is suitable for all users (**ugD**) – Recommendation 32 addresses this.

In closing, it is important to note a number of concerns regarding the radar map that were evident within the results. First was one participant's observation that websites with similar rainfall radars generally include additional information to assist in their interpretation and without which the map may be misinterpreted. This suggested a need for appropriate support information to accompany the radar map (**ugM**, **DP10**, **CP5**) – see Recommendation 33. Second was an assumption made by another participant that "I'd like to think that the rainfall map would be fairly accurate", indicating the importance of regularly updating this information and communicating its age – corresponding to an out of scope pre-design finding. Related to this, a third participant did not see the relevance of the animated nature of the map, suggesting that the change in the map's time period was not obvious/clear enough (**ugK**, **CP11**) – this is also addressed by Recommendation 33. Finally, while finding the radar "good for rainfall", a single participant saw the need for an additional map communicating atmospheric pressure – i.e. "the highs and lows; that can tell me the direction of the wind" – this was something she found useful as a recreational sailor. Since this was a highly specialised use of the suggested information (considered more appropriate to a sailing-specific service), it was not added to the design.

8.3.2.6 Final comments

The final three questions asked at the conclusion of each evaluation session served to provide user opinions relating to the service as a whole, thus adding a broader dimension to the results. The first question concerned participants' **overall impressions of the prototype service**, with each being quite positive about their experience: "I like it"; "very handy"; "I think it's great". Here, not only were participants pleasantly surprised by the amount of information provided by the service – "it had a lot more information that I expected it to have" – they also appreciated the existing and proposed features – "it's great to have that sort of functionality at your hand" – as well as the general usage of the service – "it's quite easy, simple, clear"; "it was very methodically laid out". One participant further commented on the convenience and information consistency offered by the service, having used multiple, disparate online sources for this type of holiday research in the past: "having it all wrapped up into one [service] would certainly save me time" (**ugO**).

The second question asked participants whether they would **find a fully functional version of the service useful** during their travels. To this, four of the five participants definitively answered "yes", although each expressed some uncertainty over the costs involved: "it would just come down to the cost". Content was also a factor for use/non-use: "[it would depend] on … if it had all … attractions … for a lot of the places and not just for the … main cities". In general though, the service was seen by these participants to offer value over, for example, visiting a travel agent or a tourist information booth when visiting an unfamiliar location. On the contrary, the fifth participant did not believe that the service would benefit him at all, stating: "I probably wouldn't use it … would have done [that sort of research] before I left … I'd … know where I was going or I'd have a bit more of an idea … so I probably wouldn't do it [using] the phone". He did, however, speculate that he may find the service useful if "sitting around" during his holiday and would "probably" recommend it to others. Whilst these comments have no tangible bearing on the cartographic UI design models, they do serve to emphasise the differences between individual users which must be accommodated in order to cater for each user type. Furthermore, although again not impacting the research, it is worth highlighting the emphasis that most end users place on cost when considering a product's usefulness, which will undoubtedly be a major factor in the acceptance of any new mLBS application.

The final question sought **additional functionality and features** that participants wanted to see included within the service[8]. While this type of information was collected throughout the tasks, participants produced several additional ideas at this point including: local cinema schedules, "local ownership of the content" (especially with respect to attractions, events and activities) and more information to support wayfinding throughout the service ("that would be extremely helpful"). They also specified that the content should be as current and accurate as possible – something that had been previously identified and was partially addressed by the online status of the service. Most encouraging in terms of the conceptual models embodied by the UI, however, were comments such as: "I think that's about it. It's pretty much covered it really", "I think you've covered nearly most of the bases" and "it seemed to be pretty … in-depth". Considering all of the feedback provided and the recommendations already made, no changes were deemed necessary at this point.

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From all of these results, including those concerning individual tasks, it was evident that, at least in a subjective sense, each participant was largely accepting of the preliminary design models, which appeared to address their expected geospatial goals and tasks without causing undue frustration or dissatisfaction. The next section summarises the design recommendations resulting from the interpretation and analysis process, each of which will be prioritised and implemented accordingly during the next design phase – refer to Chapter 9.

8.4 Design Recommendations

The compilation of usability problems and ideas for improvement as recommendations for redesign is "the raison d'être for the entire process of usability testing" (Rubin 1994, p.283; Nielsen 1992). It is important to reiterate, however, that such design recommendations are only one *interpretation* of the evaluation data, with numerous other courses of action being entirely feasible – i.e. there is no 'correct' answer (Rubin 1994; Nayak *et al.* 1995). Keeping this in mind, the recommendations for revising the preliminary design are presented below, grouped according to the main task from which they were generated.

Task 1

1. Change the button labelling (and associated page header) on the Main Menu to better reflect the functionality each represents.

[8] It should be noted here that in asking this question it was not expected that the small sample of evaluation participants would reveal detailed and/or ground-breaking ideas for content and techniques that may improve the design (Ramey 2005). Indeed, the brief time they spent using the prototype, the unnaturalness of the evaluation setting and the perceived novelty of the service and its presentation medium likely made it difficult for the participants to envisage new ideas and suggestions.

2. In the 'Town or region search' menu, add an option to search by 'current location'.
3. Provide greater support regarding the purpose and operation of the 'State' dropdown list, when searching for a location by name, including online help and a more appropriate page layout.
4. Provide clear instructions for the voice input procedure, in both visual and audio format, after the option has been selected.
5. If feasible, remove the use of crosshairs for map-based selection, replacing this with sequential highlighting of map features (e.g. states, regions, towns) when the joystick is moved.
6. Increase and standardise the size of all icons and text labels within the input (and other) maps.
7. Maintain the existing 'My Destinations' functionality, but add a feature that maintains a list of previously viewed locations – to be made accessible when searching for a location.
8. Retain all existing input techniques for location searching, potentially revising the 'Town or region' menu option labels to better reflect the intention of each.
9. Provide each of the following image-related alternatives for comparison:
   - a 'overview' image of the location (e.g. an aerial view) on the summary page;
   - the original image with a caption describing its relevance on the summary page; and
   - a link from the summary page to view one or more images relating to the location.
10. Enable users to configure the presence/absence of voice output throughout the service through the 'My Profile' functionality and play/stop the voice output at will within individual pages.
11. Provide the text/voice description (in its entirety) via a link from the summary page. Consider including more descriptive information when accessed via a map-based search.
12. Include a map (or link to such) on the summary page displaying the location within its wider regional context, incorporating a relatively low level of detail – e.g. only major roads, train lines, etc.

Task 2

13. Enable map panning (using both the keypad *and* the joystick) and remove the term 'pan' from the UI.
14. Alter the position and/or appearance, but not the functionality of the map zoom tool, making it more visible and self-explanatory, and removing the associated header. Consider the merits of implementing 'zoom to a point' functionality.
15. Retain the custom layout map only, making the following changes/additions:

(a) maintain the use of standard map POI/feature symbols and colours, increasing their size for easier viewing, where appropriate;

(b) enable users to personalise the display of POIs;

(c) increase the range of POI types for display, incorporating mappable attractions, activities and events;

(d) embed additional POI and feature information within the map/map symbols;

(e) enable users to request and map their current location;

(f) trial new functionality for defining the location of custom POIs; and

(g) maintain the presence of a legend whilst enabling users to configure whether or not it is contextual, through the 'My Profile' functionality.

16. Carefully consider access to the routing functionality from the location layout screens and throughout the system.

17. Include the layout map on the initial layout information screen, placing it before the textual description. Increase the geospatial content of the text/voice layout description, potentially providing it (in its entirety) via a link.

Task 3

18. Remove the checkboxes from the additional categories page and instead link each item on the list to the relevant category page. This will eliminate the need for the 'Continue' link and revisiting the tailored category list, while minimising the number of selections required.

19. Provide online support identifying the preference-based composition of the 'Category' list and the purpose/functionality of the 'See more categories' link.

20. Incorporate additional input techniques when searching for attractions, including: (a) proximity to a location, (b) voice recognition and (c) browse by image.

21. Reduce the prominence of the attraction summary/description, providing it (in its entirety) via a link. At the same time increase the prominence of the 'reference' information, revising the labels to better reflect the content.

22. Increase the visibility of the link *Find a route to or from here* within the attraction summary and associated location map page, linking its functionality closely to the map.

23. Incorporate alternative representations for geospatially distributed attractions – e.g. to-scale walking maps, cross-sections, etc.

24. Reduce the prominence of the image within the attraction summary by placing it at the bottom of the page and potentially reducing its size. Consider providing a link to view additional images on a new page.

25. Utilise the same map and map manipulation tools for the attraction location as that used for the layout map (see Recommendation 15), ensuring that the 'attraction' map symbol is at the highest visual level.

Task 4

26. Relabel the options on the 'Compare Attractions by' menu so that each is more representative of the underlying functionality. Additionally add an alternative method(s) for geospatial comparison of attractions, as described in Section 8.3.2.4.

27. Enable users to view a location comparison map comprising only a subset of the shortlisted attractions, without first having to map each attraction.

28. Consider the merits of refreshing the location comparison map each time an attraction checkbox is checked/unchecked, implementing this if deemed feasible. Rethink the resulting changes in map scale and potential addition of pan and zoom tools, as appropriate.

29. Enable users to sort the text-based attraction locations in different ways – e.g. alphabetically, by locality, by distance from a point, etc.

30. Utilise the same map and map manipulation tools for the attraction location comparison as that used for the layout map (see Recommendation 15), providing additional user tools for hiding/displaying specific map details.

Task 5

31. Maintain the existing weather and forecast content and diagrammatic representations, additionally including the following:

- The time of the 'Current Weather' information; and
- A clock displaying current local time (should be available throughout the service).

32. Retain each existing output technique for communicating current rainfall, maintaining the radar on a secondary page accessible from the weather and forecast information. Make the link to the map more obvious and increase and standardise the size of text labels within the animated radar map.

33. Provide online support to assist in the interpretation of the radar map, whilst making the change in time period more obvious and simpler to understand.

8.5 Discussion

With all of the tools now in hand to embark on a second iteration of design and evaluation, it was useful to reflect on the evaluation of the preliminary design, with the following providing a brief discussion regarding the effectiveness of the procedures and outcomes involved.

The benefits of empirical usability testing are many and should not be underestimated. Through the provision of direct information about a system's use and users' problems with the interface being tested, and when conducted as part of an iterative design and evaluation process, usability testing can help to ensure that an end system is easy to learn, satisfying and simple to use and "provides utility and functionality that are highly valued by the target population" (Nielsen 1993; Rubin 1994, p.26). There are a number of limitations associated with usability testing, however, with those considered relevant to the preliminary design evaluation summarised below, including the steps taken (where possible) to minimise their effects.

- **Sampling problems** – participant samples may be too small and/or not sufficiently representative of the actual end users to be generalisable to the larger population (Holleran 1991; Rubin 1994).

The preliminary design evaluation's function as part of an iterative design and evaluation cycle – i.e. the first of multiple tests on the cartographic UI – meant that its limited sample size of five was acceptable. Indeed, this number represented over 7% of the total target user population and 15% of the users remaining once the necessary criteria were applied (Section 8.2.2.3). Furthermore, while it is acknowledged that the true end user of a product is extremely hard to identify and describe (Rubin 1994), the representativeness of the participants was ensured by sampling directly from the identified user group, which comprised the entire target user population as far as the research was concerned.

- **Motivation and demand characteristics** – participants' interaction with the system being tested may be affected by their "motivation to act as good subjects" and tendency "to act in accordance with what they perceive to be the purposes and hypotheses of the experiment" (Holleran 1991, p.348; Myers 1994).

These factors are extremely difficult to offset due to the unavoidable artificiality of the testing situation (Rubin 1994). Some lessening of their impact was attained, however, through the participants having no vested interest in the DHR travel mLBS under evaluation, beyond being potential end users (i.e. it did not affect their everyday life). Furthermore, participants were encouraged during the sessions to provide both positive and negative feedback, as applicable, with the aim being to improve and optimise the design and not just highlight its 'good points'.

- **Experimenter bias** – the behaviour of the facilitator during an evaluation session is inevitably affected by his/her own experiences, attitudes and knowledge with respect to the system being tested. This may in turn impact on the participants' interaction with the system (often in unknown ways) and thus the results of the evaluation (Holleran 1991; Patton 2002).

While Holleran (1991) recommends that, in order to reduce the effects of experimenter bias, personnel involved in the design of a system should not be involved in its evaluation, this was not possible here due to resource limitations. For this reason, the likely presence of bias in the evaluation results (and their analysis) is recognised, even after unbiased accuracy checking in the form of peer debriefing (Janesick 2000; Creswell 2003). It should be reiterated, however, that the research was never intended to provide definitive answers to questions of optimal cartographic representation techniques for mLBS in general, but rather was aimed at demonstrating how this may be achieved for target users in a given application area, thus lessening the effects of any bias present.

- **Accuracy of evaluation procedures** – whether the evaluation 'measures' what it was intended to (Holleran 1991).

The representativeness of the tasks employed in a usability test impacts on the accuracy of the data collected in terms of satisfying the aims of the evaluation. Therefore to maximise their appropriateness (and thus accuracy), the tasks included in the evaluation were drawn directly from the preliminary design scenario – making them representative of the system's eventual use (Nielsen 1997) – while being carefully tailored to address the research aims (see Section 8.2.2.2). An evaluation's accuracy is also affected by the data collection procedures used, with experts in the field of qualitative inquiry recommending triangulation (i.e. the use of multiple methods) to provide cross-data checks on consistency and therefore increase the strength of the outcomes (Creswell 2003; Patton 2002). This was achieved by combining observations of participants' behaviours and interactions with active questioning and a think aloud protocol. Such procedures are themselves not without their own limitations, however, with verbalisation having the potential to affect task performance (e.g. in terms of technique, success, attention to detail, etc.), while 'self-reporting' can be largely inaccurate and inconsistent in representing participants' underlying cognitive processes – "a user's indication that something has happened does not make it true" (Holleran 1991, p.351). To combat these factors and thus improve the accuracy of the results, participants were asked to think aloud *while completing* each task (i.e. rather than at its conclusion), with the tasks also made simple and straightforward to ensure minimal cognitive load. Furthermore, prompting by the facilitator was kept to a minimum and specifically avoided where it had the potential to interrupt participants' cognitive processing. Finally, the data resulting from verbal reports was carefully and critically considered when it came time for interpretation and analysis, with the observational data employed to judge its consistency.

- **Interpretation of results (accuracy and rigour)** – whether the final outcomes of the evaluation process are credible (Holleran 1991; Janesick 2000; Creswell 2003).

As Holleran (1991) identifies, researchers can "misinterpret, misunderstand, or misapply the results of tests they have conducted, even if the results themselves are based on valid testing procedures" (p.352). The problem lies in the reliance on human interpretation and analysis, which are inherently subjective processes and therefore especially vulnerable to bias (Patton 2002). While the collection of quantitative data may be used for objective comparison with qualitative results, this was not an option for the preliminary design evaluation. Instead, qualitative techniques for optimising the credibility of the results were employed. Specifically, the question of rigour was addressed through: (1) careful selection and design of the evaluation procedure, including a set of standard questions which were asked of all participants after every task (contributing to systematic data collection); (2) pre-agreed consistency in the data recorded by both the observer and the facilitator; and (3) an ensuing process of systematic and iterative redesign and evaluation. Likewise, in endeavouring to optimise the accuracy of the results, the interpretation and analysis of the evaluation data complied with the following recommendations (from Patton 2002; Creswell 2003): (1) triangulation, whereby data from multiple observers and methods were combined in an effort to overcome the individual limitations of each; (2) the presentation of findings using rich, descriptive detail (Section 8.3), including the chain of reasoning behind the interpretation and analysis (Nayak *et al.* 1995), discrepant information identified within the data and alternative conclusions that were made; and (3) peer review of the outcomes (specifically by the research supervisors and consultants) which provided valuable feedback and validation. Furthermore, while they were never intended to be tested and used as acceptance criteria, the qualitative usability goals which drove the initial design were revisited during the interpretation in order to add credibility by highlighting areas where attention to particular goals (and design guidelines) was found to be evident or lacking. Despite each of these strategies, however, it is important to qualify that the results of the preliminary design evaluation – including the recommendations for redesign – remain items of conjecture, being just one interpretation of the data (Patton 2002).

8.6 Chapter Summary

This chapter has described the process by which the preliminary design models for the research were evaluated. The box below summarises the major steps and outcomes involved, all of which contributed to an encouraging result. In this respect, the initial conceptual models of the users' goals, tasks and requirements, and their support by the design specification, were successfully evaluated – preliminary design aim (a) – with very few problems revealed and no changes to the models or personas required. Furthermore, a number of alternative cartographic representation, presentation and interaction techniques were trialled and compared by representative users – preliminary design aim (b) – providing valuable information on their suitability and effectiveness for various tasks. Combining these outcomes together, the resulting design recommendations not only informed on the perceived usefulness of the preliminary design models from the target users' point of view, but also provided a basis for the next iteration of design and evaluation – the focus of the following chapter.

- Informal empirical usability testing was selected to collect the preliminary design evaluation data, comprising a combination of exploratory testing and formative evaluation, along with a degree of comparison testing for contrasting alternative cartographic representations.
- The evaluation itself took place in a specialist usability laboratory, with five participants selected from the target user population through a process of purposeful random sampling. During each evaluation session, an individual user completed realistic tasks using the prototype system, while 'thinking aloud' about their experiences and answering questions posed by the facilitator.
- The observational and verbal data resulting from the evaluation was qualitatively analysed and interpreted, yielding a set of 33 design recommendations in preparation for the next stage of the iterative design and evaluation: redesign.

9 Phase IV: Design Refinement

9.1 Introduction

As previously established, the practice of iterative design and evaluation is considered of major importance to the UCD process, enabling continual validation and refinement of conceptual models and design ideas throughout the development lifecycle, so that users' requirements are addressed by a *useful* end product. Therefore, in keeping with its UCD aims, the final phase of the research comprised an iteration of the preliminary design and evaluation activities detailed in Chapters 7 and 8. This chapter describes the revision of the preliminary design, the evaluation of which is then documented in Chapter 10[1]. It begins by defining the aims, scope and approach for the design revision (Section 9.2.1), accompanied by a discussion of the relevant qualitative usability goals and quantitative usability measures (Section 9.2.2). Following this is a comprehensive description of the 'redesign' activities, incorporating changes to the existing design components and the addition of new functionality and representation techniques (Section 9.3). The revised cartographic UI design models are then presented in Section 9.4.

9.2 Preparation for Design

9.2.1 Aims, approach and scope

Continuing the evolutionary process of design instigated in Chapter 7, the aims of the 'redesign' phase were established as follows:

- **(a)** revise the cartographic UI design based on the outcomes of the PDE; and
- **(b)** extend the cartographic UI design models, incorporating additional functionality and further (alternative) techniques for representing, presenting and interacting with geospatial information.

Identical to the preliminary design, the approach taken for the redesign activities involved the exploration of design ideas and specification of solutions through a prototype. In keeping with the *evolutionary prototyping* approach proposed in Section 7.3.3, this comprised revising and extending the existing limited functionality simulation (which remained of relatively low fidelity being still early in the design process). Notably, this approach meant that the platform capabilities

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[1] Note, the evaluation of the revised design is distinguished from the preliminary design evaluation throughout this and the following chapter by making reference to the latter using the acronym PDE.

and constraints relating to the preliminary design (Section 7.3.4) were also applicable to the redesign, as were the general design guidelines and principles upon which it was founded (Section 7.3.5).

The scope for the redesign efforts was also based on the preliminary design, enabling an assessment (through evaluation) of whether the problems identified during the PDE had in fact been suitably rectified, and whether other problems had been introduced or uncovered by the suggested changes (Nielsen 1993; Myers 1994). This meant that the same three user goals – **Obtain overview of location(s)**, **Find things to do / of interest** and (to a lesser extent) **Determine route** – were addressed during the redesign. Of note, however, was the scope's (re)inclusion of the task 'Determine what's in the immediate area' – a refinement of the goal 'Obtain overview of location(s)' which was not addressed during the preliminary design, for various reasons (see Section 7.4.3.4). With a process of scenario-based design again favoured, the preliminary design scenario was expanded to address the 'new' scope and so provide more sufficient guidance for the redesign activities. Thus the new design scenario (incorporating almost all of the original content that had been previously removed) was as follows:

Redesign Scenario

You have been sent to Fremantle by your company for a couple of weeks and it's somewhere you've never been before. You're thinking of taking your family along on your next, inevitable visit and making it into a holiday for them, so you maximise your non-work time to get to know the town and surrounding area in preparation. You start by using Holiday Helper to find out about Fremantle and the surrounding area, specifically its layout, and nearby activities that you think your family would enjoy. After this you decide it would be good to explore the area on foot. Just before heading out though, you use the Holiday Helper to check whether it is going to rain. After a particularly long walk, you become disoriented and realise that you don't know where you are in relation to your hotel. You look around but can't see any street signs, nor people to ask for directions. You pull out the Holiday Helper which tells you your current location with respect to a number of recognisable landmarks.

9.2.2 Usability goals

At the beginning of the preliminary design chapter a set of *qualitative* usability goals was formulated (Sections 7.2.1 and 7.2.2), aimed at focusing and assisting in the assessment of all potential design decisions. Prior to beginning the preliminary design activities, these goals were prioritised, resulting in ten Priority 1 (P1) goals and five Priority 2 (P2) goals (Table 7.1), with the consideration of the former being essential to achieving the preliminary design aims while the latter were anticipated for consideration only after all P1 goals had been addressed and/or during the next design iteration. In reality, each of the P2 goals was addressed during the preliminary design phase, emphasising their importance to the cartographic UI design. Hence the priority levels were removed for the current design phase, resulting in the complete list of qualitative usability goals to be addressed presented in Table 9.1.

Table 9.1 The qualitative usability goals for the design revision.

P1 – directly applicable to the design revision	
A	user may employ the system to obtain an overview of a location
B	user may employ the system to find things to do / of interest
C	*user may employ the system to determine a route*
D	individual users' different approaches to and abilities with geospatial tasks accommodated
E	different levels of geospatial information detail to be provided
F	map characteristics causing difficulties for members of the user group to be avoided
G	auditory outputs not to be used in isolation from other representation forms
H	clear, non-technical language to be employed
I	representations to be universally non-offensive
J	visual components optimised for users with colour blindness and/or difficulty seeing fine detail
K	geospatial information access to be self-explanatory, while being easy to learn and remember
L	geospatial information access to accommodate frequent users
M	incorporation of, and ready access to, necessary support information
N	geospatial information tailored to increase relevance to individual users
O	disparate geospatial information to be seamlessly (re)presented

The discussion in Section 9.3 highlights when and where the various qualitative usability goals were applied throughout the design revision (again designated by the notation **ug*L***).

In Section 7.2, the notion of *quantitative* usability goals was introduced, referring to design goals which are objective and measurable, thus being suitable for use as evaluation acceptance criteria. Such goals were initially expected to be of value during the evaluation of design revisions in order to enhance the qualitative results obtained. There are several categorisations of quantitative usability goals with any given goal likely to fall into more than one of these (from Mayhew 1999):

Ease-of-use goals – focus on frequent use by experienced, trained users; concern the potential speed, efficiency and flexibility offered.

vs.

Ease-of-learning goals – focus on infrequent users, first-time users and/or users who are still learning; concern the length and scope of the learning curve.

Absolute goals – have an absolute quantification (e.g. a specific number

vs.

Relative goals – concern users' experience relative to some benchmark (e.g. a previous release, the

of errors per task).		equivalent manual process, a competitor's product).
Performance goals – (objective) quantify actual user performance to complete tasks; use measures concerned with time and errors.	vs.	**Preference/Satisfaction goals** – (subjective) concern clear user preferences between alternative UIs (measured by 'choice'); aim at a certain satisfaction level with a UI (measured along a scale).

A major benefit of defining quantitative usability goals is their use for determining when the iterative design and evaluation cycle should end – "Design efforts are iterated with evaluation until evaluation indicates that established usability goals are satisfactorily met" (Mayhew 1999, p.124). It has been recognised, however, that such use of quantitative usability goals is most valuable towards the end of the design process, when more is known about specific user actions in certain situations, thus enabling the setting of suitable usability metrics (Dix *et al.* 1998; Mayhew 1999). This consideration was particularly relevant to the current research which, being at an early stage of the design process, was more concerned with exploring the relative usefulness of alternative cartographic representation, presentation and interaction techniques than assessing the individual usability of each – hence its focus on qualitative usability goals up to this point. Therefore, the setting of formal quantitative usability goals was deemed out of scope for the research.

In spite of this decision it *was* considered useful to implement a number of **quantitative usability measures** for (qualitatively) comparing the alternative techniques employed within the cartographic UI. While these could not be considered *goals* as such, they would provide valuable objective data regarding the 'relative' usability of various cartographic aspects of the design, while assisting in isolating problem areas within the design (Mayhew 1999). The quantitative measures selected for assessing the revised design are listed below, each of which was 'performance'- or 'preference'-based and concerned with 'ease-of-learning':

- **(a)** Number of errors during task completion.
- **(b)** Frequency of help use.
- **(c)** Preference for particular representation, presentation and interaction technique(s).

Section 10.2.2.3 details the collection of these measures within the context of the research.

9.3 Redesign and Development

The results of the PDE comprised a list of design recommendations (Section 8.4) aimed at fixing usability problems within the design and improving the overall cartographic UI. Although it is generally recommended that such a list be prioritised, with those issues of highest priority addressed first (Nielsen 1992; Mayhew 1999), being a research project and not a commercial product, the design revision endeavoured to address every item on the list, with the need for particular exclusions identified and assessed along the way. In addition to this, and in accordance with design aim (b), the cartographic UI design was extended to incorporate additional functionality as well as further techniques for representing, presenting and interacting with the underlying geospatial information. Finally, throughout this process a number of ancillary design decisions were also made that were not directly related to the recommendations or expanded scope, but were instead based on additional insights gained during the PDE process. The justification for these is included as part of the design rationale presented below[2].

9.3.1 System structure

Although not impacting on the conceptual models of the users' goals, tasks and requirements, upon re-consulting the research personas (Section 6.5.3) and scenarios (Section 6.5.6), and considering the results of the PDE, a small number of changes to the overall system structure were deemed necessary. The first of these concerned the need for access to the *My Itinerary* holiday planning functionality throughout the system (i.e. from within each of Modules 1, 2, 3, 4 and 5). The main justification for this was that at least two of the personas – Lisa and Daniel – were expected not only to require access to itineraries created prior to their travels, they may also wish to create a new itinerary and/or update an existing itinerary while using the system to search for information on locations, accommodation, attractions/events/activities and routes during their trip (e.g. Scenario 1). Furthermore, with the PDE indicating a need for better explanation of the *My Profile* concept and its use in tailoring the cartographic UI, it was considered appropriate to require users to log in to the service in order to access it, thus reinforcing the idea of personalised usage. Figure 9.1 shows the revised system structure resulting from these changes.

Based on these decisions no changes were necessary in terms of the organisation of the Main Menu, however a few slight alterations were made to its appearance in accordance with design recommendation 1. Figure 9.2 shows the changes made in this respect, comprising more representative and self-descriptive button labels, with a more appropriate icon chosen for the 'Location Info' button (**ugK**, **DP20**) – intended to better support the user goal 'Obtain overview of location(s)' (**ugA**, **DP1**) – and associated rewording of the page title. Additional to this, the main buttons' appearance was altered (essentially reversing their colours) in an effort to make their ability to be selected more obvious (**DP19**).

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2 The application of UI and cartographic design guidelines presented in Section 7.3.5 is designated throughout the design rationale by the notations **DP*n*** and **CP*n***, respectively.

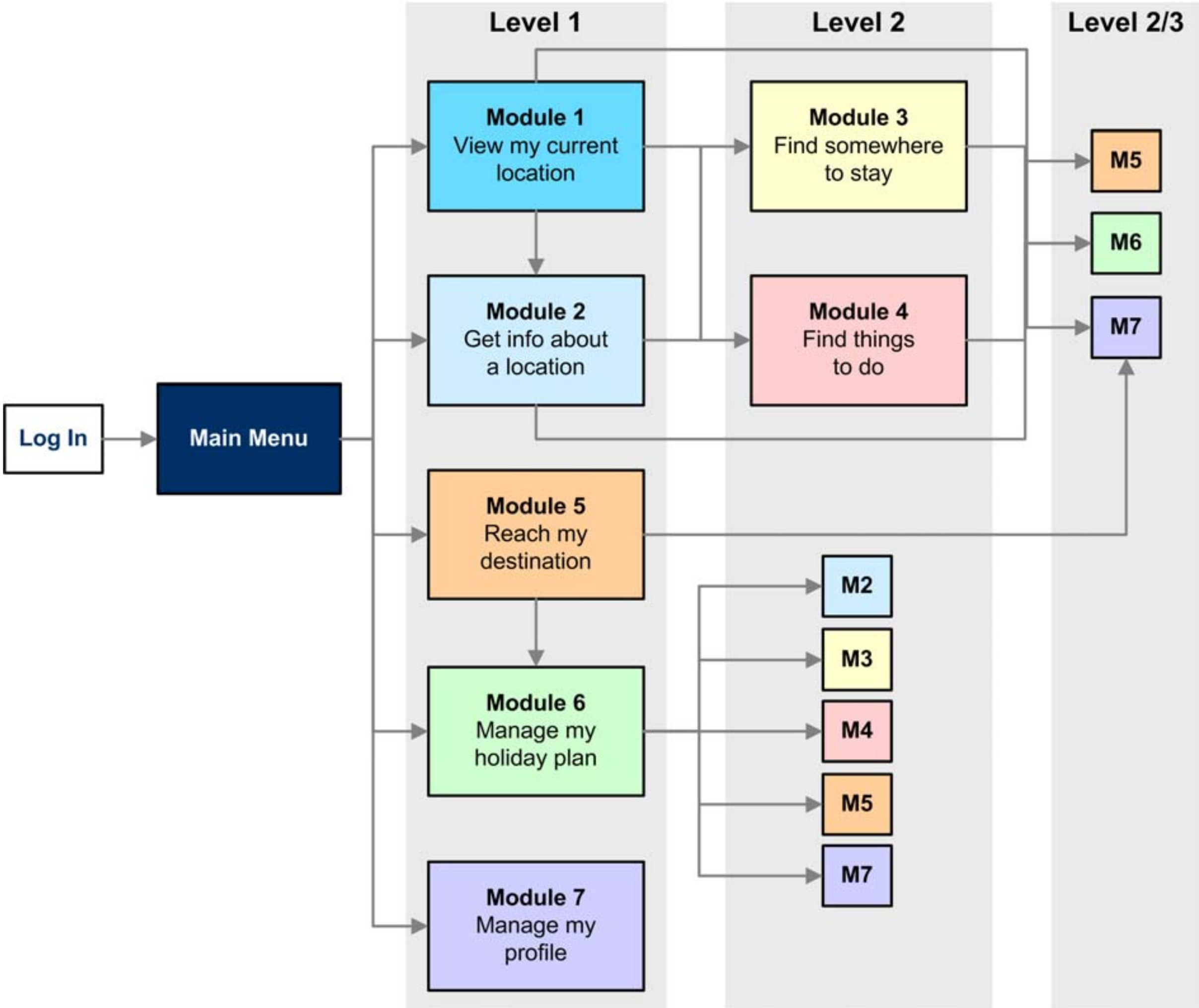

Figure 9.1 The revised system structure, addressing the results of the PDE and the requirements of the research personas and scenarios.

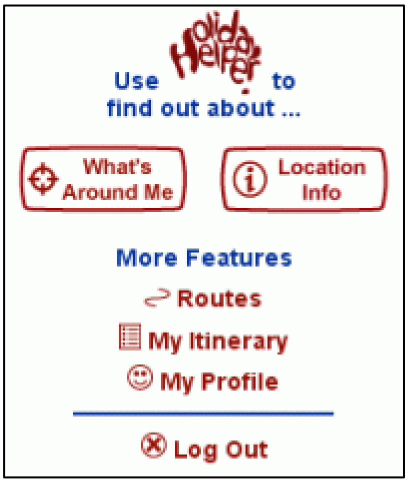

Figure 9.2 The revised Main Menu.

9.3.2 System-wide design decisions

With the majority of system-wide decisions made during the preliminary design (Section 7.4.2), the only aspects for discussion here involve minor changes impacting the UI in general and, more importantly, the selection of additional cartographic representation, presentation and interaction techniques for trial and comparison within the prototype.

- **Page header/footer** – a number of changes were made to the universal page header and footer: (1) the 'Home' (Main Menu) link on the far left was retained, but without the preceding 'HH' acronym which had confused PDE participants; (2) the *My Profile* link on the far right was also retained, with the text replaced by an icon (to save space), which was identical to that used on the Main Menu to denote this functionality; (3) due to the aforementioned requirement for access to *My Itinerary* from within each of Modules 1, 2, 3, 4 and 5, a new link was added for this to the left of the *My Profile* link, consisting of the icon used on the Main Menu to denote this functionality; and (4) the 'Menu' link, which previously opened the current Module's menu but was seldom used by PDE participants, was replaced by text and icons enabling browser-style 'back' and 'forward' page navigation (a need for these shortcuts having been observed during the testing – **DP7**).
- **Current time** – to satisfy a component of design recommendation 31, the current time was added to each page in the UI (displayed in 12-hour format), enabling quick reference should the user wish to compare their local time with any temporal information provided by the system.
- **Results lists** – to simulate a technological issue common to mobile Internet services, short delays (approximately two to five seconds) were incorporated prior to loading any search result; in addition, an abstract sound was added to the display of each results page, to represent the completion of the search and thus draw attention to the results (**DP28**).
- **Cartographic representation techniques** – during the preliminary design a variety of common cartographic representation techniques were explored for a number of different geospatial tasks, with the PDE yielding user impressions of the utility and usability of each, along with recommendations for those which should be retained and improvements to be made. Additional to implementing these changes, the design revision was intended to extend the cartographic UI and so explore the usefulness of further methods for representing, presenting and interacting with geospatial information. In this respect it was deemed necessary to employ existing techniques for different purposes as well as incorporating new techniques within the design. Based on the discussions in Section 3.2.2 which relate to the perceived relevance of different cartographic representation forms for mLBS applications, the following additional techniques/purposes were designated for exploration during the design revision:
  - *Schematic maps (2D)* – as an alternative to conventional 2D maps, to aid in localisation, orientation and the identification of geospatially distributed objects;

- *Image maps (2D)* – (incorporating remotely sensed imagery) as an alternative to conventional 2D maps, to aid in localisation, orientation and the identification of geospatially distributed objects;
- *Diagrams* – to convey different views of complex geospatial information (e.g. alternative to maps) and/or to present simple geospatial relationships;
- *Photographs and panoramas* – to aid in localisation, orientation and the identification of geospatially distributed objects;
- *Abstract sounds* – for providing feedback and alerting users to important geospatial information; and
- *Animation* – for drawing users' attention to geospatial entities.

While establishing this list, three other techniques were additionally considered. Unfortunately, however, none were deemed feasible within the constraints of the research (i.e. the selected technological platform and time):

- *3D maps* – as an alternative to conventional 2D maps, to aid in localisation, orientation and the identification of geospatially distributed objects;
- *Haptic output* – (e.g. device vibration) for providing feedback and alerting users to important geospatial information; and
- *Video* – to aid in localisation, orientation and the identification of geospatially distributed objects.

The following section describes the design revision in detail, including the application of the selected cartographic representation forms to different components of the cartographic UI.

9.3.3 The cartographic user interface

While the preliminary design used a scenario to drive the entire process, such an approach was considered less relevant during the design revision (except where new functionality was incorporated). Instead, the redesign activities focused on addressing the recommendations generated from the PDE, in the process adding additional functionality/representations and making other necessary changes. Throughout, the following materials were consulted:

- the User Profile (Chapter 5);
- the user goal and task models – including all research personas and scenarios (Chapter 6);
- the platform capabilities and constraints (Section 7.3.4);
- the UI and cartographic design guidelines and principles (Section 7.3.5)
- the redesign scenario (Section 9.2.1); and
- the re-prioritised qualitative usability goals (Table 9.1).

For consistency with the preliminary design rationale (Section 7.4.3), the following sections present the redesign activities according to the order in which each UI Module is utilised within the redesign scenario. Again, despite its linear presentation here, the process of revising the design was much more complex and iterative than it may appear.

9.3.3.1 Module 2 – location search (inputs)

Beginning with the search menu for specifying a location of interest (Figure 9.3a), the title of this was changed to match the associated Main Menu button labelling identified in Section 9.3.1. Furthermore the following revisions were made in response to the design recommendations:

- Recommendation 8 – each of the existing input techniques was retained (text entry, voice recognition, map-based selection and list-based selection – **ugD**), while the label for 'the town or region name' was revised (now 'Place name search') to better reflect the underlying functionality (**ugK**, **DP1**). Notably, the word 'place' was used to replace 'town or region' throughout the system, with the latter considered too restrictive and the former more in line with the users' own language (**ugH**, **DP2**).
- Recommendation 2 – an additional search option was added for finding information about places around the user's current location ('Places around me (GPS)' – **ugA**, **DP1**). Once selected, this option initiated an automated search simulating the retrieval of the user's position via A-GPS[3] (**DP5**, **DP28**) and the use of such to calculate and return a text-based list of nearby locations (including the wider region), showing numeric straight-line distances and ordered by proximity to the user – Figure 9.3b. From here the user could select the desired location about which to access information (**ugA**).
- Recommendation 7 – a new feature was added to the system concerned with the ongoing maintenance of a (non-editable) list of the user's eight most recently accessed locations (**ugN**, **DP27**), which was made available as an additional option on the 'location info' search menu ('Most recently viewed'). Involving list-based selection, input via this technique required the user to find and select the location about which they sought information from within the list (**ugA**), which was sorted according to order of access (i.e. most to least recent) – Figure 9.3c.

[3] The choice of A-GPS (given the more user-friendly label 'GPS' – **ugH**, **DP2**) for the simulated positioning was based on the higher accuracy of this hybrid technique compared with other methods (see Section 2.3.1.1). In reality, this input technique would be feasible for any positioning method, however the inclusion of proximal distances, and the list's ordering based on these, would likely be less meaningful using methods of lower accuracy (e.g. CGI).

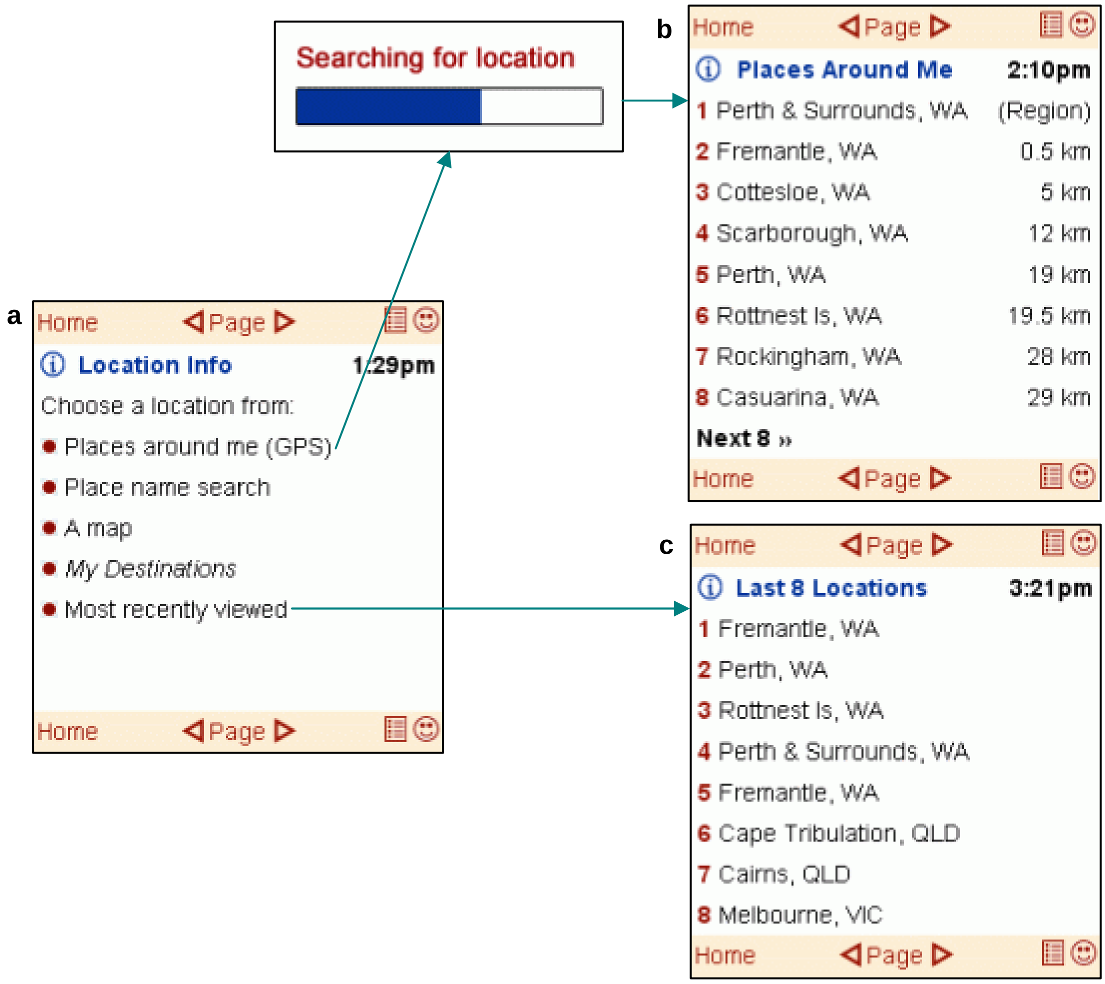

Figure 9.3 (a) The 'location info' search menu; (b) searching for a location using automated (A-GPS) input; and (c) searching within a list of recently viewed locations.

Moving on, a small number of changes were required concerning the 'place name search' inputs. First, in response to design recommendation 3, the selection of a state by which to filter the search results was made more obvious by placing the affected functionality at the bottom of the page, below a dividing line (Figure 9.4a) – this solution also endeavoured to convey the state list's equal relevance to both the text and the voice input options (**DP1**). Additionally, help text was added to describe the state selection (**ugM**, **DP10**) and, being considered non-essential content, was placed on a new page accessed by selecting a (widely recognisable) 'help' icon (**DP20**). Furthermore, the default option for the state list was renamed from 'select' to 'any' to further clarify its purpose (**DP1**). The second set of changes concerned the 'voice input' instructions, whereby the text-based help was removed from the search page and replaced with multimodal text- and speech-based instructions (**ugG**) conveyed each time the user selected to 'initiate' the voice input (**ugM**, **DP10**). In addition to this, the audible prompt following the instructions was replaced by a sound considered more recognisable as a 'tone' (**DP28**), the need for this change becoming evident during the PDE. Finally, the labels for the text and voice input fields were revised to better differentiate these and convey their individual functions (**DP1**).

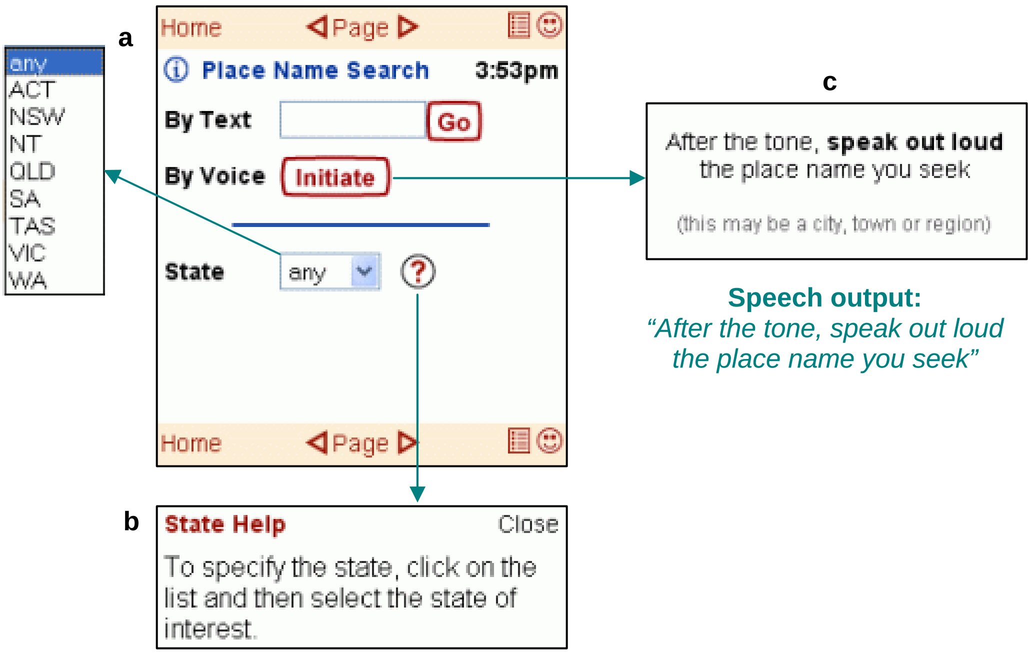

Figure 9.4 Searching for a location by place name, showing (a) the state-based results filter and (b) associated help, along with (c) the text- and speech-based instructions for voice input.

Looking finally to the map-based input, here two design recommendations were addressed (see Figure 9.5):

- Recommendation 5 – due to the constraints of the prototype platform, the use of crosshairs for map-based selection was unable to be replaced by the sequential highlighting of map features (i.e. upon scrolling the device's joystick). Nor was it possible to provide visual, audible and/or haptic feedback when a selectable map feature was 'rolled over' (**CP10**, **CP12**). An alternative design solution was found to support the initiation and subsequent operation of this task, however, by surrounding the maps with white space, thus making it easier for users to see when each map was able to be selected – **ugK**, **DP19**. Additional to this, the link to access contextual online help for using the maps was made more visually obvious by positioning it underneath each map and replacing the text with a recognisable icon (**ugM**, **DP20**). Furthermore, the help content was revised and simplified to provide better support to users (**DP10**).
- Recommendation 6 – the size of the text included within the maps was increased and standardised, per feature type (**ugJ**, **CP3**, **CP15**). Moreover, although the size of each town and capital city symbol was ultimately unchanged (in order to maintain the maps' clarity – **ugF**, **CP14**), the 'clickable' hotspot areas associated with these were made larger, thus reducing the accuracy required by users when making a selection.

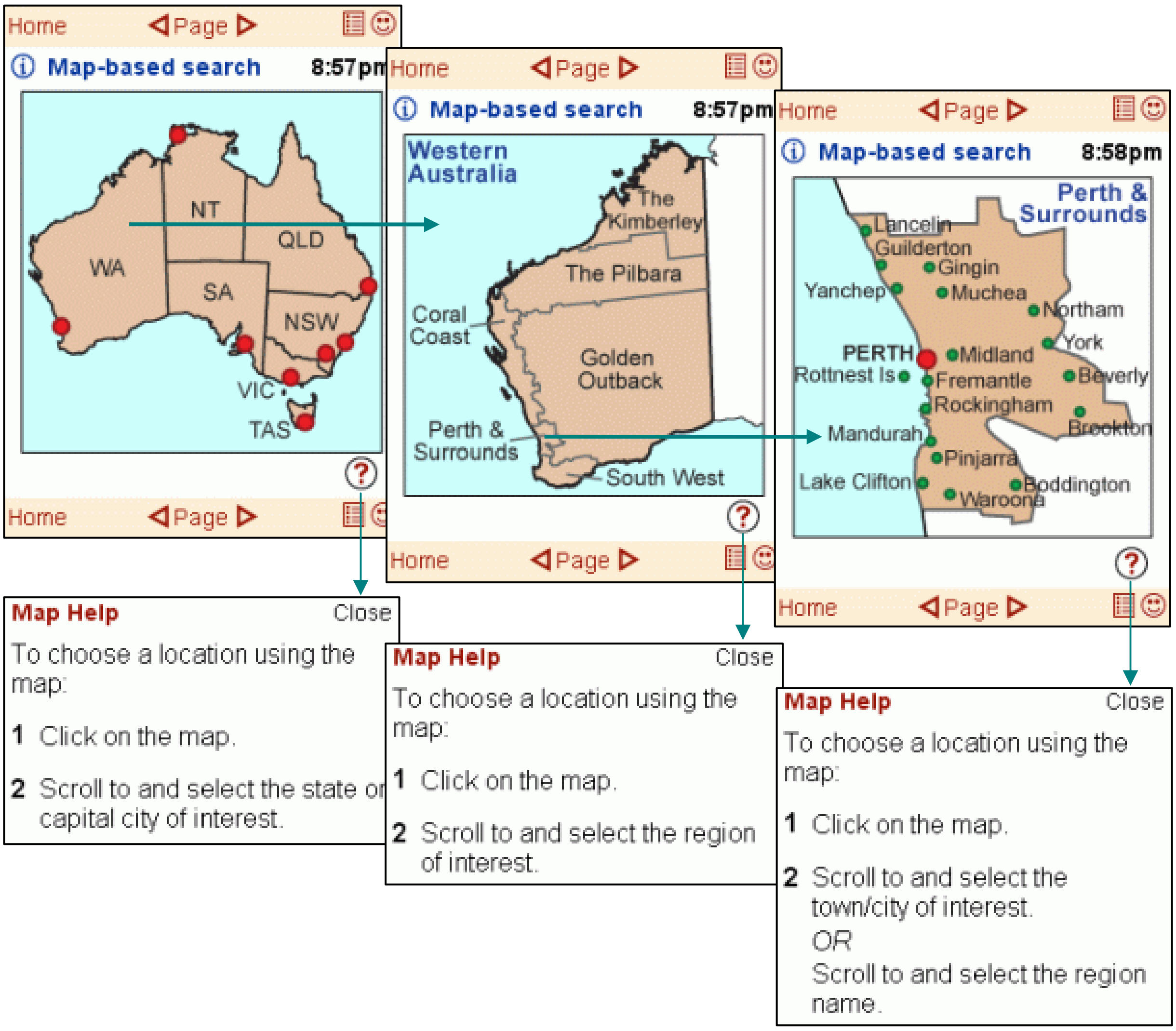

Figure 9.5 Map-based selection and the associated online help when searching for a location.

9.3.3.2 Module 2 – general location summary and layout (outputs)

Although the PDE participants were generally accepting of the content arrangement on the location summary page, a need was seen for revisions concerning the labelling and organisation of the interactive text-based links (now referred to as 'Location Options'). In this respect, the following changes were made: the 'Facilities' option was renamed 'Facilities & Services', with the latter considered more representative of the intended content (**DP1**); 'Transportation' was replaced by 'Routes To, From and Around' (and the routing shortcut removed), with the new goal-oriented option – which encompassed transportation – expected to provide better support for the users' needs (**DP1**); and 'Attractions, Events & Activities' was divided into two separate options – 'Attractions & Activities' and 'Events' – following consultation of the research scenarios (particularly scenario 3) which indicated that these should be treated as separate geospatial entities (**DP1**). As a final step, the order of the Location Options was revised, based on various comments made by participants during the PDE. Here, the links considered of greatest importance and/or likely to be used most frequently were placed towards the top of the list, while those deemed of lower priority were moved to the bottom (**DP1**, **DP22**, **DP26**):

1. *Layout*
2. *Routes To, From & Around* – Module 5
3. *Accommodation* (non-functional) – Module 3
4. *Attractions & Activities* – Module 4
5. *Events* (non-functional) – Module 4
6. *Facilities & Services* (non-functional)
7. *Climate & Weather*
8. *History* (non-functional)

Beyond the above changes, a number of design recommendations were addressed with respect to the location summary page, resulting in five different versions intended to convey each of the alternative output techniques employed. To facilitate their comparison, the different page versions were alternately presented upon searching for a location using the various input methods (Section 9.3.3.1). Furthermore, a set of temporary links was included on each page (labelled A to E) to allow rapid switching between the different outputs. The associated design revisions involved the following:

- Recommendation 11 – contextual links ('more detail'/'less detail') were provided to enable users to toggle between viewing the full text of the location description and a truncated version (**DP1**, **DP14**) – see Figure 9.6. Equivalent changes were also made to the length of the accompanying voice output. In order to garner user preferences for the initial state of the text-/voice-based description (i.e. full vs. truncated), each was alternately displayed upon searching for a location using the various input methods (Section 9.3.3.1).

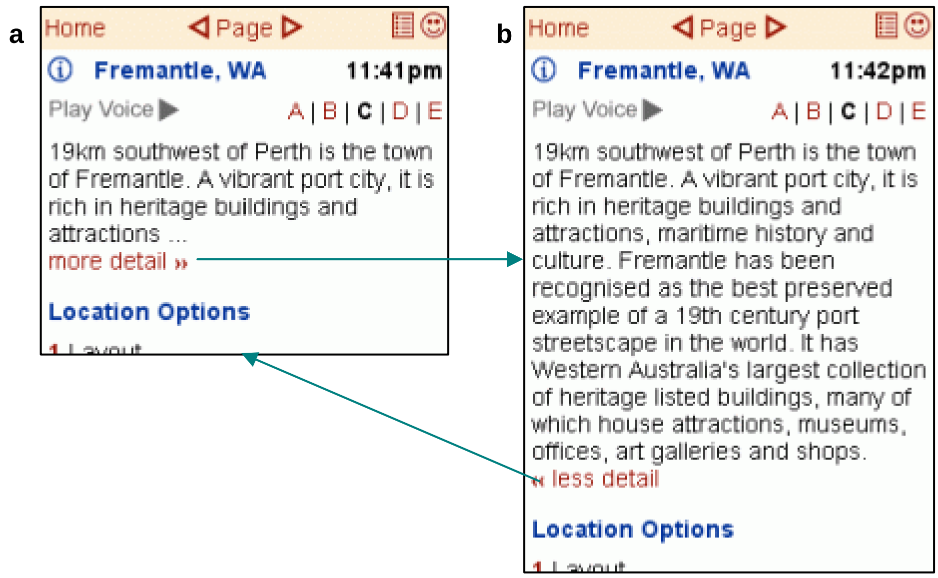

Figure 9.6 The (a) full and (b) truncated versions of the text-based location description.

- Recommendation 10 – while technical constraints prevented the implementation of functionality allowing users to play/stop the voice output on-demand, a sufficient *impression* of this behaviour was provided here and elsewhere in the system (i.e. the ‘attractions & activities’ pages, the text-based ‘layout’ page and the ‘climate & weather’ page – **DP4**, **DP13**, **DP25**), with users able to play the voice output at will but not stop it. Additional to this, it was anticipated that users would be able to configure automated vs. on-demand voice output for the entire system within *My Profile* (**ugD**, **ugN**), however the implementation of this was considered outside the scope of the prototype.
- Recommendation 9 – to further evaluate the utility of images within the location summary page, four alternative image outputs were created for comparison (again being alternately displayed upon searching for a location using the various input methods – Section 9.3.3.1). These comprised: (1) an aerial photograph of the location; (2) a labelled photograph showing a stereotypical scene from the location; (3) a labelled photograph of a landmark found at the location; and (4) no image, with an option to view multiple photographs of the location on a new page – see Figure 9.7.

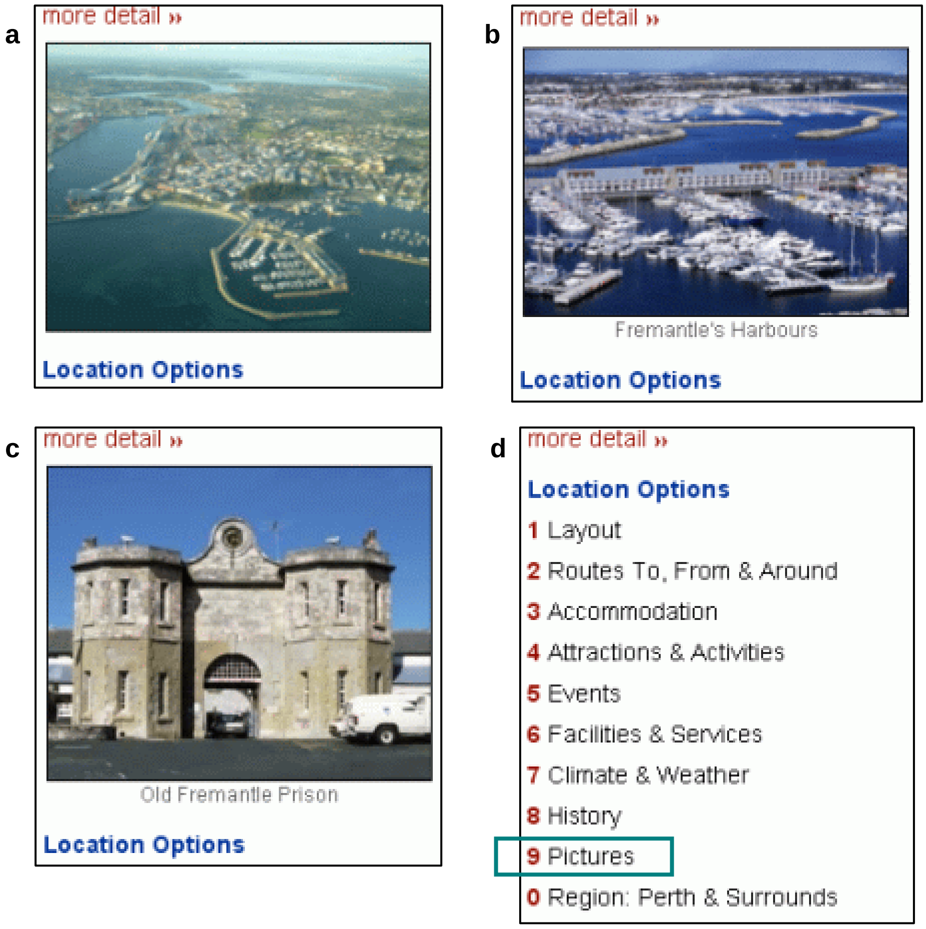

Figure 9.7 Alternative image outputs for the location summary page: (a) aerial view of the location; (b) typical scene from the location; (c) popular landmark within the location; and (d) link to a page containing multiple images.

- Recommendation 12 – providing an additional representation form for comparison, a basic (view-only) location map was incorporated within a version of the location summary page, intended simply to display the location within its wider regional context (Figure 9.8). With its design based largely on that of the 'custom' layout map (the revision of which is described below), a number of specific cartographic decisions are worthy of note:
  - **Scale and area coverage** – the decision was made to use the map to convey the location of interest with respect to the largest town/city within the same region (**ugA**). Hence the scale and area coverage were determined such that each of these locations was wholly visible (**CP1**)
  - **Selection and refinement** – with the map's purpose requiring only minimal features (i.e. sufficient for basic localisation), the following were selected: land and water, line symbols representing freeways and major roads and labelling of larger towns/suburbs in the region (**CP1**, **CP2**).
  - **Generalisation** – some displacement of text labels was required (with respect to underlying line symbols) to optimise their legibility (**CP2**, **CP4**, **CP15**).

- **Symbolisation** – the only 'new' map feature requiring design was the additional road category of freeways. Again, these were visually distinguished through the use of hue (green) and size, the latter involving a thicker line weight which reinforced the freeways' hierarchical dominance over the major roads (**CP3**, **CP6**, **CP7**, **CP14**). Furthermore, so as to place the location of interest at the highest visual level, the text for this label was increased in size, with a bold style applied (**CP3**, **CP7**, **CP15**).
- **Marginalia** – based on the view-only purpose of the map, the decision was made not to provide tools for panning or zooming. Moreover, a legend was not deemed necessary, since the map design was sufficiently similar to other maps in the system where a legend was present (**CP5**).
- **Dynamism** – in response to initial feedback obtained during the ensuing evaluation (see Section 10.2.3.1), additional attention was required to the design of the label denoting the location of interest, which was not considered sufficiently obvious (**CP6**, **CP7**). The final solution involved adding dynamism to the map by employing the variables *rate of change* and *duration* to animate the label and so draw the user's attention (**CP11**) – similar to Oppermann & Specht's (1999) 'blinking' news icons.

Figure 9.8 The location map included on the location summary page.

Looking now to the output forms used to convey a location's layout, design recommendation 17 advised combining the text- and map-based outputs within the same page. After some experimentation, however, this was found to be largely inappropriate since it required an unacceptable amount of scrolling in order to view each of the representation forms (**DP22**). In fact, were this implemented as suggested, it was considered unlikely that users would even notice the text at the bottom of the screen. Therefore the text and map outputs were maintained on separate (linked) pages (**ugD**, **ugE**), with the map comprising the initial view upon entry into this component of the UI (in accordance with the PDE participants' preferences). Responding further to recommendation 17, the geospatial content of the text output was also increased at this time (refer to Figure 9.9a).

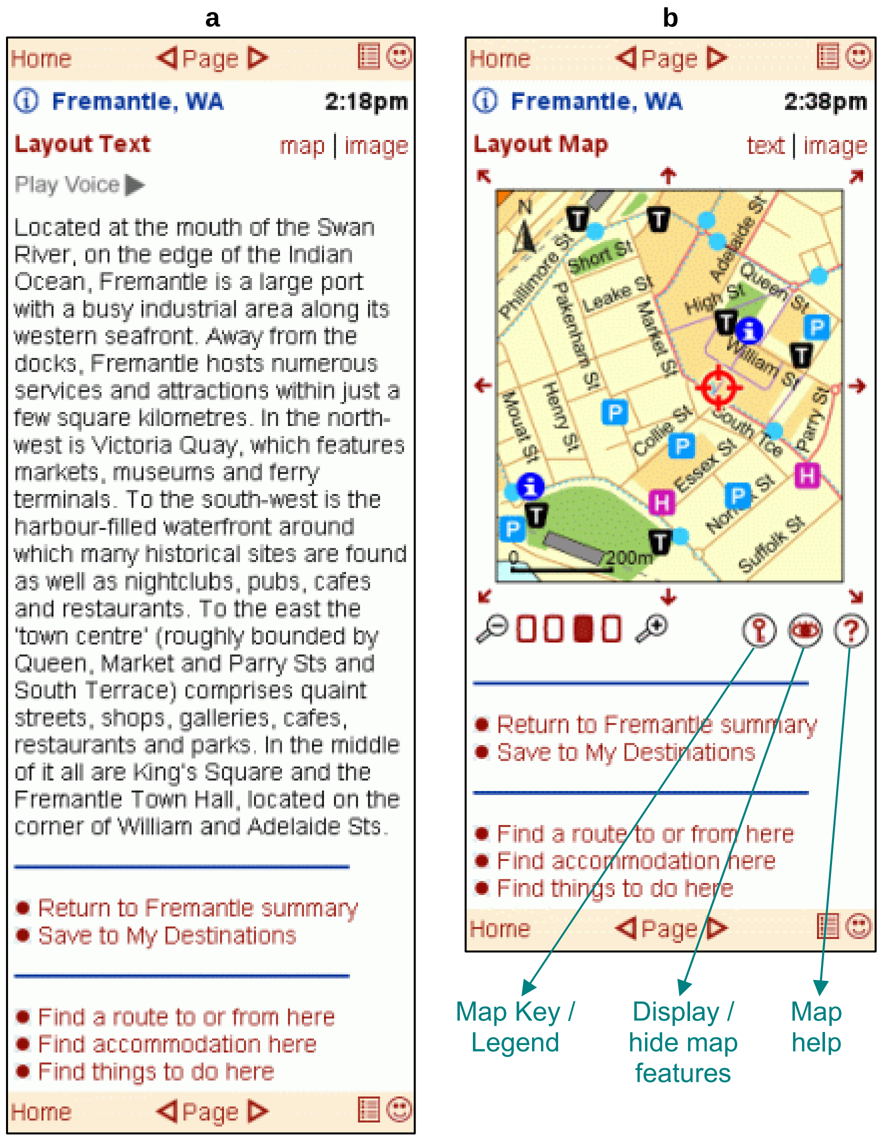

Figure 9.9 The (a) text and (b) egocentric map for communicating a location's layout.

Three of the preliminary design recommendations were concerned with improving the usefulness of the map representation employed to convey a location's layout. The following discusses how each was addressed:

- Recommendation 13 – while map panning functionality was only *implied* within the preliminary design, it was implemented as part of the design revision[4] (**CP5**). Based on the behaviour of several PDE participants (who tried highlighting the map and using the joystick to pan it left and right), the pan tool was redesigned by replacing the existing set of images with icons positioned outside the eight cardinal points of the map boundary (see Figure 9.9b). With their

[4] Due to the prototype's simulation status only certain segments of the map could be panned.

'pointing' design (**CP14**, **DP20**) and close association with the map (**CP16**), the pan icons were assumed to be largely self-explanatory (**CP10**) and so no labelling was incorporated. In terms of their interaction, each of the map pan icons was able to be selected using either the joystick or the numbered keypad (**DP7**) – resulting in the appropriate directional shift – with the layout of the latter corresponding directly to the screen icons (e.g. 2 = North, 6 = East, 8 = South, 4 = West). Note, a map help page was also implemented at this time to provide (among other things) instructions for the panning functionality (**ugM**, **DP10**), including the icon ↔ keypad mapping, with the word 'pan' replaced by the less technical term 'scroll' (**ugH**, **DP2**) – see Figure 9.10a.

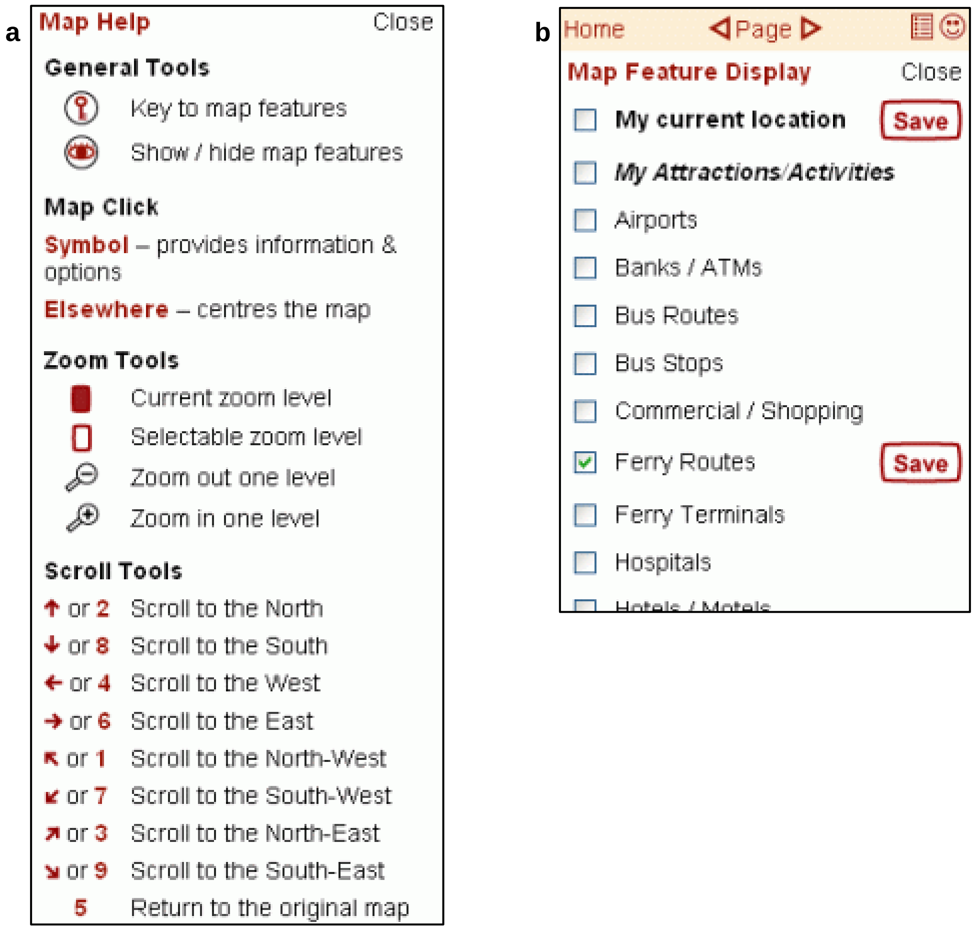

Figure 9.10 (a) The system-wide map help page and (b) functionality for personalising the map feature display.

- Recommendation 14 – the position, orientation and appearance of the map zoom tool were altered for several reasons, primarily to enable viewing of the tool at the same time as the map, but also in an attempt to make its operation more self-explanatory (e.g. by replacing the +/– text with 'magnifying glass' icons considered more familiar based on their widespread use within Web mapping applications). One particular change involved the removal of the 'map zoom', 'street' and 'suburb' labels, which were considered to be largely redundant cues that mainly served to clutter the screen – note, it was expected that the validity of this decision would become evident during the evaluation of the revised tool. Widely accepted by the PDE participants, the functionality of the tool remained unchanged, with users still able to zoom in/out by either directly selecting an individual scale icon or else selecting one of the icons positioned at the extremities of the tool (see Figure 9.9b) – the functionality of the zoom tool was added to the map help page (Figure 9.10a). Upon considering the merits of implementing 'zoom to a point' functionality, this was deemed unnecessary with the zoom tool providing sufficient functionality for changing the scale. Instead, 'map click' interaction was reserved for other functions – namely viewing more information about a specific map feature and centring the map on a point – which are discussed later on with respect to Modules 4 (Section 9.3.3.3) and 1 (Section 9.3.3.6).

- Recommendation 15 – while only the 'custom' layout map was retained, a number of changes were required, both in response to the design recommendations but also (in the case of (a)) to address symbolisation problems identified during an external review of the map design conducted by a cartographic expert[5]:
  - **(a)** The sizes of the point and line symbols were standardised (per feature) – and increased, where required – across all map scales and the legend, to conform with cartographic design rules (**CP3**, **CP14**) and ensure optimal viewing (**ugJ**); variations were made to the shape, colour and/or lettering of a number of POI symbols (e.g. public parking, public toilets) to incorporate familiarity and convention – thereby making them more self-explanatory (**CP10**) – and to improve contrast with the surrounding symbology (**CP3**, **CP6**, **CP7**, **CP14**); the saturation/chroma of specific area and line symbol colours (parkland, commercial, major roads) was decreased to improve the legibility of overlying text, with the labels for water bodies and suburbs varied in colour and weight, respectively, for the same purpose (**CP3**, **CP6**, **CP14**, **CP15**); some displacement of overlapping point symbols, as well as a number of text labels, was required to improve overall map clarity (**CP2**, **CP3**, **CP15**).
  - **(b)** The ability to personalise the display of different map features (including POIs) was added (with only limited functionality implemented), which essentially transformed the map into an *egocentric* representation (Reichenbacher 2005a, p.152; Meng 2005b) – i.e. it could be customised to cater to the user's immediate and individual needs (**ugD**, **ugE**, **ugN**, **DP14**); here, an icon was added below the map (resembling an 'eye' – see Figure 9.9b), which provided access to a new page from which the user could specify any number of map features for display by 'checking' the appropriate checkbox(es) and saving (Figure 9.10b); note, the icon was identified on the map help page (Figure 9.10a).

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[5] This individual possessed several years of industry and academic (teaching and research) experience in the field of cartographic design.

(c) The range of POIs available for display on the map was increased (**CP1**, **CP2**) in line with the results of the PDE (street numbers) and the user profiling (service stations, banks/ATMs, restaurants/bars), as well as standard road map[6] content (bus routes, bus stops); furthermore, the user's saved attractions/activities were incorporated for potential display (limited to either all or none) – refer to the second list item in Figure 9.10b; the initial display of specific POIs and other map features at the various map scales was similar to the original design (Section 7.4.3.2), however this was considered less important here, with users now having the ability to select which features are displayed (**DP14**) – note, additional functionality was anticipated for storing the user's most recent feature display selections (per scale), so that these may be applied during subsequent layout map access (**ugN**).

(d) The requirement to embed additional feature information within the map/map symbols was not addressed for the layout map, with the decision made to instead evaluate this functionality within a different part of the system – refer to the Module 1 discussion in Section 9.3.3.6.

(e) The ability for users to request and display their current location on the map was added (contributing further to its egocentric status), being accessible via the 'map feature display' page – refer to the first list item in Figure 9.10b; moreover, animation was added to the symbol, employing the variables *rate of change* and *duration* to draw the user's attention to where they are currently located (**CP11**); note, while not implemented/required as part of the prototype's simulation, additional functionality was anticipated for changing the map scale upon a request for the user's current location, in order to ensure its inclusion within the visual display (**ugN**, **DP27**).

(f) Time constraints, and the presence of sufficient UI features for in-depth evaluation, led to the exclusion of this design recommendation – concerned with trialling new functionality for defining the location of custom POIs.

(g) While out of scope for implementation within the prototype, it was anticipated that users would be able to configure whether the layout map's legend content was static (i.e. always include every feature) or contextual (i.e. tailored to include only those map features selected for display at the scale from which it was accessed), with the latter being the setting employed for the evaluation (**ugN**); furthermore, replacing the text-based 'View Legend' link previously located above the map, an icon resembling a 'key' – see Figure 9.9b – was added below it (considered by the PDE participants to be a more logical position) to provide access to the legend (**CP16**); note, for consistency with the

[6] Specifically the Melway and UBD (Melbourne) street directories.

new icon (which was identified on the map help page Figure 9.10a) the word 'key' was used in place of 'legend' throughout the UI (**ugH**, **DP2**, **DP4**, **DP13**).

To satisfy the second design aim, an additional representation technique for communicating the location layout was developed for comparison with the aforementioned text- and map-based outputs. This took the form of an image map which, similar to those investigated by Dillemuth (2005b) and Almer *et al.* (2004), comprised multi-scale satellite images overlaid with map features (Figure 9.11). The design of the image map was based on that for the conventional map representation, with a few notable differences:

- **Selection and refinement** – appropriate satellite imagery (of equivalent scale and area coverage to the conventional map), was sourced from the Whereis.com website[7] for use as the image map base (**CP1**, **CP8**, **ugE**).
- **Graphic & structural design** – the image map was designed to convey the same geospatial information as the conventional map, with the changes listed below deemed necessary with respect to the symbology (**CP3**, **CP4**, **CP6**, **CP7**, **CP14**, **CP15**, **ugF**, **ugJ**).
  - *Map ground* – based on their ready identification within the imagery, it was deemed unnecessary to include symbols for representing land, water and coastlines.
  - *Line symbols* – while each of the lines styles remained the same, the variables of size and colour (hue and chroma) required manipulation in order to make the line features stand out sufficiently from the 'dark' image background. Here, each of the line weights was increased (by 1pt), while the colours used for railway lines and walkways were changed and brightened, respectively.
  - *Area symbols* – while the colour of the symbols representing railway stations was changed to match that used for railway lines, the transparency of the commercial land use symbol was increased so that the imagery beneath it was partially visible. Again, due to their ready identification within the imagery, symbols for representing parkland were considered unnecessary.
  - *Typography* – the legibility of the map-based text was improved in various ways to sufficiently distinguish it from the 'dark' image background: (1) the water body and street number labels were each made bold and their colours 'lightened'; (2) the colour of the suburb labels was changed to white; and (3) the road names were made bold, their colour changed to yellow and a transparent grey rectangle placed below each.

[7] Under the terms and conditions of use (www.whereis.com/whereis/legal/legal.do), copyright (www.whereis.com/whereis/legal/copyright.do) and disclaimer (www.whereis.com/whereis/legal/disclaimer.do) relating to Whereis® map data.

- **Marginalia** – while the same marginalia as that designed for the conventional map (i.e. pan, zoom, feature display, legend, help) was included with the image map (**CP5**, **CP16**, **ugM**, **DP10**), only the help and the zoom tool were functional within the prototype.

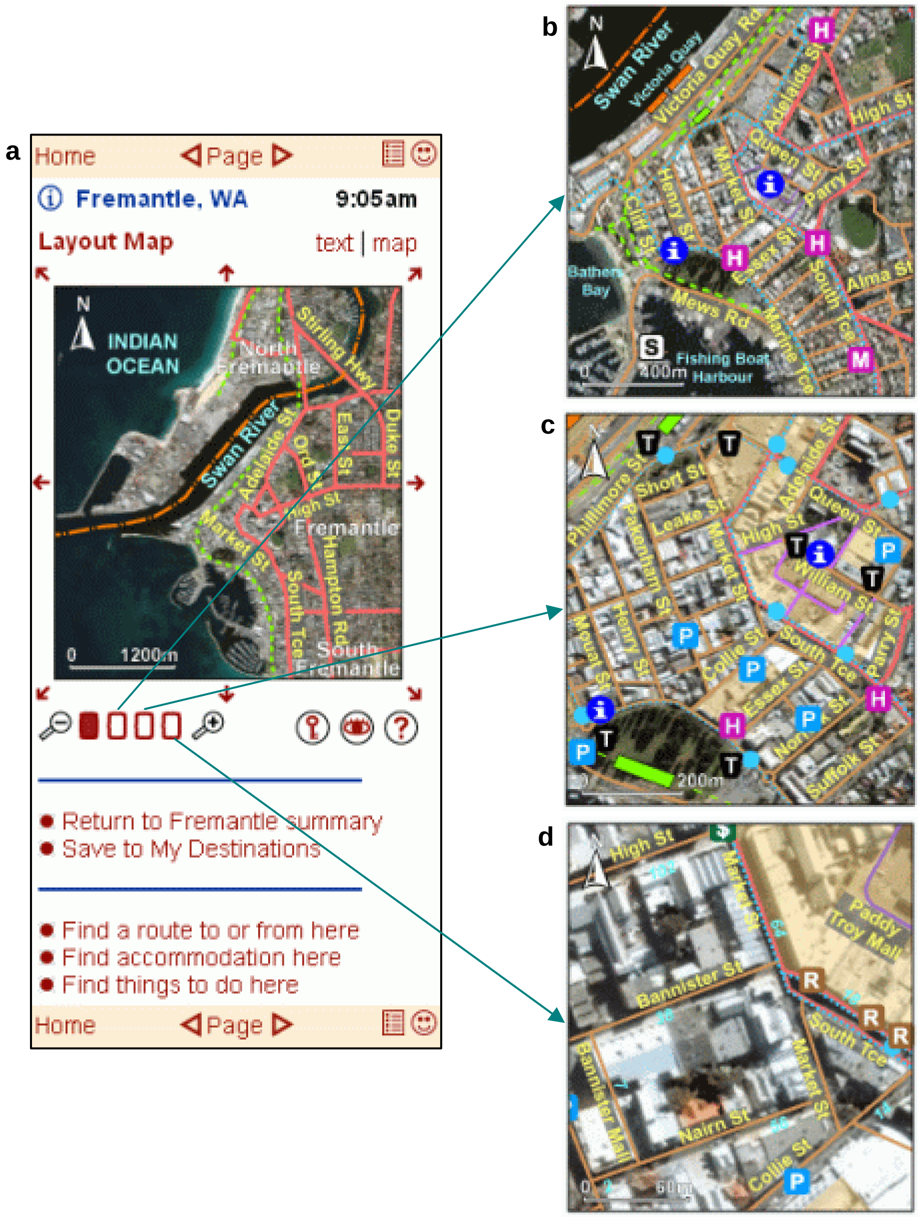

Figure 9.11 The image map for communicating a location's layout, with all four scales shown (a – d).

Once completed, the image map was interlinked with the text and conventional map representations, enabling users to easily switch between (and thus compare) all three (**ugD**). Particular care was taken to ensure that the last shown map scale was maintained when switching to either of the map representations from the text output (**DP4**, **DP25**).

Finally, in accordance with design recommendation 16, access to the routing functionality (Module 5) was added to each of the location layout pages in the form of a shortcut link ('Find a route to or from here') positioned with the links to other Modules found at the bottom of the page (**ugC**, **DP1**, **DP14**, **DP26**). Once selected, it was anticipated that this would initiate the routing Module, with the user then able to denote the location of interest as either the start or end of a new route (**DP12**, **DP21**). Note, similar links were incorporated within other parts of the system, as appropriate.

9.3.3.3 Module 4 – activity search (inputs)

The next set of design revisions concerned searching for attractions and activities in and around the location of interest (recalling that 'events' were now treated as a separate entity – Section 9.3.3.2). As evident from Figure 9.12, a number of new search options were added to the design, while several changes were made to the existing input techniques.

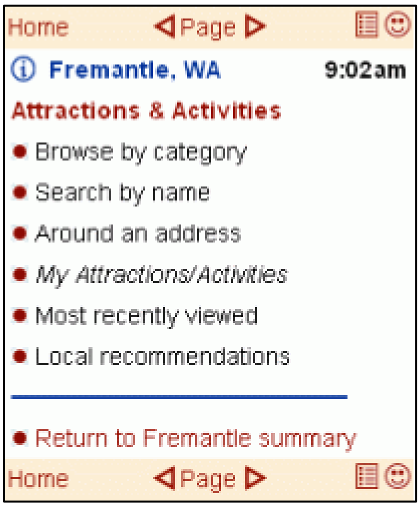

Figure 9.12 The revised 'attractions & activities' search menu.

Beginning with 'Browse by category', the first change (in response to design recommendation 18) involved the functionality for accessing attraction/activity categories additional to those on the initial (personalised) list. While the preliminary design had utilised checkboxes, allowing users to select any number of categories for addition to the initial category list, the design was revised to simplify this interaction, based on the assumption (from the PDE results) that users were only interested in a single new category at this point in time (**DP1**, **DP11**, **DP21**). Therefore the checkboxes were removed and replaced by links to each of the categories on the list (**DP23**) – see Figure 9.13b and d – note, this also provided greater consistency with other list-based functionality within the system (**DP4**, **DP13**, **DP25**). Explaining the composition of the initial category list and how additional categories may be accessed (design recommendation 19), online support was added to the initial 'browse categories' page (**ugM**, **DP10**) – Figure 9.13a. Finally, to maintain the ability for users to update their personalised list of categories, a page was also added allowing the user to optionally save the selected category to their 'My Categories' favourites list (**ugN**, **DP7**, **DP14**) – Figure 9.13c.

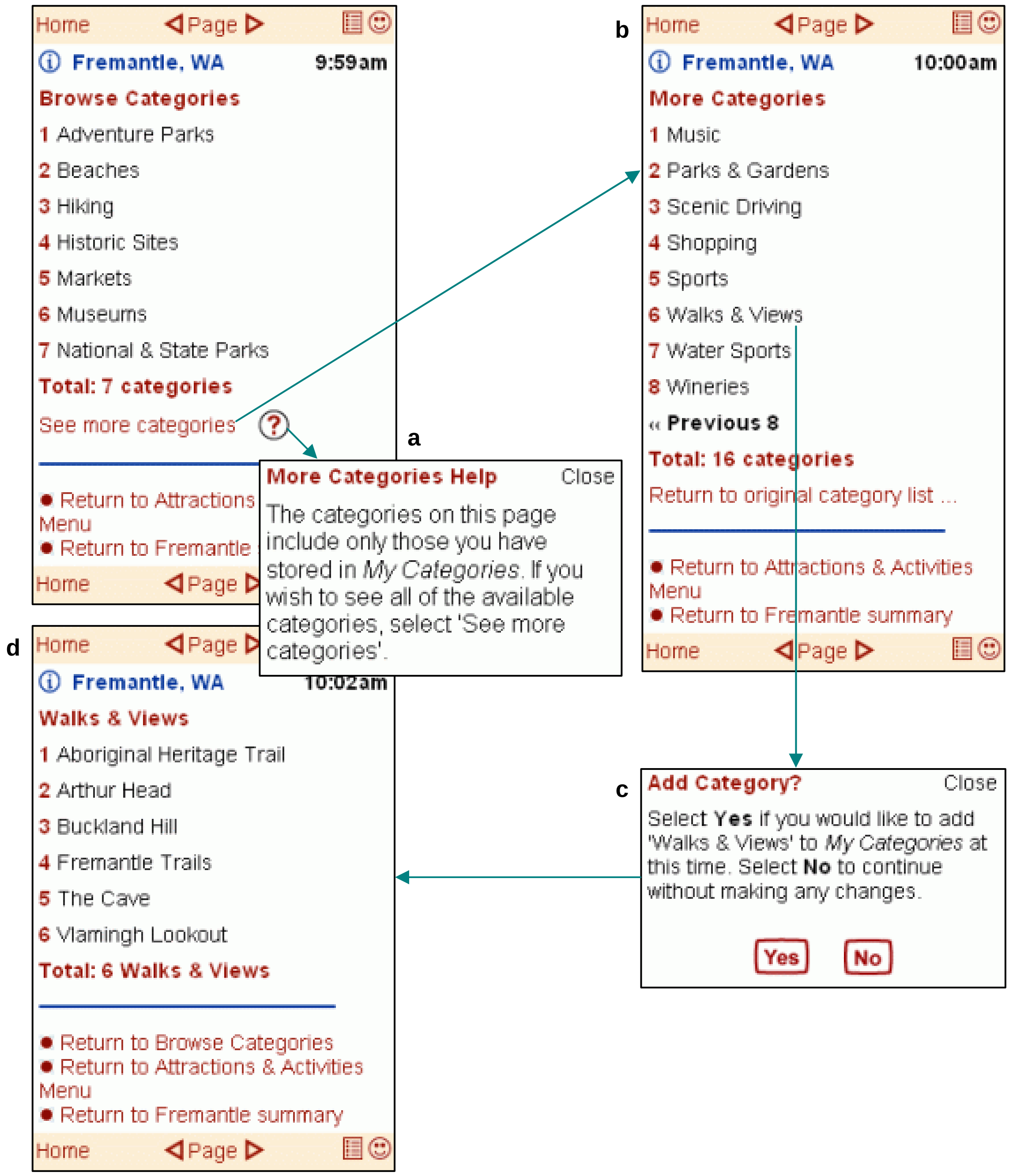

Figure 9.13 Browsing for an attraction/activity that is not on (a) the initial category list, and thus requires access to (b) additional categories. When selected, a new category may be (c) saved to the user's favourites before (d) the relevant attractions/activities are displayed.

Partially addressing design recommendation 20, the final revision to 'Browse by category' involved the addition of image-based list browsing for comparison with the existing text-based list selection (**ugD**). Figure 9.14 shows the implementation of this within the prototype, with users shown a thumbnail photograph of each attraction/activity (where available) in addition to its name (**ugE**). Selecting a particular attraction/activity opened the corresponding information page, in an equivalent manner to the text-based list selection.

Figure 9.14 Searching for an attraction/activity using image-based list selection.

Moving on to 'Search by name', this was extended (in line with design recommendation 20), to incorporate voice-recognition as an additional input technique (**ugD**) – see Figure 9.15. Once implemented, the operation of the voice-based attraction/activity search was identical to that for the voice input technique used when searching for a location – Section 9.3.3.1 (**DP4**, **DP13**, **DP25**). Additional to this, the link to 'see more categories' was removed from the 'name search' page (no longer being relevant based on previously discussed changes), while the dropdown list for specifying the category(/ies) to search within was revised, now containing the following options: all system categories; My Categories (the user's favourite's, stored within *My Profile*); and a list of individual categories, grouped by those saved within My Categories and then all remaining categories (**DP26**).

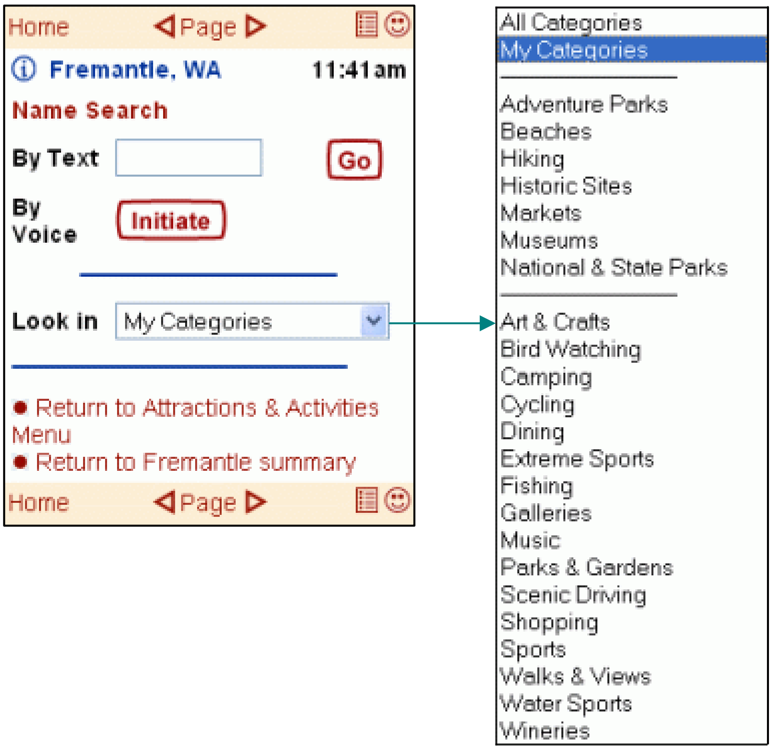

Figure 9.15 Searching for an attraction/activity using text- and voice-based input.

Completing the requirements of design recommendation 20, a further option was added to the attractions/activities search, concerned with finding all attractions and activities proximal to a specific location (**ugD**, **ugE**). Labelled 'Around an address' (originally 'Relative to an address', but renamed during the evaluations – see Section 10.2.3.1), this allowed users to specify a street address around which to search using any of the following options (Figure 9.16):

- *My current location (GPS)* – the reverse geocoded address of the user's current location, based on their position as determined by A-GPS; note, the simulation of this was identical to that employed when searching for a location (Section 9.3.3.1).
- *My Addresses* – a list of descriptions representing street addresses that the user has saved during previous system use (Figure 9.16b), including those associated with their 'favourite' attractions/activities, accommodation, etc. (**ugN**, **DP7**).
- *Most recently viewed* – a list of the last eight addresses that were geocoded by the system (Figure 9.16c) – **ugN**, **DP7**.
- *New address* – manual specification of an address through entry of the town/city, street name, street number and/or state (Figure 9.16a), resulting in a list of addresses matching the user's input (Figure 9.16d); selection of an address presented the option to save it to My Addresses.

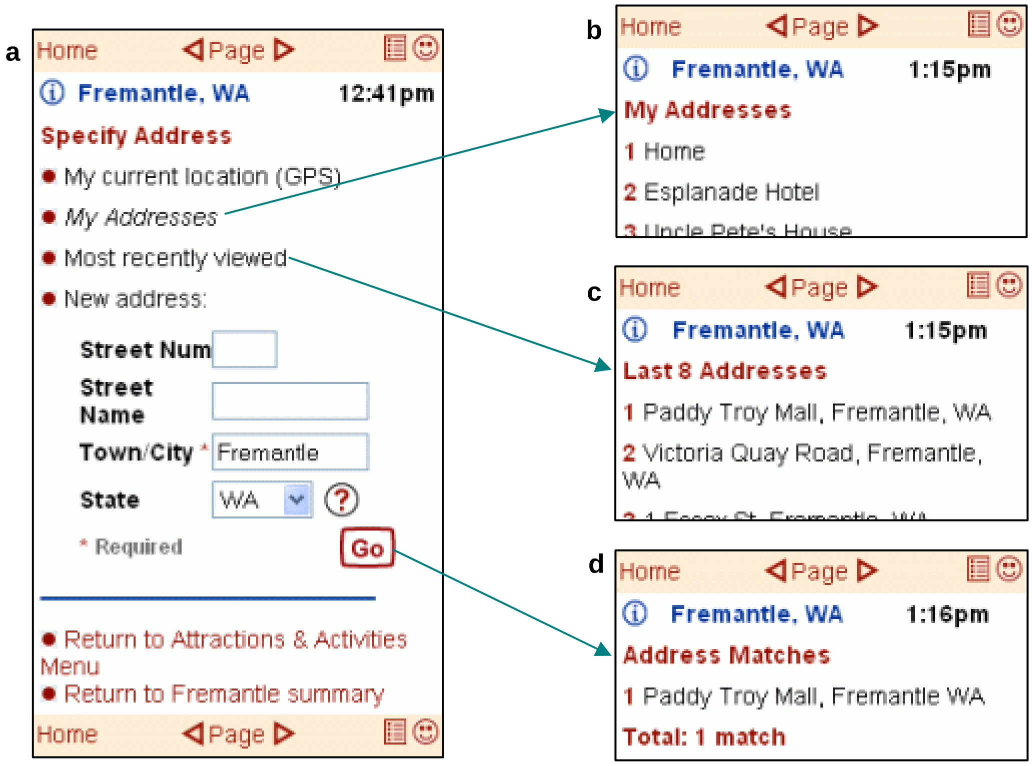

Figure 9.16 Specifying an address around which to search for attractions/activities.

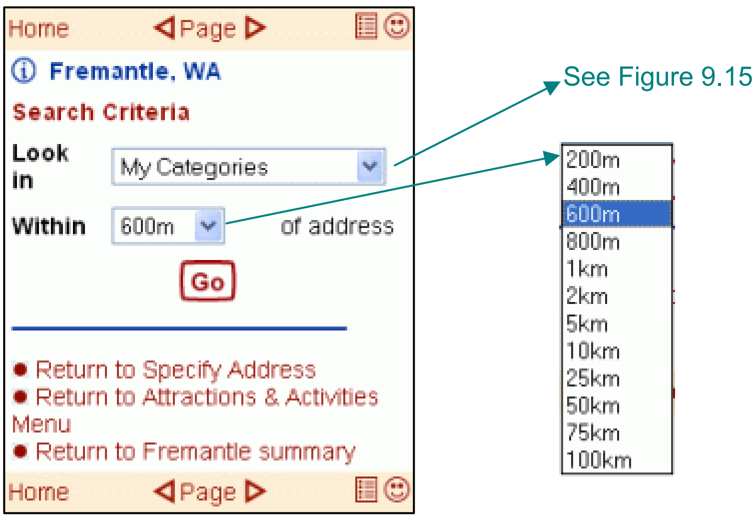

Figure 9.17 The criteria used to constrain the search for attractions/activities around an address.

Once an address was specified (using any of the above options), two search criteria were presented: (1) the particular category(/ies) within which to search for attractions/activities; and (2) the search radius (i.e. centred on the given address) – refer to Figure 9.17. Here, the user was required to make the appropriate selections and initiate the search, with the results then calculated and represented using one of three alternative presentation forms (**ugD**) for conveying the attractions/activities corresponding to the specified criteria: text-based list, diagram or map.

Looking first to the text-based list, this incorporated the name of each resulting attraction/activity, along with its straight-line distance from the search address (Figure 9.18a). Selecting an individual item from the list (which was ordered from closest to furthest) opened the corresponding attraction/activity information page. Moving on to the diagrammatic representation, this was intended to add an extra dimension beyond that provided by the text – i.e. direction. To this end a scaled, target-like drawing was created and overlaid with a north point and symbols, the latter representing the various attractions/activities returned by the search (Figure 9.18b). While the centre of the diagram was coincident with the search address, each of the attractions/activities was positioned at roughly the correct distance and direction from this (with some displacement necessary to accommodate their labels). When the user selected an attraction/activity symbol – using the same crosshair technique as that for the map-based location search input (Section 9.3.3.1) – the corresponding attraction/activity information page was displayed (**DP4**, **DP13**, **DP25**).

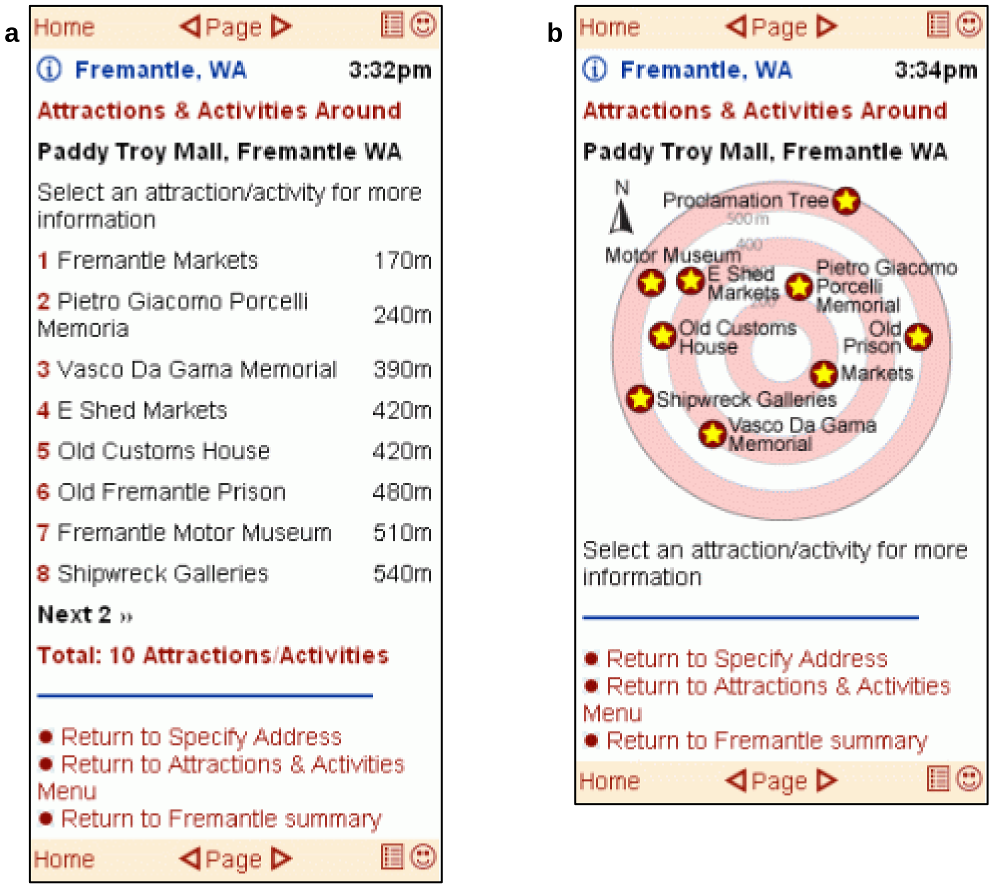

Figure 9.18 The (a) text and (b) diagrammatic techniques for representing/selecting attractions and activities around a specific address.

To provide even greater geospatial context for the resulting attractions/activities, the decision was made to include a map-based representation for comparison. Rather than create another conventional map, however, advice was taken from Brunner-Friedrich & Nothegger (2002) resulting in the development of a *schematic* map. Using the conventional map-based output from Module 2 (i.e. the layout map) as a starting point, a schematic was created by extensively simplifying, refining and displacing the incorporated labels, lines and area features (**CP2**) – resulting in a topologically correct map with a somewhat 'sketched' appearance (Figure 9.19a). Like the diagrammatic representation, the centre of the map was coincident with the search address, except here it was also marked with a black 'cross' symbol (**CP3**). In addition to this, a single symbol was incorporated to represent each attraction/activity, using the attraction/event/activity symbol described in Section 9.3.3.4. Notably, some displacement of the point features was required so that they were in topologically correct positions with respect to the rest of the map (**CP2**).

Figure 9.19 (a) The schematic map for representing/selecting attractions and activities around a specific address, and (b) a linked page identifying one of the mapped attractions/activities.

Although it could not be considered completely accurate, a scale was added to the schematic map to provide some indication of the distance between the search address and attraction/activity locations. This took a similar, target-like form to the scale inherent in the diagrammatic representation. Moreover, because the scale was superimposed on the map and had the potential to reduce its clarity, additional functionality (in the form of a checkbox) was included below the map to allow users to turn the scale on and off (**CP16**). Finally, to optimise the visibility of the various map features, the attractions/activities were not labelled on the map (**CP15**). While the ideal situation would have been for a tool tip-style label to appear as the user scrolled the crosshairs over a given attraction/activity symbol (**CP10,** as demonstrated by Heidmann *et al.* 2003; and Gartner & Uhlirz 2001), this was unfortunately not possible due to the constraints of the technological platform. Instead, upon selecting a map symbol, the user was shown a page identifying the selected attraction/activity, including its name, address and an illustrative photograph, with a shortcut provided to progress to more detailed information (Figure 9.19b).

Final changes to the attractions and activities search component included the renaming of 'My Shortlist' to 'My Attractions/Activities' – to better reflect its content and maintain consistency with the naming of other *My Profile* favourites lists (**DP1**, **DP13**) – and the addition of a final search option – 'Most recently viewed' – which enabled the user to select from the last eight attractions/activities that they had accessed (**ugN**, **DP7**). Furthermore, the shortcuts present on each page within Module 4 were revised, resulting in the removal of the links not considered relevant (e.g. 'Save to My Destinations' and 'Find Accommodation here') and the addition of new links for returning the user to previous levels of the search hierarchy (e.g. 'Return to Attractions & Activities Menu' and 'Return to Specify Address') – **ugL**, **DP6**, **DP7**, **DP17**.

9.3.3.4 Module 4 – activities (outputs)

Two sets of outputs had been implemented for Module 4. Beginning with the detailed attraction/activity information pages, various revisions were required here in order to satisfy the associated design recommendations[8]:

- Recommendation 21 – to reduce the prominence of the text-based attraction/activity summary, contextual links ('more detail'/'less detail') were provided enabling users to toggle between viewing the full text and a truncated version (**DP1**, **DP14**) – see Figure 9.20a. Serving to increase the prominence of the 'reference' information listed below it, the initial state of the summary was set to the truncated version (**DP22**, **DP24**). At this time the reference information was also reordered, with items considered of highest relevance placed closest to the top, while two of the items were renamed in an effort to make them less ambiguous – 'Entry' became 'Cost'; and 'Contact' became 'More Info' (**ugH**, **DP2**, **DP26**).
- Recommendation 24 – the prominence of the attraction/activity image was also reduced by replacing it with a thumbnail photograph and a link which opened a new page containing multiple, larger photographs (**ugE**, **DP1**, **DP22**). These remained in the same location on the page, beneath the summary and above the reference information (Figure 9.20a).
- Recommendation 25 – the attraction/activity map (Figure 9.20b) was revised so that its design matched that of the layout map (Section 9.3.3.2), mainly requiring the addition of the same

[8] Recommendation 24 – 'incorporate alternative representations for geospatially distributed attractions' – was not addressed, partly due to time constraints, but also to ensure that the prototype was not too extensive to allow for sufficiently in-depth evaluations. Since this recommendation concerned attraction-specific geospatial information, as opposed to more commonly applicable representations, this was not seen as a major omission.

marginalia/functionality (i.e. pan, zoom, feature display, legend and help) – **ugM**, **CP5**, **CP16**, **DP10**, **DP25**. This contributed towards an impression that the various maps within the system were in fact *the same* map, but with different initial area coverage, scale and visible map features (which varied with each map's purpose/setting). In terms of this map's initial status, while maintaining the attraction/activity of interest as the centre point, the scale was slightly increased and additional map features (e.g. certain POIs, minor roads, bus routes) were selected for display to provide greater information (i.e. context) about the immediate area (**CP1**). In response to an external review of the map design, conducted by a cartographic expert who found problems with the visibility of the attraction/activity symbol, this feature was enlarged and the colour of its centre 'star' changed from white to yellow. In addition, the symbol was animated (in an equivalent manner to the current location symbol on the layout map) and the colour of its label was changed to match the symbol's background (dark red). All of this served to place the attraction/activity symbol at the highest visual level within the map (**CP3**, **CP6**, **CP7**, **CP11**, **CP14**).

Figure 9.20 The attraction/activity page showing (a) the truncated summary, image (with link) and reference information and (b) the map output.

- Recommendation 22 – the visibility of the shortcut link 'Find a route to or from here' was increased for both the attraction/activity information and map pages, by moving it upwards to just below the reference information and map tools, respectively (**DP1**, **DP14**, **DP26**). Furthermore, the icon used on the Main Menu to denote the routing functionality was incorporated within the link to better emphasise its functionality (**ugC**, **DP4**, **DP13**, **DP20**, **DP25**). Note, the provision of additional transportation network information within the map and the optional display of the user's current position were deemed sufficient for supporting wayfinding using the map only, whilst the 'route' link was anticipated to provide more detailed route selection/instructions.

Moving on to the comparison of attractions/activities stored in the user's favourites list, here some major changes were made to the design. First, in response to design recommendation 27 an additional step was added following selection of the link to 'Compare My Attractions/Activities' (from the 'My Attractions/Activities' menu – Figure 9.21a). Whereas the preliminary design had provided a list of comparison options at this point and proceeded to include all of the saved attractions in the resulting comparison, here a new page was presented allowing the user to select a sub-set of attractions/activities to compare (**ugN**, **DP1**, **DP14**) – see Figure 9.21b.

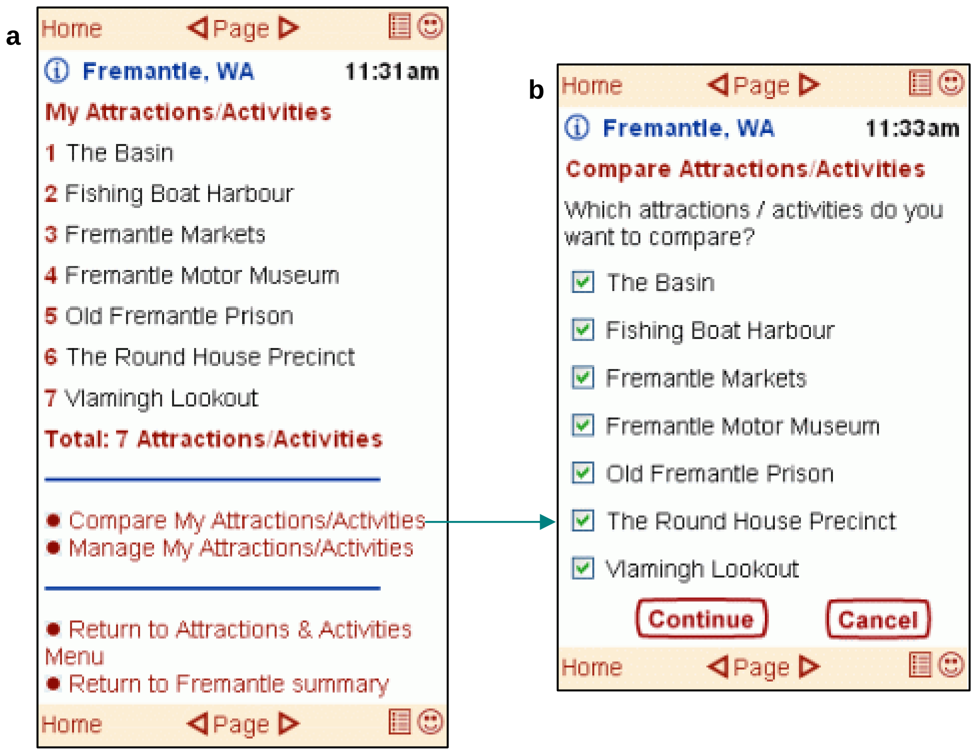

Figure 9.21 (a) The My Attractions/Activities menu which provides (b) the ability to compare either some or all of the listed attractions/activities.

The second major revision involved the attraction/activity comparisons offered to users. In response to design recommendation 26, the menu labels were reorganised and made more self-explanatory (with particular emphasis on ensuring that the labels for the location and proximity comparisons were sufficiently intuitive[9]; **ugH**, **DP2**), while an additional comparison option was included – transportation to/from – intended to enable the comparison of transportation options and travel times between each selected attraction/activity and a specified location (refer to Figure 9.22). Note, due to the need to keep the redesign scope and its evaluation within manageable limits, the second part of design recommendation 26 was not addressed (this involved the aggregation of multiple geospatial comparisons into a single option, thus enabling combined comparisons to be conducted).

Figure 9.22 The attractions/activities comparison menu.

While the 'Relative locations' comparison already incorporated two representation forms (text- and map-based outputs), the design of which required some revision, the new 'Proximity to an address' comparison had no existing design. Dealing first with the former, in response to design recommendation 29, an option was added to the text-based output to sort the selected attractions/activities either alphabetically (the initial state) or by locality (i.e. grouping them according to the town/city name in their address) – see Figure 9.23a (**ugD**, **ugN**, **DP3**, **DP14**). An additional representation form was also added, associated with the text-based output, which comprised a table/chart (i.e. diagram) conveying the linear distance between each attraction/activity based on the major road and/or ferry networks (**ugD**, **ugE**) – see Figure 9.23b. Notably, this new representation was presented in landscape format, requiring the user to

[9] Initially the location and proximity comparisons were combined into one option (called 'Location') which, when selected, asked whether the user wanted to compare the relative locations of the selected attractions/activities or the proximity of the selected attractions/activities to a separate location. During the evaluation, however, it soon became evident that this had the potential to confuse users (see Section 10.2.3.1) and so the design was changed for the remainder of the sessions to again use separate 'location' and 'proximity' menu items, as described above.

rotate the device 90° clockwise in order to view it properly. As a final change, further functionality was added to the text output page, providing users with to access their full My Attractions/Activities list and so enabling them to add/remove any number of items to/from the current comparison, as required (**DP1**, **DP6**, **DP7**, **DP14**) – see Figure 9.23c.

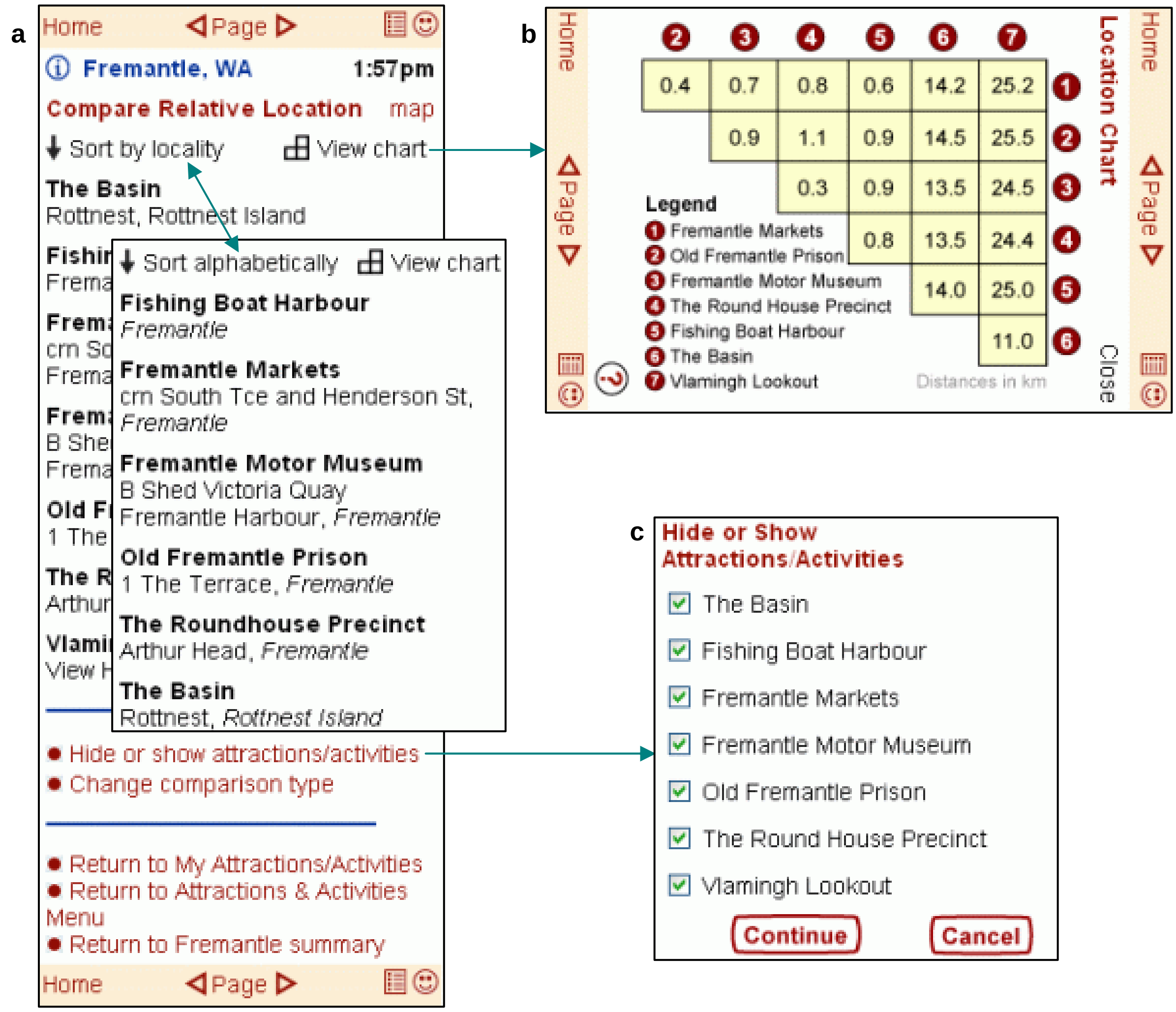

Figure 9.23 The (a) text-based and (b) diagrammatic 'relative location' comparison outputs.

In terms of the map-based output for conveying relative locations, this was revised – in response to design recommendation 30 – so that its design matched that of the layout map (Section 9.3.3.2), mainly requiring the addition of the same marginalia/functionality (i.e. pan, zoom, feature display, legend and help) – **ugM**, **CP5**, **CP16**, **DP10**, **DP25**. While the map's (initial) display of minimal features remained unchanged, the attraction/activity symbols were increased in size to improve their clarity (**CP3**). Furthermore, the colours of the various attraction/activity symbols (including new additions) were revised – in response to recommendations from an external review conducted by a cartographic expert – to ensure that each was sufficiently distinct (**CP6**). While the ability for users to add and remove attractions/activities from the map using the checkboxes in the quasi-legend was retained (**DP1**, **DP6**, **DP7**, **DP14**) – see Figure 9.24 – the implementation of this functionality was changed somewhat (in response to design recommendation 28), so that the map was refreshed as soon as an item was checked/un-checked[10] – i.e. without requiring the user to manually 'reload' it (**DP1**, **DP23**). Finally, the preliminary design's dynamic scaling (i.e. linked to the quasi-legend) was maintained (**CP16**), thus minimising the need for users to physically zoom the map in and out to see the attractions/activities of interest (**DP1**, **DP23**). Note, the map was interlinked with the text-based representation, enabling users to easily switch between (and thus compare) the two (**ugD**).

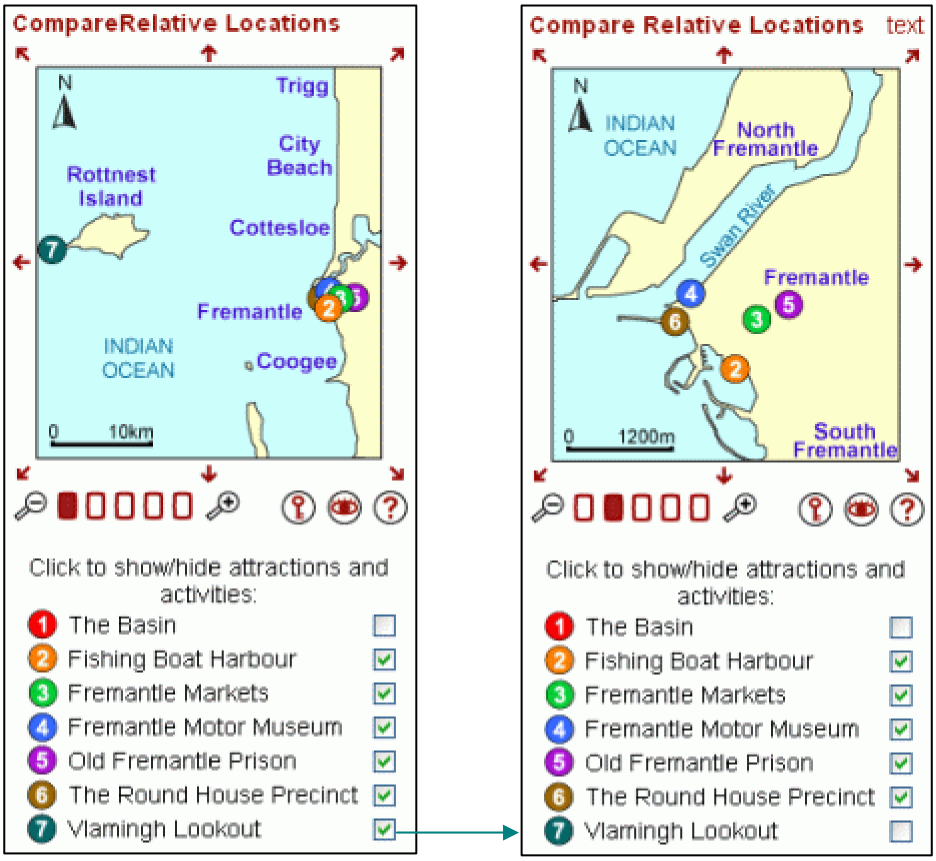

Figure 9.24 The revised map-based output for comparing the relative location of selected attractions/activities.

Turning now to the design of the 'Proximity to an address' comparison, having close similarities to the task of searching for attractions/activities 'around an address' (Section 9.3.3.3), that formed the basis for the functionality and representations employed here. With this in mind, to begin the comparison task the same address specification functionality was incorporated (Figure 9.16), thus enabling users to specify the location to which the selected attractions/activities would be compared (**DP4**, **DP13**, **DP25**). With an address selected, the user was then presented with one of three alternative outputs for the comparison: text (with animation), diagram or schematic map (**ugD**).

[10] Discussions with expert staff at Tenzeng (a consultant to the research) confirmed that this implementation technique was feasible without requiring a new map to be downloaded and so would be unlikely to result in slow display speeds.

Like the 'around an address' search text output (Figure 9.18a), this text-based representation incorporated the name of each selected attraction/activity, along with its distance – based on the major road and/or ferry networks – from the specified address (Figure 9.25). Here, however, animated graphics were also included (**CP11**), taking the form of arrows which 'grew' from the left-hand side of the page, the length of each corresponding to the distance between the associated attraction/activity and the specified address. Like the text-based output for the 'relative locations' comparison, this page also provided to access the user's full My Attractions/Activities list, thus enabling them to add/remove any number of items to/from the current comparison, as required (**DP1**, **DP6**, **DP7**, **DP14**).

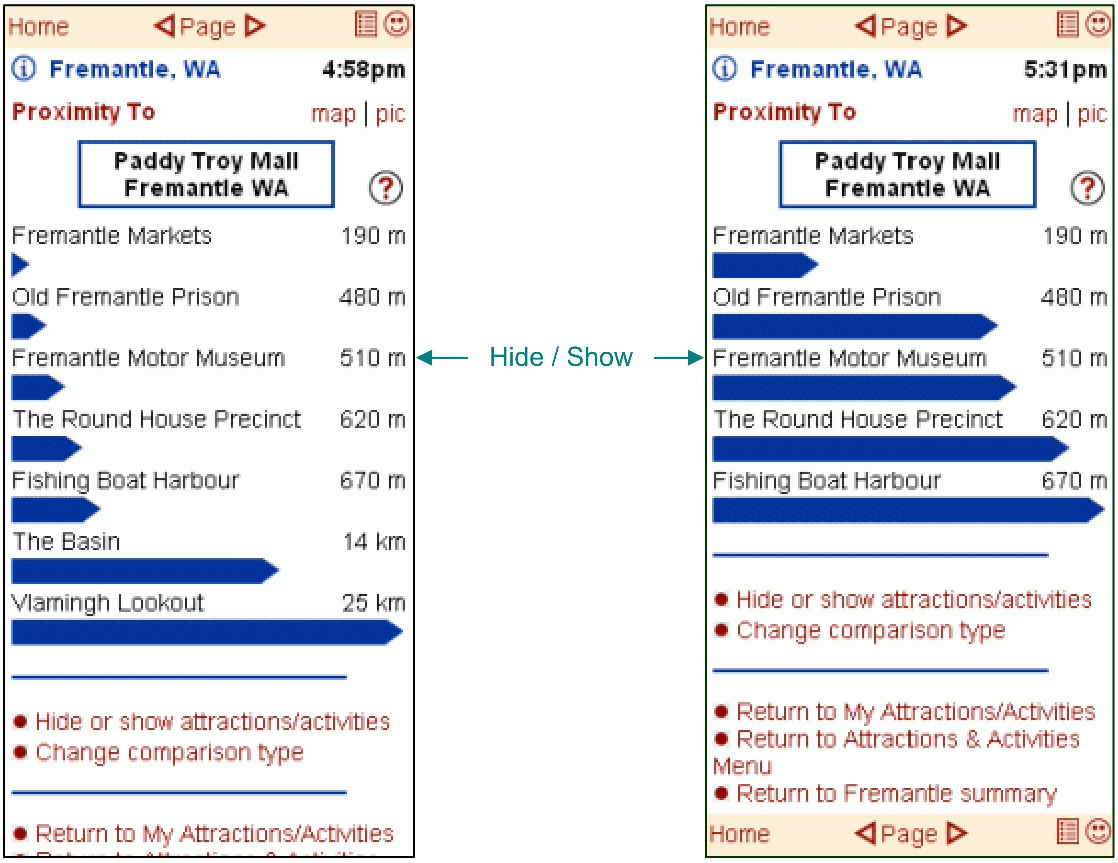

Figure 9.25 The text (with animation) output for the 'proximity to an address' comparison.

Again, like that for the 'around an address' search (Figure 9.18b), the diagrammatic representation was intended to provide the added dimension of direction. To this end a scaled, target-like drawing was created and overlaid with a north point and symbols (Figure 9.26), the latter being the same as those employed in the 'Relative locations' map-based comparison to represent the selected attractions/activities (**CP4**, **CP25**). While the centre of the diagram was coincident with the search address – marked with a black cross (**CP3**) – each of the attractions/activities was positioned at roughly the correct distance and direction from this. A legend was provided below the diagram for identifying individual attractions/activities (**CP5**). Finally, the user could employ the same technique as that in the text-based representation to add/remove items to/from the current comparison (with the diagram's scale dynamically updated to 'fit' the displayed attractions/ activities).

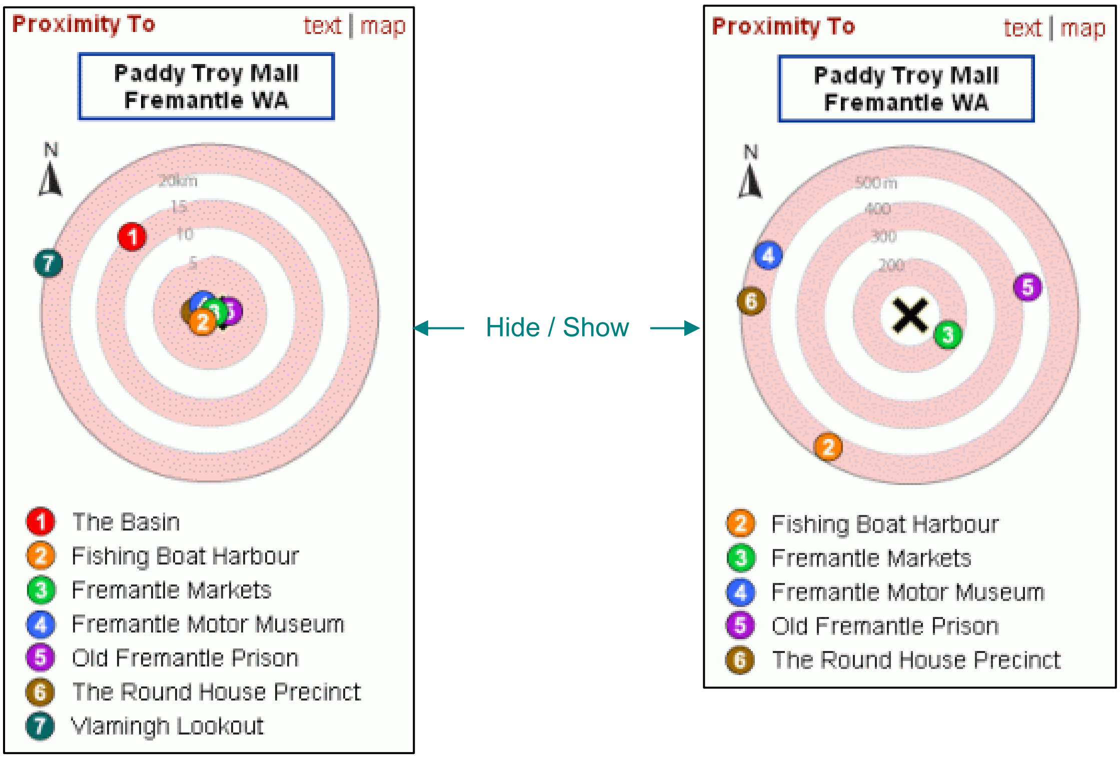

Figure 9.26 The diagrammatic output for the 'proximity to an address' comparison.

The schematic map representation was intended to provide even greater geospatial context for the comparison, but without the high level of detail common to conventional maps. Similar to that employed for the 'around an address' search (Figure 9.19a), the design of this map was achieved by extensively simplifying, refining and displacing the features of the conventional map-based output from Module 2 (**CP2**). Here, however, all labels (except for town/city names at the smallest scale) were removed – see Figure 9.27. With the centre of the map again coincident with the specified address (and marked with a black cross), the same attraction/activity symbols as those used elsewhere within the comparison pages were plotted on the map, in approximately correct positions (**CP2**). The 'quasi-legend'-style add/remove functionality (and associated dynamic scaling) from the map-based output for the 'relative locations' comparison was also employed here (**CP16**). Once completed, the schematic map was interlinked with the text and diagrammatic representations, enabling users to easily switch between (and thus compare) all three (**ugD**).

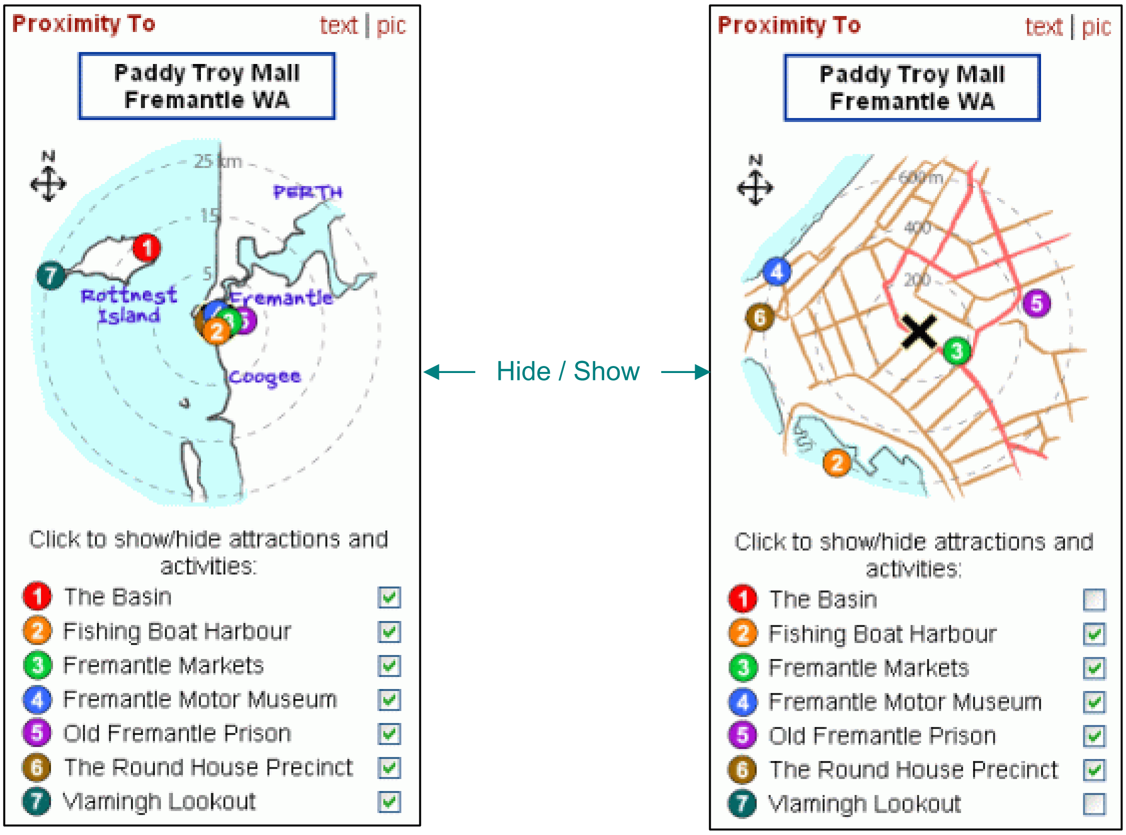

Figure 9.27 The schematic map output for the 'proximity to an address' comparison.

9.3.3.5 Module 2 – location weather (outputs)

The final design component requiring revision concerned the pages conveying weather for a location. Here, three design recommendations were addressed:

- Recommendation 31 – recalling that the current time had already been added to each page of the UI (Section 9.3.2), an additional time was incorporated here (Figure 9.28a), conveying when the weather information on the 'weather & forecast' page was collected/current. For the purposes of the simulation, this was set to the beginning of the current hour.
- Recommendation 32 – both the text- and animated map-based outputs were retained for conveying the current rainfall situation, with the latter accessible from the former via a link (**ugD**, **ugE**) – see Figure 9.28a. Furthermore, the readability and overall quality of the map was improved (involving customisation of the sourced radar map[11]) by: (1) standardising and increasing the size of all text labels (**ugF**, **ugJ**, **CP3**, **CP15**); (2) replacing the 'target-like' scale with a scale bar and adding a north point (**CP5**); (3) reducing the number of towns/cities displayed and adding the study location (**ugF**, **CP1**, **CP2**); and (4) labelling the legend 'Rain Rate' and ensuring that the colours here matched the equivalent map features (**CP3**, **CP5**,

[11] A standard radar map continued to be employed for this component of the design based on anticipated data availability – i.e. this was this most likely source of such information in terms of a real world product.

CP14) – see Figure 9.28b. Note, some of these changed were made in response to problems identified during an external cartographic expert review of the map design.

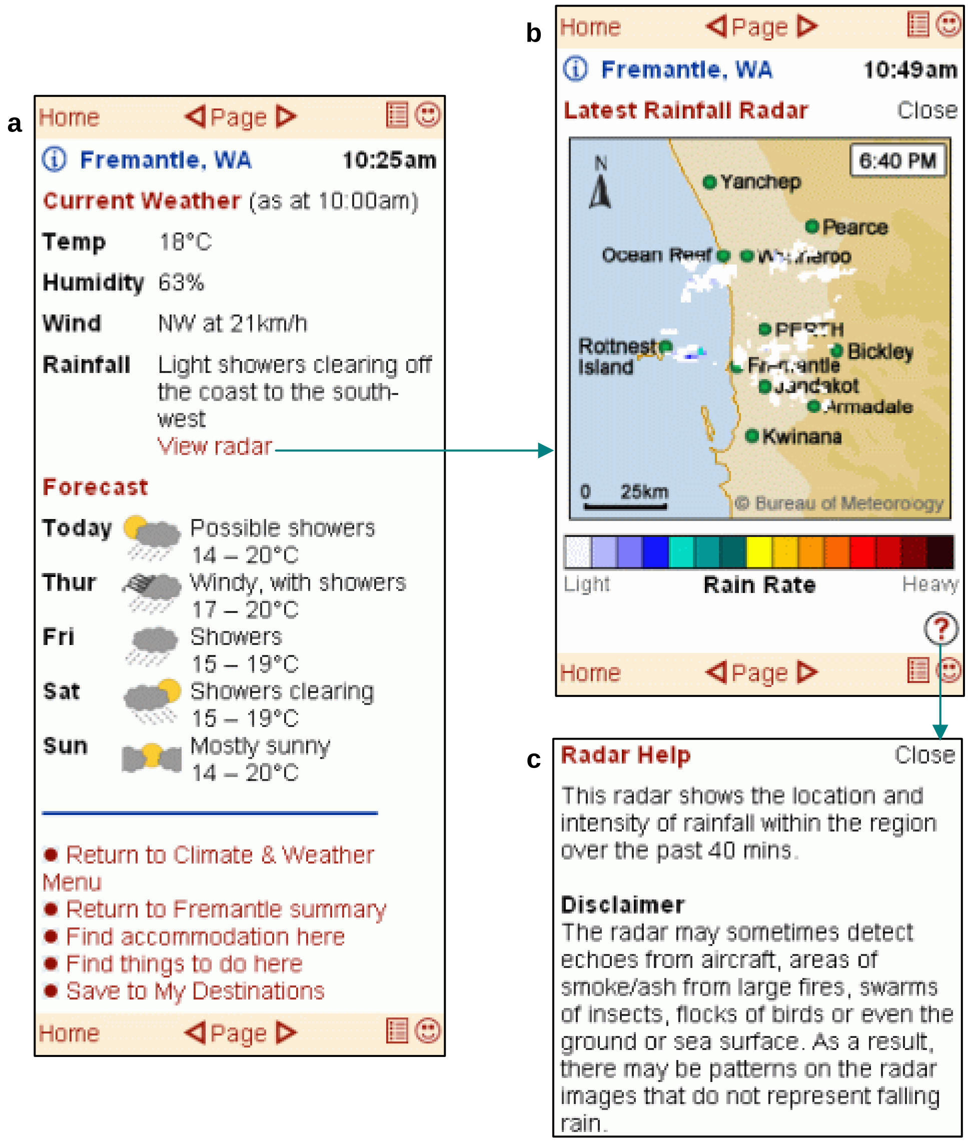

Figure 9.28 (a) The text-based weather & forecast page which links to (b) the rainfall page incorporating animated map-based output.

- Recommendation 33 – help text was added to support users' interpretation of the radar map (**ugM**, **DP10**) and, being non-essential content, was placed on a new page accessed by selecting the same 'help' icon employed elsewhere within the system (**DP20**) – see Figure 9.28c. Furthermore, the change in time period on the animated radar map was made visually clearer (Figure 9.28b) with a short pause added between the end and start frames to emphasise its cyclic behaviour (**ugK**, **CP11**).

Additional to the weather & forecast content, an extra weather component was implemented in order to trial a new representation technique, namely the use of abstract sound to alert users to 'urgent' geospatial information. Here, a page was created to appear upon selection of the 'Current

Warning' link on the 'Climate & Weather' page. The content of this was very simple (see Figure 9.29a), being intended simply to provide context for the alert representation to follow. The alert itself consisted of a page, accompanied by an abstract sound (**CP12**), which was displayed during normal use of the system (Figure 9.29b), its 'automated' appearance being prompted by time- and location-critical information (in this case a weather warning) matching the user's current situation (**DP27**). The page itself conveyed the required message, incorporating diagrams to clarify the content (**DP20**), and also included a checkbox allowing the user to cancel the automated alerting functionality (the initial configuration of which was anticipated for *My Profile*) – **ugN**. For the purposes of the evaluation, a random point in the system was selected for demonstrating this functionality/representation.

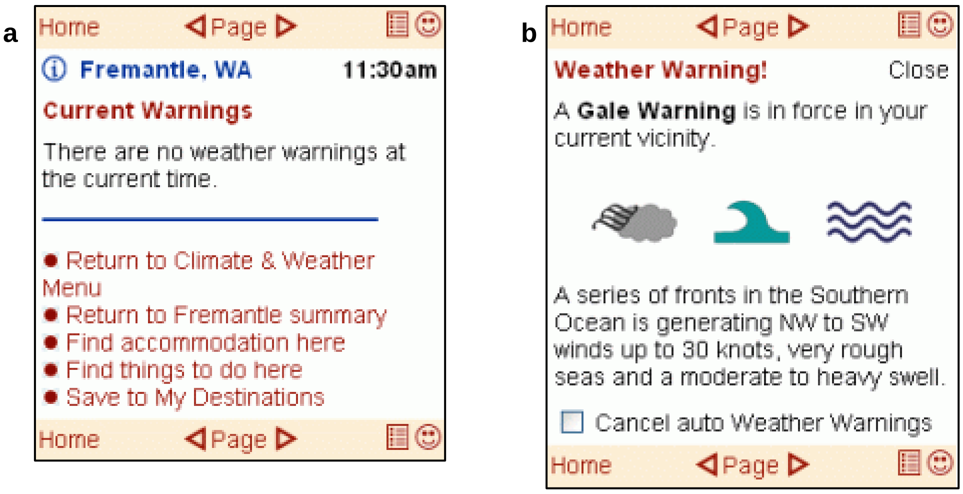

Figure 9.29 (a) The 'current warnings' page within the climate & weather UI component and (b) the automated weather warning alert incorporating abstract sound.

9.3.3.6 Module 1 – current location search (outputs)

Perhaps the biggest change made to the cartographic UI during this design phase was the implementation of functionality and representations relating to Module 1, which was intended to support the user task 'Determine what's in the immediate area' (part of the goal 'Obtain overview of location(s)'). In accordance with the scenario-based design approach established for the research, the following extract from the redesign scenario was used to drive this final design component:

> *"… You pull out the Holiday Assistant which tells you your current location with respect to a number of recognisable landmarks."*

Although it was assumed that the system would generally have some automated knowledge of where the user was located (e.g. through A-GPS), it was also acknowledged that users may wish to use this functionality to find local-level detail about a distant location (**ugD**) and/or that automated positioning may not always be available (e.g. if the device is not enabled for this, the GPS signal is blocked, etc.). Therefore a method of manual location entry was required, in addition to automated positioning. With this in mind, the entry page for Module 1 (accessed by selecting the 'What's Around Me' button on the Main Menu) comprised a prompt asking the user whether they wanted to use GPS positioning for their location or else manually specify an address[12] (Figure 9.30a). Note, a checkbox also present here allowed the user to opt for automated GPS positioning to always be used when determining their current location (the configuration of which was anticipated for *My Profile*) – **ugN**. Depending on their response to the prompt, the user was then either automatically positioned (Figure 9.30b) or else provided with the same address specification options (Figure 9.30b) as those described for the 'Around an address' attraction/activity search in Section 9.3.3.3 – excluding 'My current location (GPS)' (**CP4**, **CP13**, **CP25**).

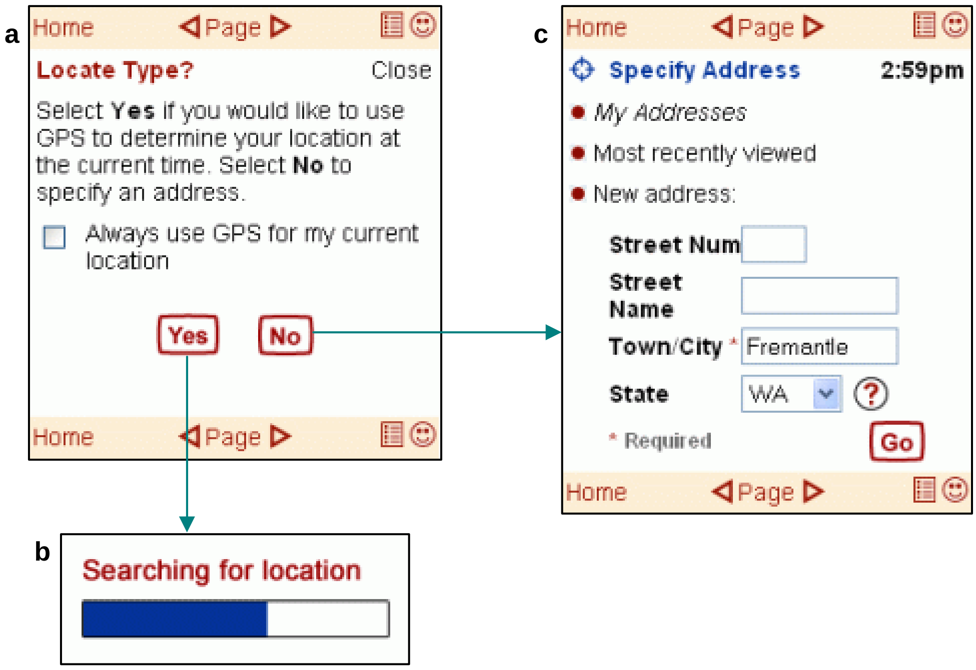

Figure 9.30 (a) The options for determining the user's current location including (b) A-GPS and (c) manual address entry.

Once the user's current location was determined (using either technique), they were presented with a menu offering two different scales of information related to their surrounding area (Figure 9.31). The first – 'The immediate area' – was intended to provide highly localised detail about the user's immediate area, while the second – 'A nearby town or city' – would return the towns and cities located within an expanded radius of the user, along with the ability to access more detailed information about any of these (**ugA**, **ugE**).

[12] Note, this assumed (for the purposes of the simulation) that A-GPS was available and functional for positioning the user. If this was not the case, manual address entry would be the only option presented.

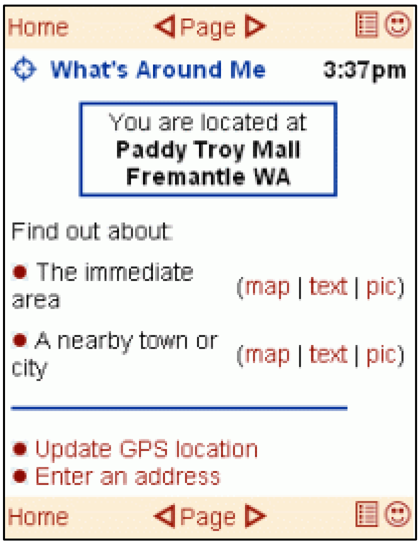

Figure 9.31 The 'What's Around Me' menu.

Beginning with 'The immediate area', three alternative output forms were designed for comparison here: conventional map, text and schematic map (**ugD**). Looking first to the design of the conventional map, this was again based on the layout map within Module 2 (Section 9.3.3.2), incorporating largely the same selection, generalisation, symbolisation, visual composition, marginalia construction, figure-ground organisation and hierarchical organisation (**DP25**). There were a number of differences between the two, however, based on their different purposes/settings, with the following being applicable to the new map:

- The initial scale was the largest (Figure 9.32a), so as to provide highly localised, immediate context for the user's current location, upon which the map was centred (**CP1**). From here, the user could zoom out to obtain a broader view. Note, the current location symbol was not animated on this map.
- Two new point symbols were designed (each intended to be self-explanatory), representing (**CP3**, **CP10**, **CP14**)
  - landmarks – consisting of a single, generic 'building-like' symbol of similar size but contrasting colour (and shape) to the existing POI symbols; and
  - panorama points (i.e. locations for which a photographic panorama was available) – a circular symbol with detail resembling a 'camera', also of similar size but contrasting colour to the existing POI symbols.
- The selection of features for initial display at each map scale was revised (note, the user's current location was displayed at each scale), resulting in (**CP9**)
  - *Scale 4* (Figure 9.32a) – (the initial scale) additionally included landmarks, panorama points and further labelling (landmarks, parkland); no POIs were displayed.
  - *Scale 3* (Figure 9.32b) – additionally included landmarks; no POIs were displayed.
  - *Scale 2* (Figure 9.32c) – additionally included landmarks.

- *Scale 1* (Figure 9.32d) – no changes.

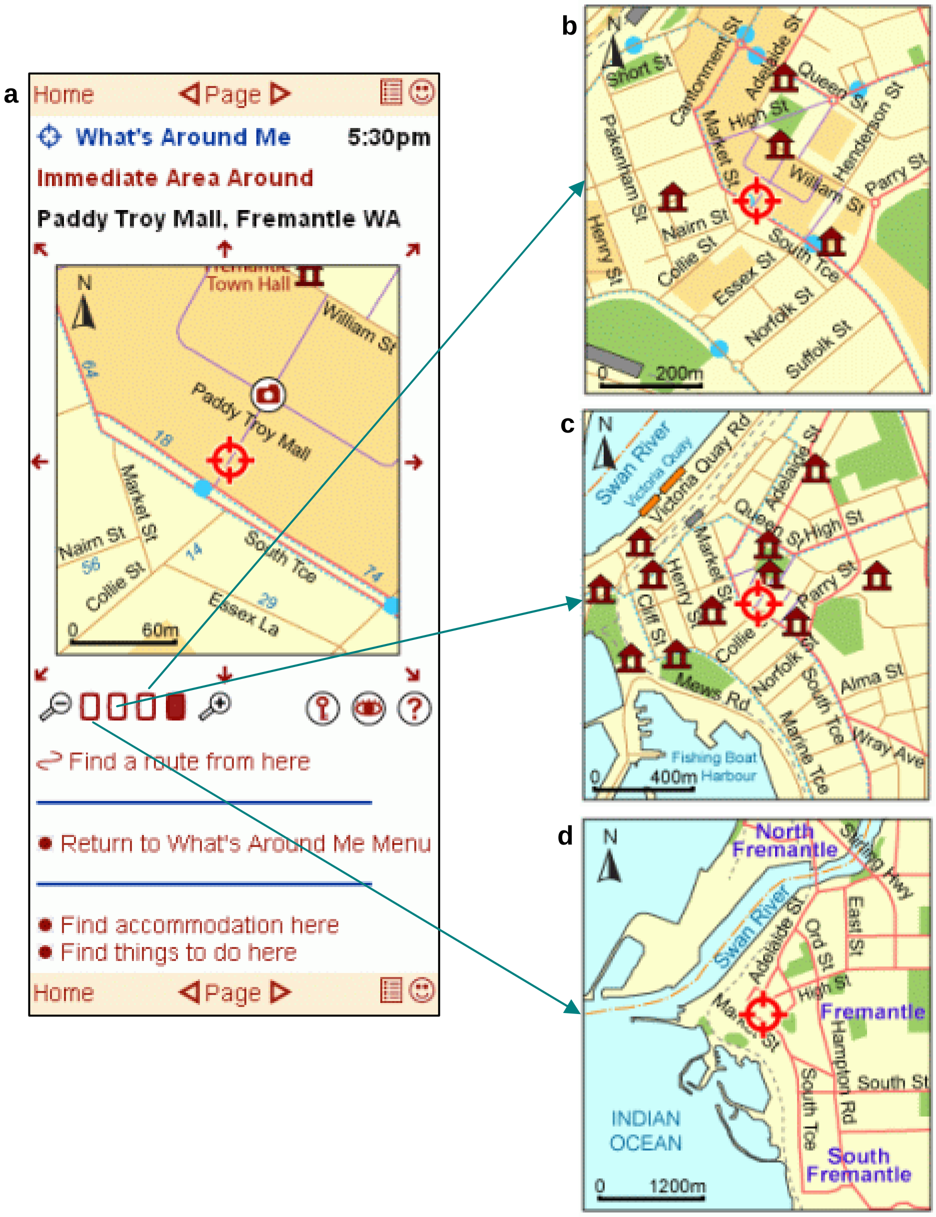

Figure 9.32 The map-based output for conveying the user's 'immediate area', with all four scales shown (a – d).

Two further additions were made to the map representation. First, functionality was added to the 'map click' behaviour (Figure 9.33), whereby – similar to that on the schematic map used to select attractions/activities around a specific address (Section 9.3.3.3) – selecting a particular point symbol (e.g. a landmark) opened a page incorporating its name, address and a photograph (i.e. for identifying the feature[13]), as well as options to either: (1) centre the map on the feature (zooming in to Scale 4 – Figure 9.33c); or (2) progress to more detailed information (contained within Module 3 or 4, where applicable) – **ugE**.

[13] Recommended by Gartner & Uhlirz (2005).

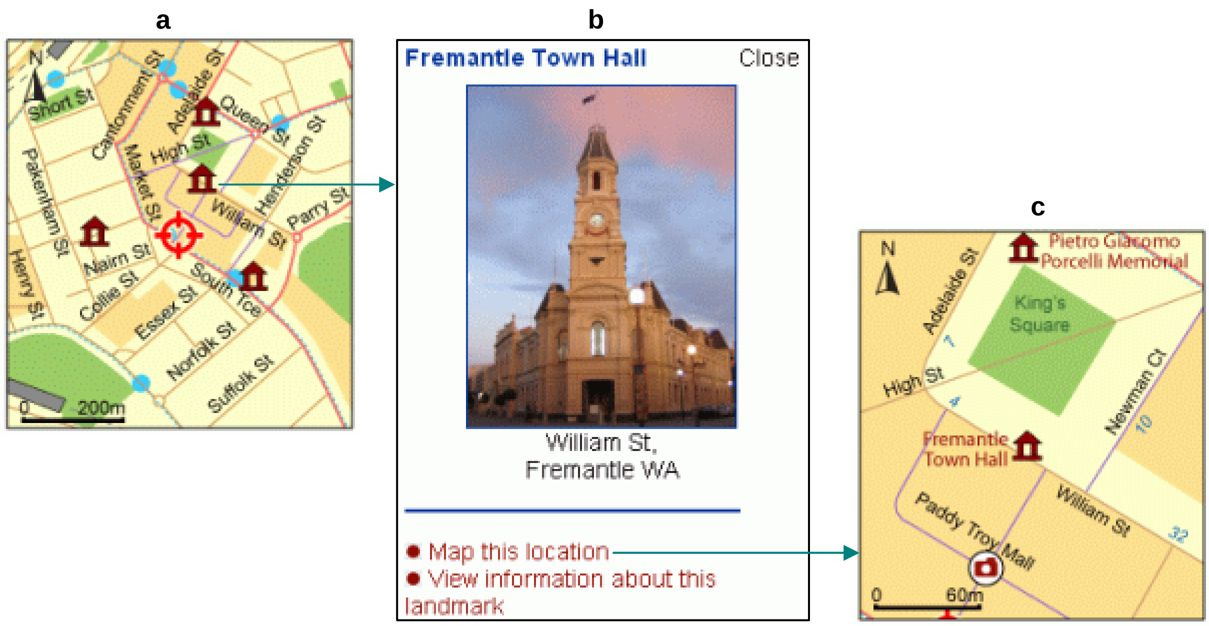

Figure 9.33 (a) The 'immediate area' map click behaviour for point symbols which (b) opens a new page containing information about the feature, also providing the ability to (c) centre the map on the feature.

The second addition involved the aforementioned panorama points, which consisted of map symbols linked to photographic panoramas. Recommended by several mLBS researchers (Jiang 2006; Gartner & Uhlirz 2005; Beeharee & Steed 2006) for providing users with a view of their surroundings, the panoramas in the prototype consisted of four images comprising perpendicular photographic views from a given point (**ugE**) – see Figure 9.34. While not animated, the images were interlinked with the user thus able to gain an impression of viewing the scene 360° around a point. Furthermore, each image was minimally annotated with the direction of its centre point and the name of any visible road(s) to provide the user with cues for matching their position on the map with the surrounding environment (**ugD**). Note, the photographs were presented in landscape format, requiring the user to rotate the device 90° clockwise in order to view them properly.

Looking now to the text-based output for 'The immediate area', this comprised purely textual content describing the geospatial arrangement of the surrounding area, divided into three sections – see Figure 9.35 (**ugE**). Under 'streets' were simple sentences identifying the roads closest to the user at each of the cardinal points (i.e. North, East, South and West). Under 'landmarks' was a paragraph identifying the surrounding landmarks (grouped by direction from the user), including the distance to each from the user's current location, and links to additional information pages – equivalent to those accessed from the map-based representation via 'map click' (Figure 9.35b). Finally, under 'coastline' were simple sentences identifying nearby coastal features, including the approximate direction of each from the user's location.

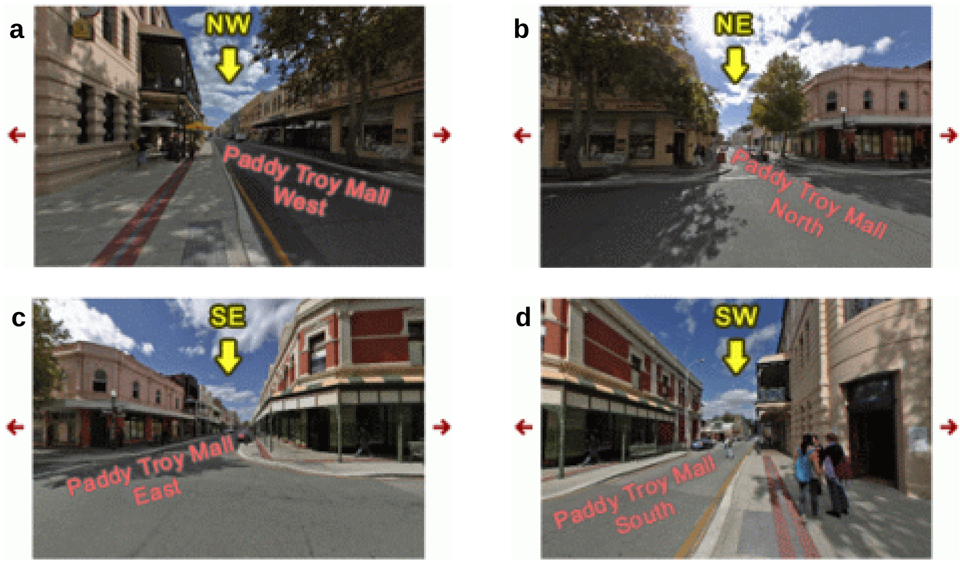

Figure 9.34 An annotated panorama, accessible from the 'immediate area' map representation, providing 360° photographic views from a single point (a ↔ b ↔ c ↔ d ↔ a).

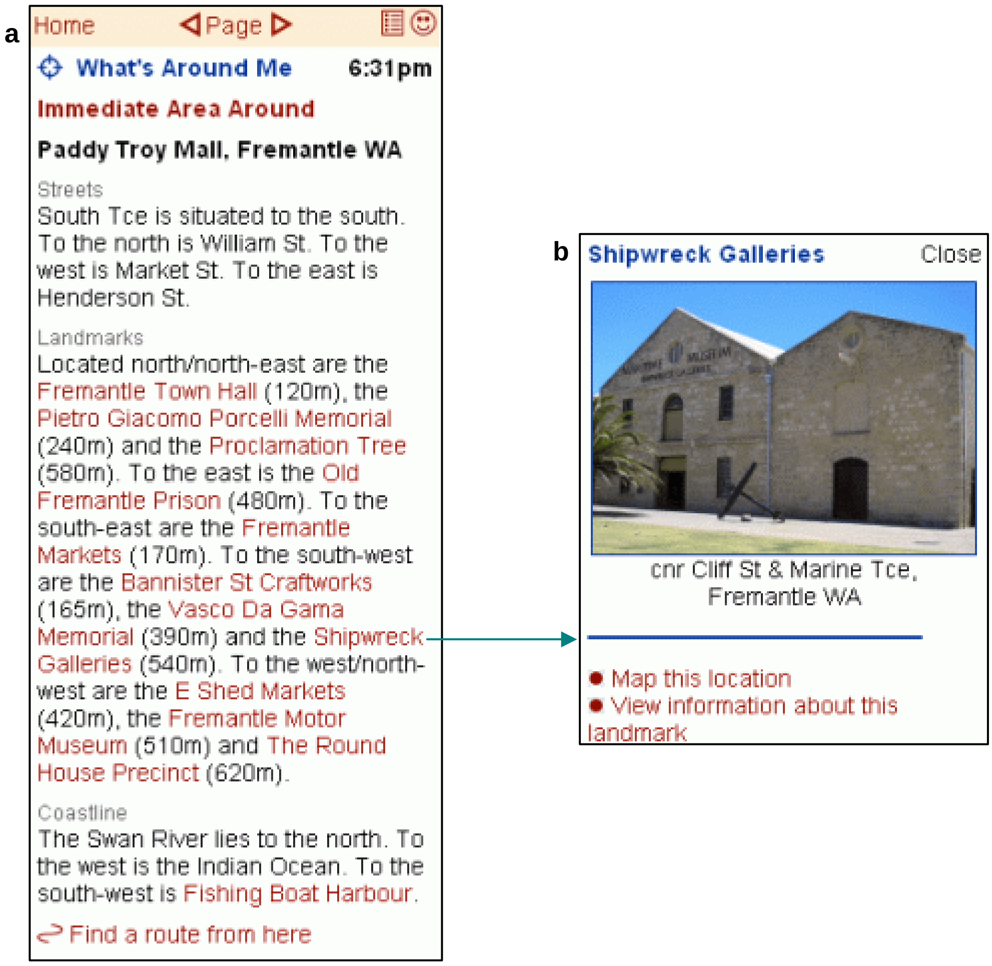

Figure 9.35 (a) The text-based output for conveying the user's 'immediate area', incorporating (b) links to more information.

The final output for 'The immediate area' was a schematic map, the design of which was achieved by extensively simplifying, refining and displacing the labels, lines and area features contained within the conventional map-based output (**CP2**). Like the other schematic maps in the system, this resulted in a topologically correct map with a 'sketched' appearance, here conveying all roads (major, minor and walkways), parkland and landmarks within a few hundred metres of the user's current location (i.e. the map's centre) – see Figure 9.36a. Again, an approximate scale was added to the schematic to provide some indication of the distance to each of the included map features. Moreover, two checkboxes were included below the map to allow users to turn the scale and landmark symbols on/off and thus improve its clarity, as required (**CP16**). Selecting a landmark resulted in the same outcome as the 'map click' functionality included with the conventional map (Figure 9.36b). Notably, no tools were provided for panning or zooming the schematic map.

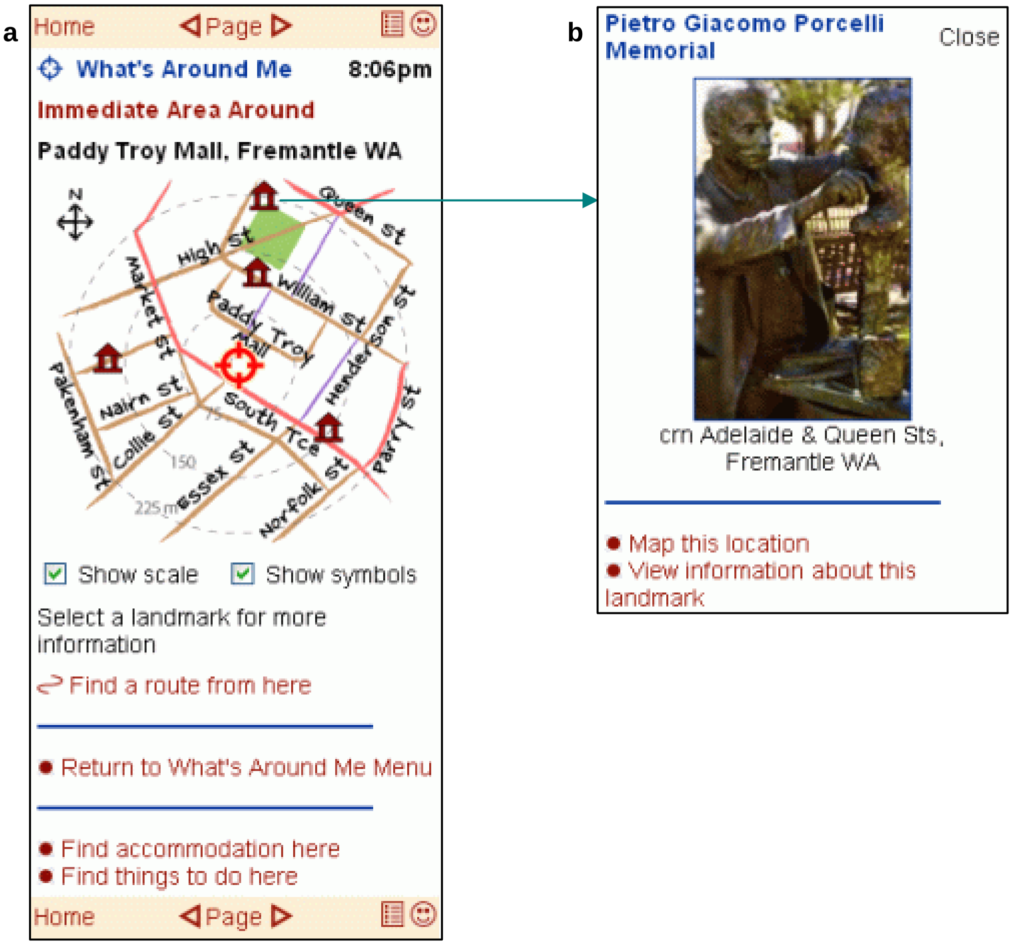

Figure 9.36 (a) The schematic map output for conveying the user's 'immediate area', incorporating symbols linking to (b) more information.

Turning finally to the functionality and representations incorporated within the menu option 'A nearby town or city', again three alternative output forms were designed and made available for comparison here: conventional map, text and diagram (**ugE**). Beginning with the map, its design was once more the same as the other conventional maps in the system (**DP25**), except that here the initial scale was much smaller than the others, in order to display a very broad area, roughly 30km in radius (centred on the user). While only the initial map scale was implemented in the prototype, the intention (and impression provided to users) was that it could be zoomed and panned in the same manner as elsewhere (**CP5**, **CP16**). Regardless, this scale possessed minimal features (freeways, major roads, town/city labels and the user's current location), with the map primarily intended to convey the location of nearby towns/cities (**CP1**, **CP2**) – see Figure 9.37a. Importantly, selecting a town/city on the map took the user to Module 2 where an overview of that location could be explored (**DP1**). Again, the current location symbol was not animated on this map.

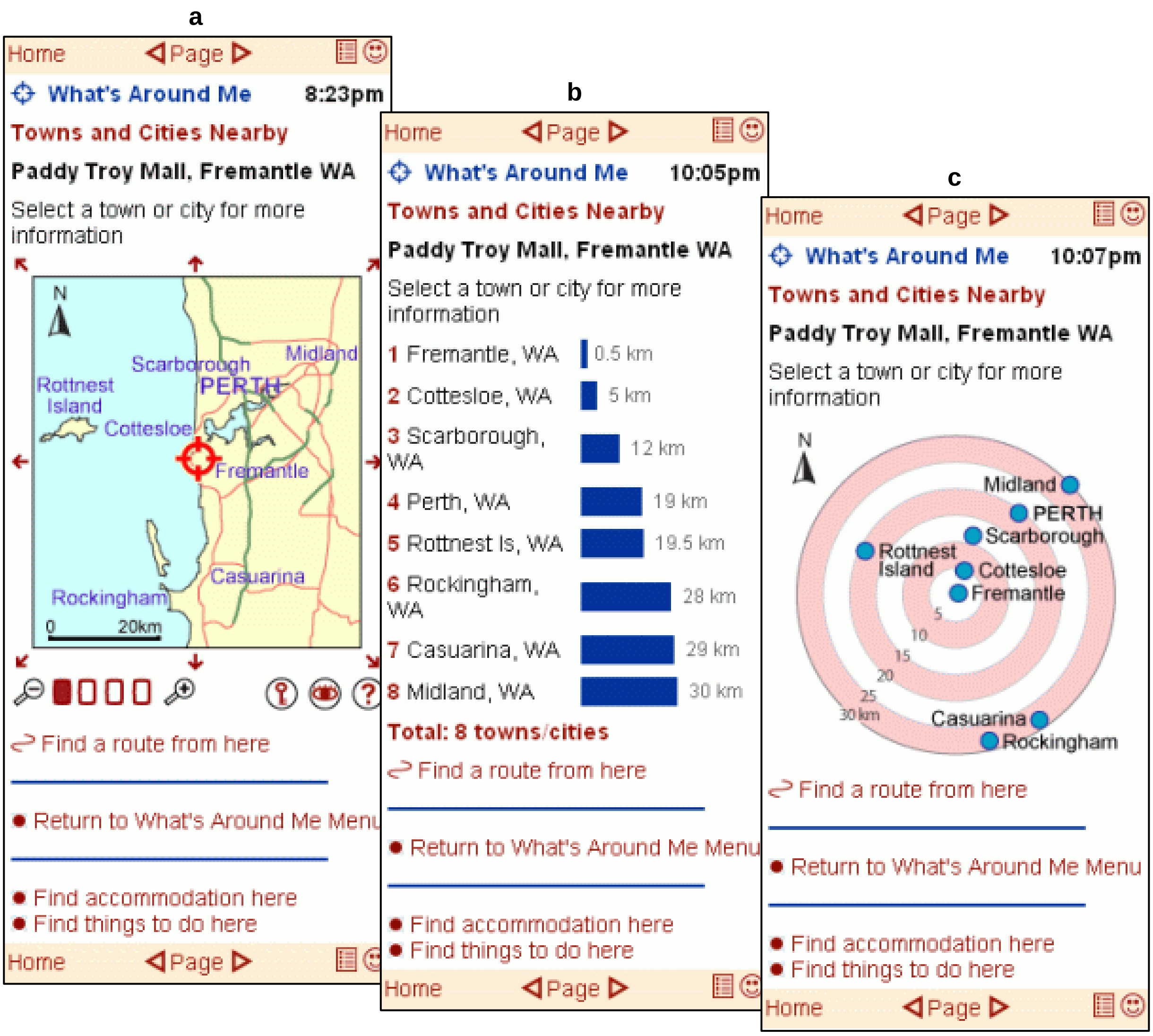

Figure 9.37 The (a) map-based, (b) text-based and (c) diagrammatic output techniques for conveying towns and cities nearby the user's current location.

The design of the text-based output comprised a list of towns/cities within 30km of the user's current location (ordered from closest to furthest), along with the straight-line distance to each and accompanying scaled 'bar' diagrams – Figure 9.37b. Similar to the map representation, selecting any town/city name on the list took the user to Module 2 and an overview of that location (**DP1**). Looking finally to the diagrammatic output, this utilised the same scaled, 'target' design as other diagrams within the system (**DP25**), and was overlain with a north point and labelled symbols representing the towns/cities within 30km of the user's current location (which was the centre of the diagram) – see Figure 9.37c. Once more, selecting a symbol/label on the diagram took the user to the location overview component (**DP1**).

✧ ✧ ✧ ✧

This completed the cartographic UI design revision for the prototype which, along with the overall system structure and design, comprised an updated specification of cartographic UI design models for a DHR mLBS. Note, the revised design prototype is included in its entirety on the attached CD (go to \Revised Design\index.html). With the procedures followed for this design phase being equivalent to those employed during the preliminary design – i.e. scenario-based design, focus on an established set of qualitative usability goals, adherence to UI and cartographic design principles, documentation of a design rationale and design specification through a prototype – a separate discussion of their effectiveness was not deemed necessary here (refer instead to the preliminary design discussion in Section 7.6). Therefore this chapter concludes by presenting the revised cartographic UI design models, the evaluation of which is then documented in Chapter 10.

9.4 Revised Cartographic UI Design Models

As with the preliminary design, it was considered useful here to develop a more manageable and high-level summary of the information presented above, particularly for the purposes of communicating the research results. To this end the flow diagrams representing the preliminary cartographic UI design models were updated and expanded, incorporating all design changes and additions – refer to Figure 9.38, Figure 9.39 and Figure 9.40.

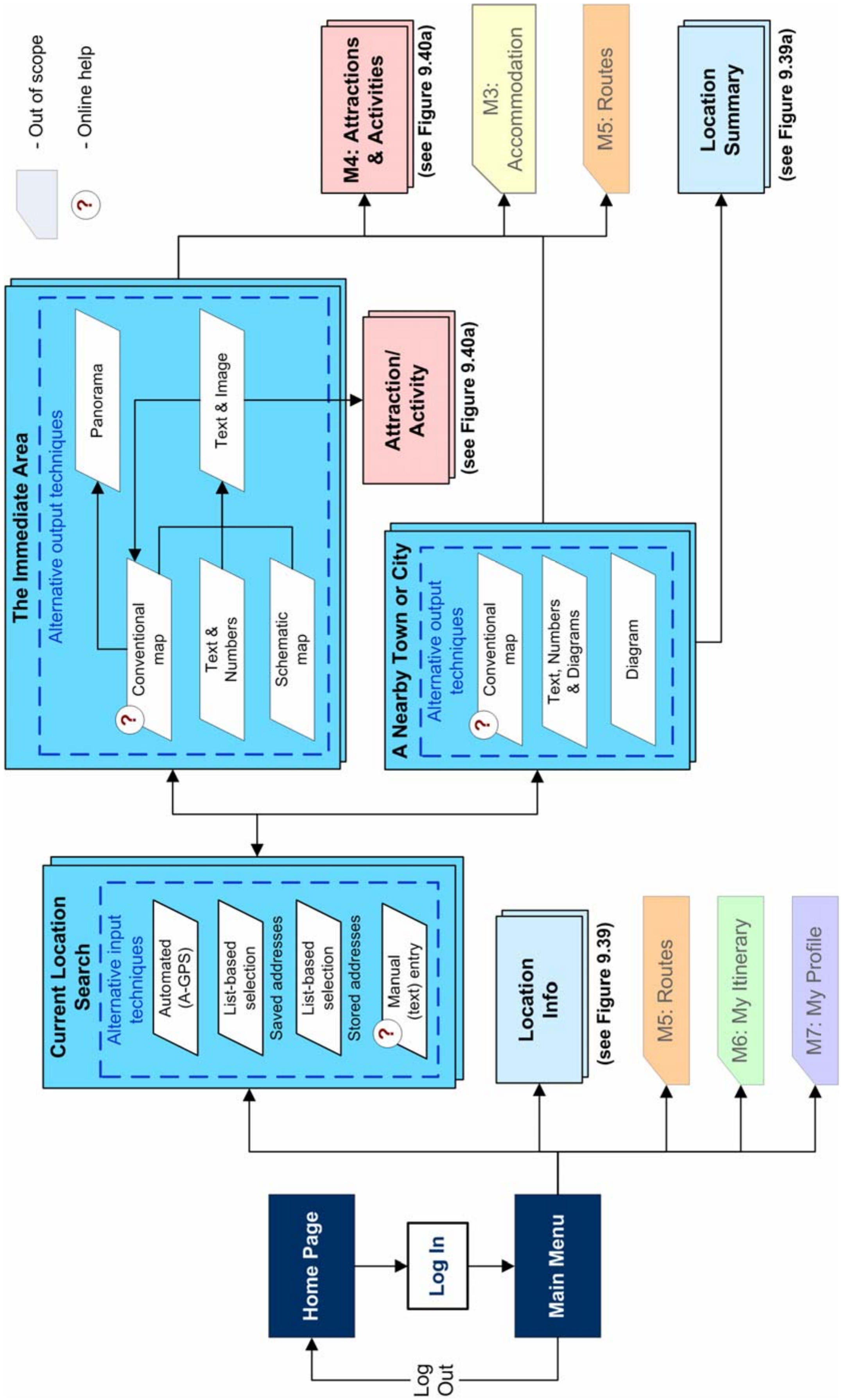

Figure 9.38 Segment of the revised design models showing the structure of the Main Menu and Module 1 (note, universal links to *My Profile*, *My Itinerary* and the Main Menu are not shown).

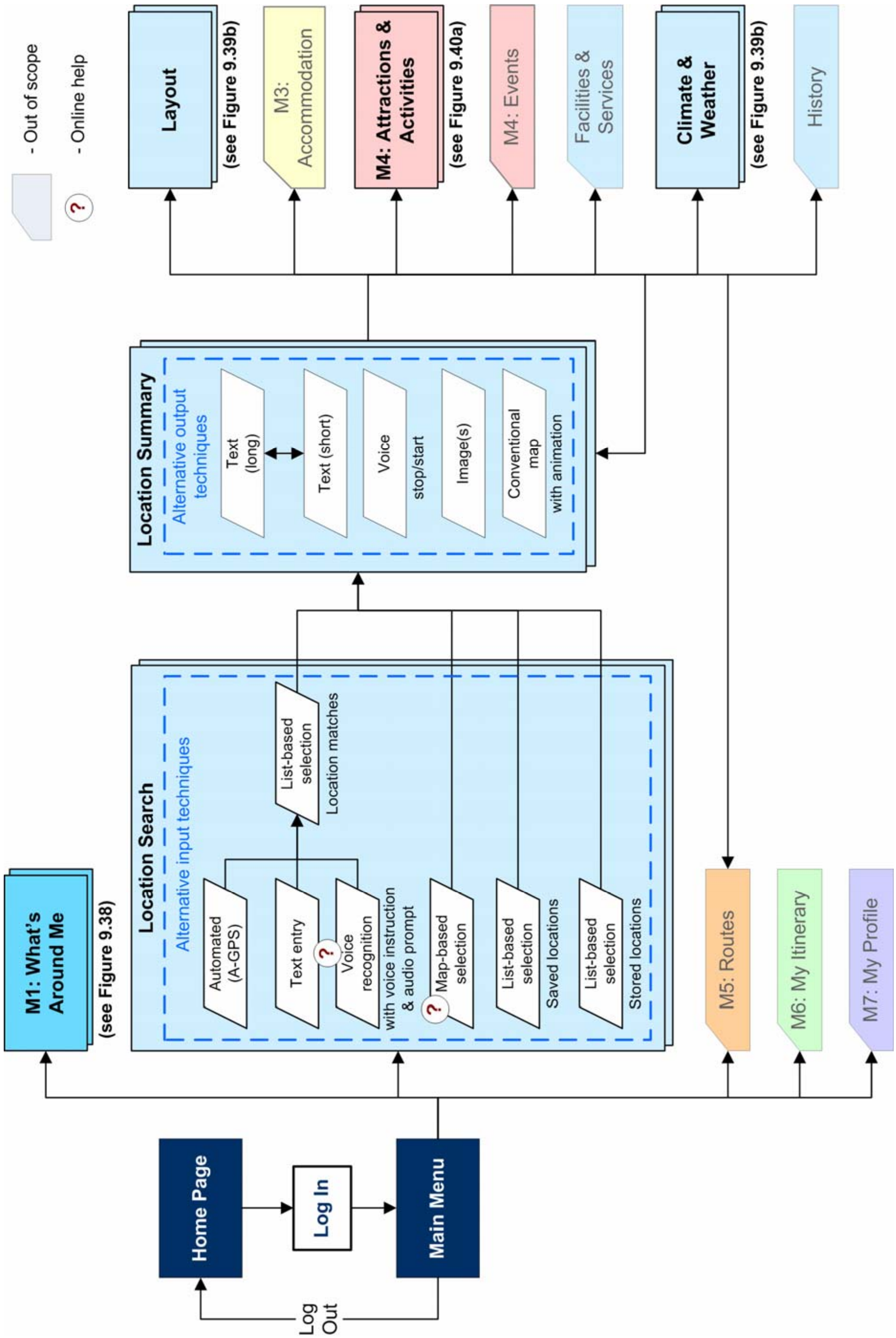

Figure 9.39(a) Segment of the revised design models showing the structure of the Main Menu and the highest level within the Module 2 information hierarchy (note, universal links to *My Profile*, *My Itinerary* and the Main Menu are not shown).

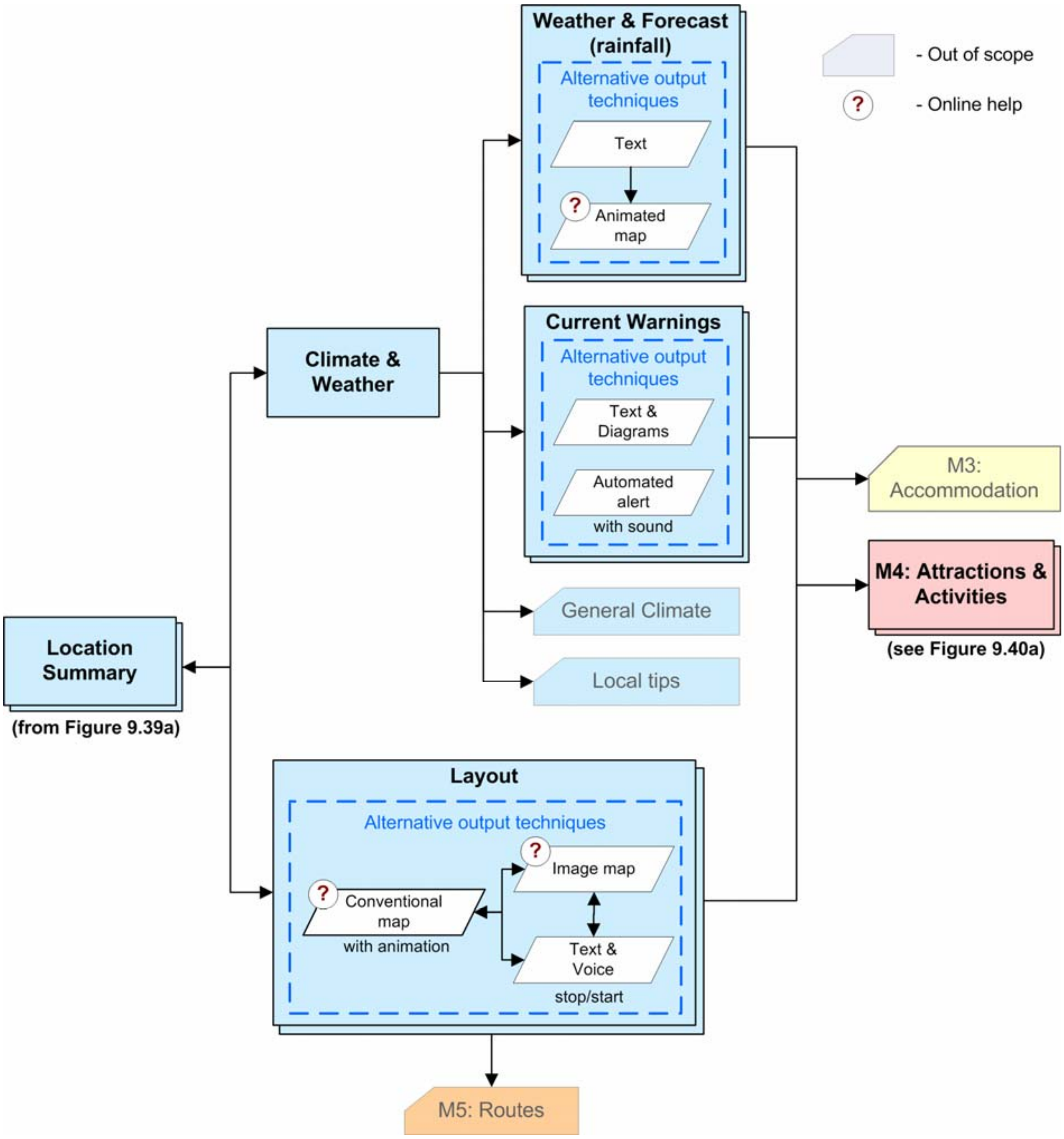

Figure 9.39(b) Segment of the revised design models showing the structure of the lower levels within the Module 2 information hierarchy (note, universal links to *My Profile*, *My Itinerary* and the Main Menu are not shown).

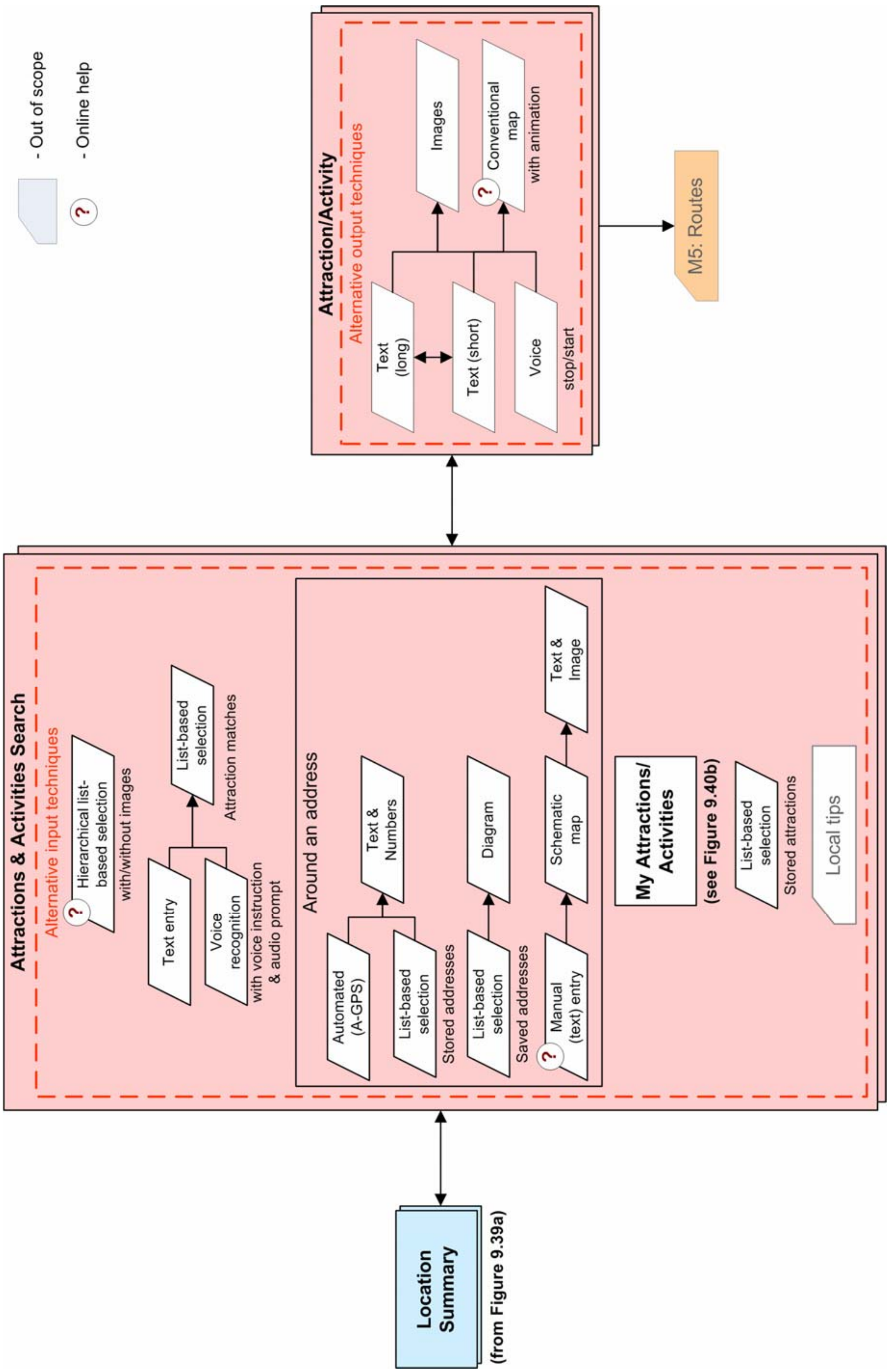

Figure 9.40(a) Segment of the revised design models showing the structure of the search component within Module 4 (note, universal links to *My Profile*, *My Itinerary* and the Main Menu are not shown).

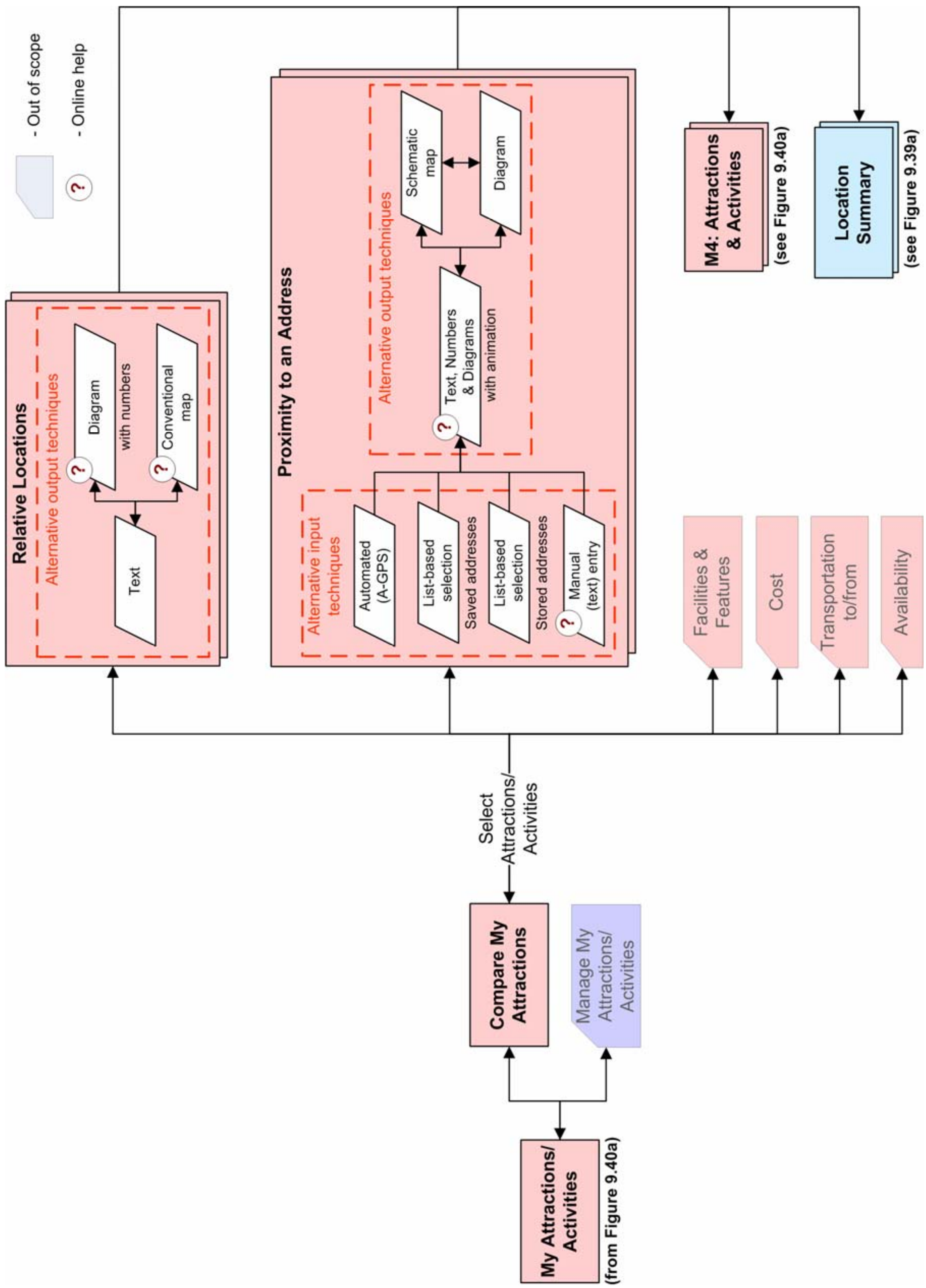

Figure 9.40(b) Segment of the revised design models showing the structure of the comparison component within Module 4 (note, universal links to *My Profile*, *My Itinerary* and the Main Menu are not shown).

9.5 Chapter Summary

This chapter has described the process by which the cartographic UI design models for the research were revised and extended in accordance with the UCD practice of iterative design. The box below summarises the major steps involved, in addition to the outcomes. Overall the redesign process was considered a success, addressing almost all of the PDE recommendations while extending the design's functionality and implementing additional techniques for representing, presenting and interacting with geospatial information. The next chapter describes the process by which each of these changes was evaluated, thereby completing the current iteration of design and evaluation.

- The aims for the design iteration were established to be:
  (a) revise the cartographic UI design based on the outcomes of the PDE; and
  (b) extend the cartographic UI design models, incorporating additional functionality and further (alternative) techniques for representing, presenting and interacting with geospatial information.
- Continuing the evolutionary prototyping procedure established during the preliminary design, the existing limited functionality simulation was employed to explore design ideas and specify solutions.
- A scenario-driven approach was once more established for the design process, extending the preliminary design scenario to incorporate the task 'Determine what's in the immediate area'.
- The existing set of qualitative usability goals was retained, with each considered a priority for the redesign. These were again used to focus and assess all design decisions.
- A number of quantitative usability measures were established in preparation for the ensuing evaluation, to provide objective data regarding the usability of various cartographic aspects of the design and assist in isolating problem areas.
- Addressing the recommendations produced during the PDE, while extending the functionality and representations included, the design revision process was conducted in accordance with the established qualitative usability goals and UI and cartographic design guidelines and principles, with all decisions documented in a design rationale.
- The end result comprised a set of revised design models and a semi-functional prototype embodying the redesign in a form that could be evaluated.

10 Evaluating the Revised Design

10.1 Introduction

With the design revision now complete, it was ready for evaluation in order to assess whether (a) the problems identified during the PDE had been rectified and (b) any new problems had been introduced (Mayhew 1999). More importantly, however, this cycle of iterative evaluation was intended to expand on the findings of the PDE related to the usefulness of the cartographic UI and specific representation, presentation and interaction techniques. As part of the participatory design approach established for this stage of the research (Section 7.3.1), the evaluation was again planned to take the form of empirical usability testing involving representative users. The process by which this was undertaken, as well as a comprehensive analysis of the results comprises the content of this chapter. In particular, Section 10.2 describes the data collection procedure, first introducing the evaluation aims (Section 10.2.1), before describing in detail its preparation (Section 10.2.2) and conduct (Section 10.2.3). The qualitative interpretation and analysis of the evaluation data is then presented (Section 10.3), followed by the major outcomes of this in the form of a new list of recommendations for improving the usefulness of the design (Section 10.4).

10.2 Data Collection

10.2.1 Aims and method

Specific aims for the second and final evaluation phase for the research were defined as follows:

- **(a)** identify usability problems within the cartographic UI (both pre-existing and new) along with their causes; and
- **(b)** trial and compare the usefulness of alternative representation, presentation and interaction techniques employed for particular tasks.

These aims were established in conjunction with the selection of a specific usability testing approach for this stage of the research, based on the classifications described in Table 8.1. Ultimately, a combination of *assessment testing* and *formative evaluation* was chosen, again involving *comparison testing* (to a greater extent than the PDE). While formative evaluation and comparison testing were considered relevant for the same reasons as those given for the PDE (Section 8.2.2), assessment testing offered a straightforward method for expanding the findings of the preceding exploratory test, at the same time taking into consideration the early and still largely exploratory status of the design. As was the case here, an assessment test is typically conducted once the conceptual models of the users' goals, tasks and requirements have been verified and the basic design of the system (i.e. the cartographic UI) has been established. In this way not only does the evaluation allow the intuitiveness of the UI to be explored, it also provides insight into "how well a user can actually perform full-blown realistic tasks" and can serve to "[identify] specific usability deficiencies that are present" (Rubin 1994, p.38).

The conduct of an assessment test is similar to that of exploratory testing, although it incorporates some of the more formal aspects of validity testing. Specifically, in an assessment test: participants always perform tasks (as opposed to the walkthrough-style of exploratory testing); the level of facilitator ↔ participant interaction is minimal (with more emphasis placed on user behaviours than thought processes); and quantitative measures, in addition to qualitative observations, are collected (Rubin 1994; Mayhew 1999) – this last point being a major motivating factor behind the definition of quantitative usability measures in Section 9.2.2. Despite the requirement for less interaction between the participant and the facilitator, the decision was made to again apply a 'think aloud' protocol (Section 8.2.2.1) during the evaluation, in order to obtain insights into the users' understanding of the cartographic UI and therefore facilitate the process of identifying and explaining any problems related to this. This was not seen as detrimental to the assessment testing method, however, with no timing data planned for collection and the same care to be taken in interpreting the think aloud data as was achieved during the PDE analysis. Furthermore, active questioning by the facilitator would be limited to only what was necessary to obtain the required feedback (e.g. preferences for different representation techniques), with all questioning reserved for times when a participant was no longer in the process of completing a task/sub-task. Finally, as with the PDE, the current testing would be *assisted*, with participants asked to complete each task/sub-task on their own, only asking for help when they felt they could progress no further.

Before proceeding with the evaluation design, the setting and length of the sessions were established. Once again field-based testing was the optimal choice, in order to test within real usage contexts, however resource limitations continued to make this an impractical option compared with testing in a usability laboratory (refer to Section 8.2.2.1). Fortunately the use of a laboratory, while substantially more controlled than any realistic mobile usage situation, could be considered acceptable for the evaluation, taking into account the still early stage of the design process and the tasks being tested – each of which was likely to be completed in the real world when stationary (e.g. sitting in a café or hotel room, standing on the footpath) unlike, for example, a wayfinding task which requires more interaction with the surrounding environment.

Moreover, like the measurement of formal quantitative usability goals, testing in the field was considered more valuable towards the end of the design process, when the UI was in a more complete state thus "allow[ing] users to do real work" (Nielsen 1992, p.18; Rubin 1994).

The sessions were again scheduled to take place in the Sensis specialist usability laboratory, with the same observation setup as in the PDE sessions – i.e. each participant would be observed from behind the one-way mirror and videotaped (with sound recorded) for later analysis, using one camera to capture their interaction with the prototype and another to provide an overhead view recording any larger movements they made. Refer to Figure 8.1 for an example of the visual output from the session recordings. The evaluation sessions were once more limited to two hours each, allowing for sufficient time to complete the evaluation tasks without participants becoming too tired or bored with the process.

10.2.2 Preparation for evaluation

10.2.2.1 Test scenario and tasks

When developing a scenario and set of tasks for participants to follow/complete during the evaluation sessions, a number of things were considered. Of primary importance was the previously established need for the scenario and tasks to be suitably representative while enabling the required cartographic UI aspects to be tested (Section 8.2.2.2). Prompted by the PDE findings, a further requirement involved more careful wording of the scenario/task descriptions so that they did not 'lead' participants in any way – e.g. to select particular UI options. Finally, being an assessment test, the tasks (and scenario) had to be more formally structured than in the PDE (Mayhew 1999), thus there should be none of the specific interaction cues that were provided during the PDE. Keeping all of these factors in mind, the design scenario was updated with its final form for the evaluation – broken into three parts – presented below.

Evaluation Scenario

You have been sent to Fremantle by your company for a couple of weeks and it's somewhere you've never been before. You're thinking of taking your family along on your next, inevitable visit and making it into a holiday for them, so you maximise your non-work time to get to know the town and surrounding area in preparation.

(1)

You start by using the Holiday Helper to find out about Fremantle, specifically its spatial arrangement, and nearby activities that you think your family would enjoy.

(2)

You decide it would be good to explore the area on foot. Just before heading out, you use the Holiday Helper to check whether it is going to rain.

Evaluation Scenario (cont.)

(3)

After a particularly long walk, you become disoriented and realise that you don't know where you are in relation to your hotel. You look around but can't see any street signs (and you're too embarrassed to ask for directions). You pull out the Holiday Helper to try and figure out where you are.

The tasks were then carefully written using those from the PDE as a starting point. Again, their final form resulted from a process of iteration and refinement, which was aimed at satisfying the above requirements while producing realistic, meaningful tasks which could be completed within the two-hour timeframe. In the end, each of the six tasks comprised two or more sub-tasks designed to break them up into more manageable units of work, while ensuring that each alternative design technique was evaluated. The final form of the tasks employed during the evaluation are listed below along with a brief description of what each was designed to test.

Task 1: Find out local level detail about the location (overview)

As its title suggests, this task was designed to contribute towards evaluating the cartographic UI components embodying the conceptual model for the goal 'Obtain overview of location(s)' (**ugA**). To this end, participants were required to use the prototype to find general information about the study location. Importantly, the first sub-task served to have participants 'log in' to the system, thus reinforcing the concept of a personal usage session. It also required them to conduct a search using an input method of their choosing. The second sub-task required participants to try each of the remaining search techniques (in any order), thus testing their reactions to and interactions with all of the input techniques built into the design: automated (A-GPS), text entry, voice recognition, map-based selection and list-based selection. Furthermore, the achievement of this and the third sub-task exposed them to each of the different output techniques: text, voice, images and conventional map. The task was considered complete once each of the input and output representation forms had been encountered.

Task 1

(a) Log in to the service and find out some general information about Fremantle. Use the following credentials:

Login: test
Password: test

(b) Explore & comment on the other ways of searching for this information.

(c) Explore & comment on the different presentations of the information provided (click on the links labelled *A to E*) [1].

Task 2: Find out local level detail about the location (layout)

This task extended the specific UI evaluation begun in task 1 (**ugA**), additionally enabling participants to interact with and compare the different representation forms used to convey the location layout: conventional map, text and image map (with voice being an additional, but non-functional option). The inclusion of three sub-tasks served to ensure that all alternative outputs were encountered – including the display of the user's current location on the conventional map – the achievement of which signalled the task's completion.

Task 2

(a) Get an idea about Fremantle's general spatial arrangement (i.e. how the town is laid out, where things are, etc.).

(b) View your current location.

(c) Explore & comment on the different presentations of the information provided (click on the links labelled *text*, *map* and *image*) [1].

Task 3: Identify & select pursuits / find out the characteristics of each pursuit

Task 3 was designed to contribute towards evaluating the cartographic UI components embodying the conceptual model for the goal 'Find things to do / of interest' (**ugB**). Here, participants were required to use the prototype to find information about a number of attractions in and around the location of interest. The separation of the task into two sub-tasks was undertaken to test participants' reactions to and interactions with each of the different input techniques built into the design: hierarchical (and basic) list-based selection, text entry and voice recognition for the first sub-task and address-based searching – involving text, numbers, diagram, schematic map and image – for the second. Both sub-tasks exposed participants to the alternative output techniques: text, images and conventional map (with voice again being an additional, but non-functional option). This task was considered complete as soon as each of the input and output representation forms had been encountered.

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[1] Note, some specific interaction cues were provided to ensure that alternative representations of the same geospatial information were comprehensively compared and evaluated.

Task 3

(a) Find out about a number of Fremantle's attractions, based on the following information:

→ You looked up the **Fishing Boat Harbour** the last time you used Holiday Helper (but didn't save it). Use a shortcut to find it again, and then save it to your favourites list.

→ You've heard of a place called **The Basin** but don't know where or what it is. Find it and then save it to your favourites list.

→ Based on the categories under which they fall, find **The Round House Precinct** ('Historic Sites'), the **Fremantle Motor Museum** ('Museums') and **Vlamingh Lookout** ('Walks & Views'). Save each to your favourites list.

(b) Explore and comment on the 'Around an address' search, including each of the address input methods available.

Task 4: Determine the accessibility of each pursuit

This task extended and completed the specific UI evaluation begun in task 3 (**ugB**), additionally enabling participants to interact with and evaluate the different representation forms used to compare the locations of different attractions: text, numbers, diagrams, conventional map, schematic map and animation. The inclusion of three sub-tasks served to ensure that all alternative outputs were encountered, the achievement of which signalled the task's completion.

Task 4

(a) View and compare the whereabouts of all of the attractions/activities saved to your favourites list (note, there are two extra attractions here that were saved during a previous session).

(b) Explore & comment on the different presentations of the information provided (click on the links labelled *text*, *map* and *pic / chart*) [1].

(c) Compare the whereabouts of only those attractions/activities on the mainland.

Task 5: Find out local level detail about the location (weather)

Task 5 further extended the specific UI evaluation begun in tasks 1 and 2 (**ugA**), enabling participants to trial and compare the different output techniques built into the design to convey weather-related information: text, diagrams and animated map. While the first sub-task ensured that each alternative representation form was encountered, the second was included only to provide context for the alert component of task 6 – with the achievement of both signalling the task's completion.

Task 5

(a) Check the weather forecast. Explore and comment on the different presentation components.

(b) Check to see if there are any current weather warnings.

Task 6: Determine what's in the immediate area

Task 6 extended and completed the specific UI evaluation begun in tasks 1, 2 and 5 (**ugA**), requiring participants to use the prototype to find out about their surrounding environment. The inclusion of three sub-tasks served to ensure that all alternative outputs were encountered – with participants able to view these in any order – which comprised: conventional map, text, numbers, diagrams, images, panorama, schematic map and automated alert. The task was considered complete once each of the output representation forms had been encountered.

Task 6	
(a)	Use the service to find out where you are.
(b)	Explore & comment on the different scales and presentations of the information provided: → The immediate area (click on the links labelled *text*, *map* and *pic*) [1]. → A nearby town or city (click on the links labelled *text*, *map* and *pic*) [1].

10.2.2.2 Qualitative information

Following the task definition, another major set of preparations involved determining what data would be collected during the evaluation and procedures for doing so. It was established earlier (Section 9.2.2) that both qualitative and quantitative data would be collected during this evaluation, each contributing to later *qualitative* analysis. Looking first to the qualitative data collection, analogous to the PDE this was planned to be gathered as behaviour and opinion data – with both the facilitator and an assistant/observer taking notes throughout each session, specifically concentrating on participants':

- main stumbling blocks in initiating and/or completing tasks; and
- needs for assistance or additional information.

Supplementing this would be any 'think aloud' comments made by the participants as they worked through the tasks using the prototype, and their subjective answers to questions posed upon the completion of certain sub-tasks, which allowed for systematic data collection while additionally contributing to the quantitative data collection described below. The questions, used mainly as prompts for more information (where required), were largely concerned with participants' subjective opinions and preferences regarding the various representation techniques employed within the design. These are listed below.

Task 1b

- Preferences for the different input techniques (are any unnecessary)?
  - Places around me (A-GPS)
  - Name-text
  - Name-voice
  - Map
  - My Destinations
  - Most recently viewed

- When would you use each (if at all)?

Task 1c

- Preferences for the different output techniques?
  - Truncated description vs. full description
  - Voice output (auto vs. on-demand)
  - Image (aerial, harbours, link, landmark) vs. locator map (with pictures link) vs. nothing

Task 2c

- Preferences for the different output techniques?
  - Conventional map (with animation for current location)
  - Text description
  - Image map (hybrid)

Task 3a

- Opinions of the different input techniques (are any unnecessary)?
  - Browse by category (lists vs. images)
  - Search by name – text/voice
  - Most recently viewed
- Preferences for the different output techniques?
  - Truncated vs. full description
  - Conventional map
  - Pictures link (with thumbnail)
  - Listed details

Task 3b

- Preferences for the different input techniques (are any unnecessary)?
  - Current location (GPS)
  - Most recently viewed
  - My Addresses
  - New address
- Opinions / preferences for the different output techniques?
  - Schematic map
  - Diagram
  - Text list

Task 4b

- Preferences for the different output techniques?
  - Locations – text list vs. chart vs. conventional map
  - Proximities – text with animated graphics vs. schematic map vs. diagram

Task 4c

- Preferences for the different ways of hiding/showing items?
  - Checkboxes below map/diagram (refresh after each is clicked)

- Checkboxes on another page

Task 5a

- Preferences for the different output techniques (rainfall): text vs. animated map

Task 6b

- Preferences for the different output techniques?
  - Immediate area – conventional map (with panorama) vs. text description vs. schematic map
  - Nearby town – conventional map vs. text list with diagrams vs. diagram
- Thoughts on the automated weather warning alert?

Additional to the above, the three final questions (identical to those employed during the PDE) were incorporated to gather further subjective information about the design/prototype as a whole. These were to be asked at the conclusion of each evaluation session:

1. What was your overall impression of the Holiday Helper (keeping in mind its prototype status and currently limited functionality)?
2. Looking to the future, would you find a fully functional version of this system useful while travelling within Australia? Why/Why not?
3. What other functionality would you like to see included in the system?

10.2.2.3 Quantitative measures

A number of quantitative usability measures were also planned for the evaluation, in order to inform further on the participants' performance with and preferences for certain representation, presentation and interaction techniques, and to highlight specific usability problems with the cartographic UI. Originally introduced in Section 9.2.2, the procedure for collecting the quantitative data was established as follows.

(a) Number of errors during task completion

This measure involved counting the errors made by participants while completing a task/sub-task, so as to identify specific UI components causing problems for users. Errors were defined for the evaluation as:

- the selection of an incorrect pathway/navigation option;
- misinterpretation of a UI element; and
- omission of a task/sub-task requirement.

Here it was anticipated that the higher the error count, the more critical the problem was.

(b) Frequency of help use

Related to the previous measure, this involved counting the number of times a participant accessed the online help or requested assistance from the facilitator to complete a task/sub-task. This was expected to inform on both the usability of the UI in general and that of specific cartographic representation, presentation and interaction techniques. While not all help requests were expected to indicate critical problems (e.g. a participant may just be exploring the page options), in general it was anticipated that high frequencies of help use would highlight aspects of the UI requiring attention.

(c) Preference for particular representation, presentation and interaction technique(s)

Following a meta-analysis of multiple studies, Nielsen & Levy (1994) concluded that user opinions and preferences can provide valuable evaluation data, particularly when combined with relevant objective measures. Furthermore, it has been suggested that subjective satisfaction is especially important for systems used on a discretionary basis, with satisfaction and preference closely tied to user behaviour and the decision to use/reject a particular system (Nielsen 1993; Lund 2001). While parameters (a), (b) and (c) were intended to *objectively* measure performance, it was considered useful to additionally include *subjective* measurements for identifying user preferences relating to the cartographic UI (note, this was informally undertaken during the PDE). Specifically, participants' relative preferences for alternative representation, presentation and interaction techniques would be gathered both from their verbalised thoughts, intentions and expectations (i.e. thinking aloud), as well as their answers to the subjective questions presented in Section 10.2.2.2. Without large numbers of users being asked an identical set of questions[2], however, the preference data could not be objectively analysed (Nielsen & Levy 1994). This was not an issue for the research, however, with any quantification of the preference-based information, along with the objective measures identified above, intended only to inform *qualitative* analysis of the evaluation data – as such these measures will not be presented here as quantitative results.

10.2.2.4 Pilot testing

Considering the more structured nature of this evaluation compared to the PDE, it was important to pilot test the evaluation procedure and its supporting materials to ensure their effectiveness. Indeed, pilot testing can reveal a plethora of problems with an evaluation, such as: errors in the prototype; incomplete/inadequate support materials; difficult to understand or easily misinterpreted tasks; insufficient time to complete all tasks; tasks that are too difficult or too

2 With a focus on users' preferences, as opposed to their satisfaction with the system as a whole, the administration of a subjective satisfaction questionnaire – i.e. incorporating rating scales (see Nielsen & Levy 1994; Bevan & Macleod 1994; Lund 2001; Harper *et al.* 1997) – was not considered useful for this stage of the design.

simple; and biased questions or tasks (Nielsen 1997; Rubin 1994; Mayhew 1999). As was the case for the user profiling and user task analysis pilot tests, it was important to involve participants who were representative of the target users and to conduct the testing under similar conditions to those planned for the actual evaluation. These requirements were satisfied during a small scale pilot test involving a single participant selected from the target user population, which was conducted in the Sensis specialist usability laboratory using the prepared evaluation procedure and materials. While the data from the pilot test session was not included in the evaluation analysis, the feedback obtained was particularly useful for identifying problems with the wording and structure of the evaluation scenario, tasks and questions. Similarly, it allowed the identification of a number of problems with the prototype itself, which could therefore be fixed prior to the evaluation sessions, namely:

- The voice input prompts (speech and text) for the 'attraction/activity name' search erroneously contained the word 'event' – this was removed.
- Incorrect page linking was detected within the 'around an address' search results – all errors relating to this were rectified.
- The volume of the alert and warning sounds was found to be unnecessarily loud – this was subsequently reduced by one quarter.

10.2.3 Sampling and conduct

The final preparation before conducting the evaluation was sourcing and scheduling the test participants. In line with the sampling decisions made for the PDE (Section 8.2.2.3), five representative (novice) participants were selected from the target user group using the established purposeful random sampling procedure. Additional care was taken, however, to source participants who were not involved in the PDE – since "each iteration of the testing should involve different users" (Myers 1994, p.78). A copy of the script followed to recruit the evaluation participants is included in Appendix E, Section E.1. As users were recruited, a schedule was updated, incorporating the evaluation session time, contact details and user characteristics. A representation of the final schedule is shown in Table 6.3, indicating a diverse and comprehensive range of pertinent user characteristics within the sample[3]. At the conclusion of this process, all five participants were sent an email to confirm their session date and time, provide instructions for their arrival at the interview and supply them with the Plain Language Statement (PLS) and Consent Form in advance of the evaluation session (refer to Appendix E, Sections E.2, E.3 and E.4).

[3] Similarly to the PDE, each participant was asked at the end of the evaluation session which persona(s) they most closely identified with in terms of their travel-related goals and behaviours, being provided only with the research persona descriptions. Here it was found that each persona was covered to at least some extent: P1 = Lisa, P2 = Daniel & Kevin, P3 = Kevin, P4 = Daniel & Linda, P5 = Lisa.

Table 10.1 The final evaluation schedule.

Characteristics	Day 1	Day 2	Day 3	Day 4
Session 1				
gender	Male	Male	Female	Female
age	31-40	25-30	25-30	31-40
holiday frequency	12+	3	1-3	1-3
holiday distance	Inter/Intrastate	Inter/Intrastate	Inter/Intrastate	Inter/Intrastate
holiday length	1-2 weeks	1 week	1 week	2 wks-1 mth
mLBS opinion	Definitely	Unsure	Unlikely	Probably
Session 3				
gender				Female
age				41-50
holiday frequency				2
holiday distance				Inter/Intrastate
holiday length				1 week
mLBS opinion				Unlikely

During the evaluation sessions there were three people in attendance: the facilitator, the participant and an assistant/observer who was responsible for taking notes and recording the session. At the beginning of each session, the participant was asked to read and sign both the PLS and Consent Form, in acknowledgement of having been informed of the research, the evaluation's purpose and other pertinent details (e.g. privacy). Following this, they were given a cash voucher to thank them for their time and effort, and asked to sign another form which stated that they had received the gratuity and were willing to be videotaped during the session.

Before beginning the actual evaluation, each participant was given instructions on thinking aloud, a brief orientation on the use of the SmartPhone upon which the prototype was installed (including a printed reference guide for its operation – identical to that in Appendix D, Section D.6) and an information sheet explaining the configurations that had been 'pre-saved' within *My Profile*, which would be of relevance during their use of the system (see Appendix E, Section E.5). At this time they were also informed of the structure of the evaluation session, including the presence and purpose of multiple sub-tasks for evaluating alternative representations of the same geospatial information)[4]. A copy of the evaluation session script is provided in Appendix E, Section E.6.

The conduct of the evaluation began by asking the user to read the Evaluation Scenario aloud. After this they were asked to work through each task/sub-task, reading it aloud before attempting its completion using the prototype (note, to keep within the allotted session time,

[4] The order of the sub-tasks was not randomised for this evaluation, with options instead built into the prototype allowing participants to choose the order in which they accessed alternative representations – the sequences chosen were considered valuable feedback for the evaluation analysis.

participant 4 did not complete tasks 5 or 6). At the end of relevant sub-tasks, any of the evaluation questions not yet addressed were asked by the facilitator. Analogous to the PDE, throughout each session the facilitator encouraged the participant to think aloud using the techniques of neutral prompting, echoing, 'conversational disequilibrium' and summarising at key junctions (see Section 8.2.2.3). Again in doing so special care was taken not to bias the participant in any way, express personal opinions, or indicate whether they were doing well or poorly. Participants were also encouraged to complete each task without assistance from the facilitator, asking for help only when they felt they could progress no further – in which case enough assistance was provided to allow them to continue. At the conclusion of each evaluation session the participant was asked the final three questions prepared to collect subjective opinions about their overall experience with the prototype, while being invited to make any additional comments they had about the prototype and/or the evaluation process.

10.2.3.1 Rapid prototyping

Similar to the PDE, but to a greater extent, rapid prototyping was undertaken between the evaluation sessions, involving changes made to the prototype/design (and the task wording) prior to the next session in order to correct observed issues (Medlock *et al.* 2002). This had the potential to enable subsequent participants to identify remaining problems in the cartographic UI that had previously been 'masked' (Nielsen 1993), as well as serving to correct non-cartographic problems which distracted participants from satisfying the aims of the evaluation. As described by Medlock *et al.* (2002), the rapid prototyping required 'on-the-fly' interpretation and analysis of the evaluation data, with changes made as soon as a problem was identified and a solution to this clear (generally before the next day of testing). Notably, only those problems with an obvious cause and solution, and which could be implemented quickly, were fixed. The subsequent evaluation sessions were then used to verify the effectiveness of the changes made (where applicable), in terms of whether the observed issues had been alleviated and to ensure that no new problems had been introduced. Table 10.2 summarises the issues identified and the changes made, including the evaluation task to which each related and the sessions following which they were made.

Table 10.2 Changes made after individual evaluation sessions as part of the rapid prototyping process.

Session	Identified Issue	Change(s) Made
Task 1 – Find out local level detail about the location (overview)		
1	The alphabetical ordering of the place name (text entry) search results did not match the input – 'fre'.	The place name matches were reordered, listing those starting with 'fre' first, followed by alphabetical sorting.
1	The alphabetical ordering of the place name (voice recognition) search results did not match the input – 'Fremantle'.	The place name matches were reordered, listing those sounding most like 'Fremantle' first, followed by alphabetical sorting.

Table 10.2 (cont.) Changes made after individual evaluation sessions as part of the rapid prototyping process.

Session	Identified Issue	Change(s) Made
1	The ordering of the most recently viewed locations list did not match recent system usage which had involved viewing information about Fremantle.	Fremantle was moved to the top of the list to show that it was the most recently viewed location.
1	The Fremantle label was not sufficiently obvious on the summary page's location map.	A grey outline was added to the label which was also animated – making it 'blink' to draw attention.
Task 2 – Find out local level detail about the location (layout)		
2	The incorrect map tile for scale 4 of the layout map appeared upon accessing this scale.	The UI was changed to link to the correct map tile (on which the user's current location was centred).
Task 3 – Identify & select pursuits / find out the characteristics of each pursuit		
1	The purpose of the menu option 'Relative to an address' was initially unclear due to its naming.	The option was renamed using less technical terminology – now 'Around an address'.
1	The ordering of the most recently viewed addresses list did not match recent system usage which had revolved around Paddy Troy Mall.	Paddy Troy Mall was moved to the top of the list to show that it was the most recently viewed address.
1	An incorrect page link was detected upon adding 'Fishing Boat Harbour' to My Attractions/Activities from the attraction page.	The UI was changed to link to the correct page (dependent on the search method initially employed).
1 & 2	The wording of Task 3 proved to contain excessively leading interaction cues	The task was re-worded appropriately.
3	An incorrect page link was detected upon adding 'Fishing Boat Harbour' to My Attractions/Activities from the map page.	The UI was changed to link to the correct page (dependent on the search method initially employed).
Task 4 – Determine the accessibility of each pursuit		
1	The method for selecting 'location' vs. 'proximity' comparisons (using a single menu option) was difficult to understand.	The technique was simplified by creating two separate menu options for 'location' and 'proximity' (see Section 9.3.3.4).
Task 6 – Determine what's in the immediate area		
1	The symbol representing the user's current location was missing from the 'Towns and Cities Nearby' map.	The current location symbol was (re)added to the map.

Note, there were no issues/changes relating to Task 5.

10.3 Analysis of Results

The qualitative analysis of the evaluation data proceeded in a similar fashion to that for the PDE, using the established aims as guidance and founding all interpretations upon thick, rich, detailed and concrete descriptions of the phenomena discovered within the data. Thus the analysis began by organising the raw evaluation data into a more accessible form through the creation of descriptive transcripts for each evaluation session. Employing the video recordings and observer and facilitator session notes as inputs, the transcripts incorporated specific participant quotes, movements, behaviours and interactions, as well as pertinent researcher comments/inferences that arose during the transcription process (see example in Table 8.3). Additional to this, points relating to the quantitative measurements were also identified and marked within the transcripts –

i.e. wherever a participant was considered to have made an error (E), required/utilised help (H) or expressed a preference (P) for a particular representation, presentation or interaction technique.

Table 10.3 Extract from an evaluation session transcript (second evaluation).

Time	Task	Quote / Interaction / Movement	Measures	Comment / Inference
2:31:55	2b	map symbols? "yeah, they're fairly standard – information, hotel, 'P' parking 'T' for telephone; can he confirm his guesses? "I can probably go to the help symbol"; clicks on the Help button; page opens "and there we go, there's the legend, is it? No, not yet"; "information on what to do, scroll to the north"	H	misinterprets the 'T' symbol has noticed the keypad shortcuts for panning
2:32:57	2b	scrolls down further "key to map features is the lock symbol"; "I wouldn't have expected that … I suppose when I actually first saw that lock symbol I thought it was some way of … locking the map to a point"; clicks 'back' key and returns to map		the 'key' symbol on the legend button is confusing/unfamiliar
2:33:38	2b	clicks on 'legend' button; reads content aloud; "oh, 'T's a public toilet!"; directed to look at legend for another zoom level; clicks directly on 2nd scale; "I've got an 'S'. So there's a new one that wasn't on the last one"; selects legend button; "service station, excellent. So it only shows you, typically, what's valid on that map"; his opinion of that? "I like that feature"; clicks directly on 1st scale; "now I've got no features, apart from a crosshair … and my roads"; "that makes sense, yep"	P	he doesn't realise that the 'S' symbol **was** included at the other zoom level, it just wasn't present on the map tiles he viewed

The next step involved inductively analysing the evaluation transcripts to uncover patterns and themes within the data. As with the PDE this was accomplished by collectively analysing and interpreting the participant data with respect to the aims of the evaluation process, and in accordance with the qualitative and quantitative focus of the data collection, thereby specifically concentrating on:

1. Identifying usability problems within the cartographic UI.
   - *Qualitative information* – main stumbling blocks in initiating and/or completing tasks; and needs for assistance or additional information.
   - Quantitative measures – E; and H.
2. The relative usefulness of alternative representation, presentation and interaction techniques employed within the design.
   - *Qualitative information* – main stumbling blocks in their utilisation; need for assistance or additional information; participants' preferences for particular technique(s).
   - Quantitative measures – E; H; and P.

The following section describes the outcomes and reasoning behind the analysis and interpretation process. As with the PDE, this was included to address questions of credibility and 'observer bias' that may be raised due to the unavoidable subjectivity that characterises interpretations of observational data. Note, the following references are again used to denote relevance to particular research concepts:

ug*L* – a qualitative usability goal (defined in Sections 7.3.2 and 9.2.2);
DP*n* – a UI design principle (defined in Section 7.3.5.1); and
CP*n* – a cartographic design principle (defined in Section 7.3.5.2).

10.3.1 Findings

10.3.1.1 Task 1: Find out local level detail about the location (overview)

Concerned with accessing geospatial information about a specific location, and comparing the alternative input and output techniques involved, Task 1 also introduced participants to the Holiday Helper prototype and its operation.

Inputs

Beginning with **Task 1a**, the first requirement was to log in to the service, which all participants managed without issue – although four of the five leaned closer to the screen to do so. Next, participants had to find out general information about Fremantle, making a selection from the options on the Main Menu to initiate this. While three of the participants instinctively chose the correct option here – "I think I'd go to *Location Info* to find out about Fremantle" – two erroneously selected the *What's Around Me* button, one admittedly doing so against her initial judgement ("maybe just because it was on the left … I thought it was the most important … I probably should have checked out *Location Info* first – that made more sense"), and the other believing this to be the required option (E=1), based on the design scenario wording ("according to this, I'm already in Fremantle so if I go to *What's Around Me* …"). When prompted further about his selection, the latter participant commented that the *Location Info* button looked "more like a GPS button that just gave me my latitude, longitude … [for] the location that I'm currently at" (**DP20**). Based on this, although it appeared that the changes made to the design of the Main Menu buttons had indeed improved their support for the 'Obtain overview of location(s)' goal (and made their ability to be selected more obvious), it was felt that more could be done to support the task of searching for general information about a location (**ugA**, **DP1**), with Recommendation 1 formulated to address this.

Continuing their search for information about Fremantle, participants were asked to choose an option from the *Location Info* menu, with their various selections demonstrating the differences between individual users (**ugD**): two participants chose the list first option – *Places around me (GPS)*; two others selected the second – *Place name search* – each then using text entry; and the final participant chose the fourth list option – *My Destinations* – doing so largely because it had been italicised (representing its association with *My Profile*). Of particular interest during this process was the following comment made by one of the participants: "I'd assume it'd almost bring [my location] up automatically 'cos … it'd know where I am so it could almost pre-empt me and say 'do you want to know about Fremantle?'". With this considered a valid user expectation while travelling (**DP1**), a new menu option identifying the town/city closest to the user's current location was recommended for inclusion within the design (see Recommendation 2). Before moving onto a discussion of the participants' experiences with, and preferences for the various input techniques (all of which were utilised as part of **Task 1b**), it is pertinent to note that following their initial selection each participant generally progressed through the remaining *Location Info* search menu options in the order of their listing on the menu – thus there were no insights to be gained from their subsequent selection processes.

Looking at each menu item in turn, *Places Around Me (GPS)* generated no errors or requests for help from participants, implying that it was a relatively straightforward option which was readily understood – "it's given me places around me in Western Australia, starting from the closest and going further out" (**DP1**). Problems were encountered, however, with the next menu item, *Place name search*, which offered two separate input techniques. While both the text entry and the voice recognition were operated without issue (vindicating the associated design revisions), and their respective results readily understood – "it's given me a number of matches in order of which ones are most applicable" – none of the participants correctly used, or identified the purpose of, the 'state' selection field (E=4). With one participant not evaluating this functionality, the observed problems comprised: (1) complete oversight of the state field; (2) an expectation that the field enabled searching 'by state' (i.e. returning all locations within the selected state); (3) a belief that the state was specified by its addition to the text entry field; and (4) an expectation for hierarchical searching using the voice input technique, beginning at the state level. Furthermore, despite obviously requiring instruction, none of the participants was observed to access the associated online help (despite one noticing its icon), implying that its contents would perhaps have been better placed alongside the state field. From this it was clear that the design revisions aimed at improving users' recognition and understanding of the state-based results filtering had failed, and potentially created further issues. While one option would have been to remove the state-based filtering of results altogether, it was anticipated that as an optional feature this may at times prove useful for limiting the size of the results set. Therefore the recommended course of action was to move the state field back to its preliminary design position while providing 'on page' instructions regarding its purpose/use (**ugM**, **DP10**) – see Recommendation 3.

When attempting to find the location using *A map*, all participants were initially confused as to how they might initiate the search (**ugK**): "I'm choosing the state … somehow"; "there's [*sic*] no comments here on what to do"; "an image of Australia – it's not quite clear how to navigate round that"; "I'm not quite sure how I'd do that". In spite of this, however, each person was able to initiate and conduct the search, generally doing so after having explored the page and noticing that the map was selectable ("the cursor's actually around the whole thing"; "I'll select the map and then see what happens") – **DP19**. Notably, no one actively sought help for this task (apart from a single participant who 'accidentally' selected the online help icon). While the participants' eventual success meant that the design revisions had improved the usability of this input technique, it was still not considered ideal, with several participants citing initial expectations for the search operation which were similar to those identified by the PDE participants:

> *"[I thought] I might be able to use the [joystick] here to select each of the red dots on the map – the capital cities in turn … that'd be pretty easy I think";*
>
> *"I guess because … you're used to the Internet, it feels like you're on a page … you feel like you should have a [mouse pointer] or something"; and*
>
> *"I think originally I was expecting a little box … on the big map to highlight as I used the [joystick], so that I'd click on Perth and it'd take me into Perth".*

Furthermore, a number of participants had trouble physically selecting the map and/or correctly positioning the centre of the crosshairs over map features, with at least two requiring help from the facilitator to do so (H=2). In light of these various 'stumbling blocks', the original PDE recommendation for improving the usability of the map-based selection was again advocated here, with some minor modifications (Recommendation 4). In general, the clarity of the input maps appeared to have been improved by their design revision, with participants observed leaning closer to the screen less often than during the PDE (**ugJ**).

While the fourth menu item, *My Destinations*, was immediately understood by three participants (**DP1**) – "It's where I've saved locations I've been before or want to go" – two others made errors (E=2), with one interpreting the list as recently viewed locations and the other believing it to comprise "capital cities initially" which could then be used as a starting point for finding other locations. However, after being directed to review the *My Profile* information sheet provided to them at the start of the session, both participants readily understood the list before them ("so that makes sense"). Based on this, it was assumed that the two errors were in fact not usability issues, but more likely a result of the participants 'forgetting' the description of *My Destinations* that they had previously read – had they created this list themselves (as would be the case with a fully functional system) they would have undoubtedly recognised its composition from the outset. Looking finally to the fifth menu item, *Most recently viewed*, no errors were generated nor requests for help made by participants in the operation of this input technique, with the list's composition seeming to be readily understood (**DP1**): "these are the last 8 locations that I looked at"; "I'm assuming 1 would be the most recent, down to 8 being the [oldest]"; "Fremantle's at the top, which I'd expect". Thus no usability issues with this PDE-recommended technique were identified.

When asked to compare the various input techniques and provide their preferences, mimicking the results of the PDE, the participants expressed mixed opinions and provided an overwhelming sense that their choice of technique was highly dependent on their current context (**ugD**). Looking first to the map-based search, two participants expressed this as their clear preference (P=2) – "the map [search], definitely"; "I'm a visual person so I do like the map" – despite one of them admitting that "I didn't like the actual [way of using it] – it seemed to take too long". Others, however, expressed a general aversion to this technique ("I think I'd use most of them, probably just not the map"), finding it generally cumbersome to use and seeing it as useful only where a location's whereabouts was already known (otherwise "you could be searching that map for a long time to find it") or "when you want to just look for places to go – you're not looking for anything in particular … you don't know the area and you're planning a trip … just to explore". Considering this, and one participant's desire to use the maps "to go from A to B", it may be argued that maps are more suitable as a representation form for geospatial information output, as opposed to input tasks such as this. Changes were not recommended based on this generalisation, however, with suggested improvements to the map-based selection technique expected to improve its usability in the future while more extensive, field-based testing is required to fully assess its usefulness (or lack thereof).

Another clear preference was expressed by a single participant (P=1) with respect to the *Places around me (GPS)* search (**DP1**, **DP22**, **DP23**): "if I was in the area I wanted to go to, the GPS one was probably the best … I think it's the quickest, the simplest way to do things – I don't have to click on a map, I don't have to type in a lot of text, I don't have to speak to my phone (which some people might find embarrassing)". While not stating this as a preference, a further participant agreed, citing that it would be the easiest and fastest technique "if I didn't know where I was … or if I do know where I am and I did want a location close by". Moving on to the text entry and voice recognition, these were generally considered by participants to be "standard" input techniques and were each attributed a relatively high level of usefulness. Concerns were expressed, however, over their use when the spelling or pronunciation of a location name was unknown, with two participants also having misgivings about the reliability of the voice recognition software ("past history might make me not choose that as a first option"). Looking finally to the list-based inputs, both *My Destinations* and *Most recently viewed* were seen to offer benefits as 'shortcuts' to required information: "If you've been there before then you can just go straight back to it". One participant, however did not see much use in *My Destinations*, believing it unlikely that he would ever set up "bookmarks, 'cos [*sic*] I wouldn't remember to go in there; it wouldn't be the first thing I'd think of".

Like the PDE results, these findings suggest that it would be preferable to retain each of the alternative input techniques evaluated, since all were considered useful by different users in varying contexts (**ugD**). Two suggestions for additional features/functionality may be made, however, embodied within Recommendation 5. The first of these concerns making the *Location Info* search menu adaptive, whereby it is reordered according to the user's most frequent selections – while this could be a potential source of confusion, it may also reduce the amount of navigation required by users to access the information of interest (**DP1**, **DP23**). The second suggestion is to combine multiple search techniques – similar to Hurtig's (2006) multimodal speech and gestural (pen-based) input for requesting navigational information – to evaluate whether this can potentially offer increased usability (and utility).

Outputs

In addition to trialling the different location search inputs, participants were asked to explore and comment on the alternative output techniques employed to communicate general geospatial information about a location. Having already been exposed to each output form during Tasks 1a and b, in completing **Task 1c** participants undertook direct comparisons between the alternate versions of the location summary page using the temporary links provided.

Dealing first with the textual location description included at the top of each page, the participants were almost unanimous (P=4) in their preference for this to be truncated upon loading the page, thus enabling the content below to be immediately visible (**DP22**) – "I like less detail 'cos [*sic*] it showed straight away that there was a map on there, whereas on the more detailed screen it wasn't instantly obvious". Similarly, most participants (P=4) found the 'more detail'/'less detail' functionality to be a useful feature overall (validating its addition to the design) – "it *is* good … 'cos [*sic*] the screen's so small … if you wanna [*sic*] see something more you have it there. The good thing is too, it's not an option down the bottom … it's right there" (**DP1**, **DP14**, **ugE**). A single participant, however, preferred to always see the full description ("I think I'd rather that it just all came up in one go") leading to the suggestion that, to cater to user differences (**ugD**), the initial display state should be user-configurable and/or adaptive, automatically changing to match recent user behaviours (i.e. if the user consistently chooses to view more detail, this should become the initial state – **ugN**). Recommendation 6 addresses this. In terms of the text itself, while not appearing to affect their comprehension, participants did make comments regarding the 'small' font size employed, stating that: "6pt font would be very difficult to read"; "some people might struggle if they need glasses"; and "[the font's] not that big". For this reason, Recommendation 7 advocates an option for users to increase/decrease the font size of all text output within the system (**ugJ**).

When asked about the voice output, three participants saw some necessity for this feature (P=3), citing the aforementioned potential difficulties in reading the text output as one reason to use this alternative representation ("if it's hurting my eyes too much I can go to 'Play Voice'"). Other situations where participants expected the voice to be useful included when driving or walking (i.e. when their visual attention was needed elsewhere), or to share the information with a companion. With two participants asserting that they were unlikely to use the voice feature at all– "I'd rather read it in my own time" – a number of specific misgivings with this output technique were identified. The first of these concerned the effectiveness of the voice in mobile settings: "if you were outside somewhere, it might be a struggle to hear it, and concentrate as well". The second had to do with the voice content – "it's good that the voice reads out the description of Fremantle, but [I'm] not sure why they have to read out the [*Location*] *Options* as well" – with the implication being that this would make more sense if the options could be selected using voice-based input. Linked to this, a further participant inferred that the voice output was inconsistent with the largely gesture- and vision-based interaction techniques used to arrive at this point ("not quite sure how that would work"). Before making any recommendations regarding these findings, however, it was decided to first review the participants' preferences concerning on-demand vs. automated voice output. Here it was found that each person overwhelmingly preferred the voice representation to be playable on-demand (P=5), thus supporting the addition of this feature – "playing them automatically would annoy me … I'd rather have the ability to play it if needed"; "otherwise every page you select you're gonna [*sic*] have someone speaking to you and you might not want to hear it … you can read it a lot quicker than someone can speak it". Based on this, and the previous findings, a number of implications were recognised (summarised by Recommendation 8): (1) although the voice output would likely be used less frequently than other techniques (e.g. text), its availability should be retained to cater for those situations where it *is* found useful (**ugD**); (2) automated voice output is not considered useful and should therefore be removed from the system; and (3) voice recognition should be explored further in terms of its potential as an input technique at decision points throughout the system.

Looking finally to the provision of graphical outputs, participants had clear opinions about the relative usefulness of the map and image representations employed for communicating geospatial information about the location. In particular, four commented on the non-suitability of the landmark image, feeling that it was not sufficiently representative of the location to appear on the summary page ("doesn't really do much"), being instead more suited to accompanying "specific information about an attraction". Conversely, the aerial view and photograph of Fremantle's harbour were considered by all participants to provide an "attractive" overview of the location – "it sort of gave a feel for the place" – and were thus more accepted here. The location map, however, was attributed even greater relevance ("it shows how far away other places are"), with the participants' overall preference (P=5) being for the location summary page to include a map and a link to view photographs of/from the location – "I think that [I prefer] the map … and then, yeah, the ability to go and select pictures". Recommendation 9 recognises this, while also advocating a number of changes prompted by participants' comments and behaviours. The first of these concerned the placement of the *Pictures* link – considered "hidden", "right down the bottom of the screen" – which resulted in three participants requiring assistance to find it (H=3). Here, a change in position was suggested to avoid the need for scrolling in order to see the link (**DP22**). The second set of changes concerned the location map, with participants seeking similar functionality and coverage to that already inherent in the layout map – "I'd wanna [*sic*] highlight [Fremantle] and select it and go into a lower level of detail" (**ugF**). A potential solution was readily apparent for this, with Recommendation 9 suggesting that the location map be directly linked to the layout map (**DP1**, **DP14**). And finally, with respect to the changes applied to the 'Fremantle' label following the first evaluation session, while making it "easier to see", the addition of animation was considered unnecessary (and potentially distracting – "Freo's [*sic*] blinking at me") and so was recommended for removal, with some participants noting "I think you'd get the picture anyway" because "it's bolder than the other places".

10.3.1.2 Task 2: Find out local level detail about the location (layout)

Task 2 required participants to find out about the geospatial arrangement of the location of interest, in the process comparing a number of alternative output techniques. Accessing the system component *Layout* from the *Location Options* on the location summary page was the first step in this process, with three participants instinctively making the correct selection ("I'm assuming 'Layout' would be the most logical"), one participant expressing uncertainty but managing to follow the same pathway ("I'm looking at [the] different options. One of them is layout, I'm not really sure what that is, so I might just click into it"), while the final participant navigated to *What's Around Me* (E=1) – most likely a result of the design scenario wording rather than a usability issue – before being redirected to the location summary page (H=1) and eventually making the correct selection. These results suggest that, while intuitive to most, the label *Layout* was perhaps not entirely representative of its purpose, with a potential solution being to rename this (**ugH**, **DP2**). No changes were made at this time, however, with Recommendation 9's linkage of the location map to the layout map expected to minimise the use of the *Layout* link, which as a result may ultimately prove largely redundant.

Outputs

Participants' opinions regarding a conventional map representation formed the basis of **Task 2a**, with this output comprising the initial display upon accessing the *Layout* component. As a first impression, participants were generally satisfied with having access to a map, which they felt addressed their needs according to the task (**DP1**) – "it shows me where Fremantle is in relation to things around it, so it gives you an idea of where things are". Being then given free reign to explore the representation, each person proceeded to interact with the map and identify its features.

Looking to specific findings, most participants readily identified the purpose and functionality of the map zoom tool – "ah, this is where I can zoom in and out a little bit" – having no hesitation or problems using this to change the map's scale (**ugK**). This implied that the revisions made to this tool had in fact improved its usability without introducing other issues and/or that the participants possessed prior experience with similar zoom functionality (note, this is often used for applications beyond map interaction). Of particular note here, all but one participant changed the map scale by directly selecting the various zoom levels, with the other using this method in addition to selecting the 'magnifying glass' icons at either end of the tool. With no benefits to be gained from removing the latter (which arguably assisted in conveying the tool's purpose), however, no recommendations were made regarding this. While the ability to pan the map was generally evident to the participants (**ugK**), three had to be prompted to use this tool. Furthermore, difficulties were encountered by three participants in physically scrolling to and selecting the arrow icons used to pan the map, while another highlighted inconsistent behaviour between this and the input maps – i.e. she had expected to select the map and use the crosshairs for panning. Furthermore, only a single participant utilised the numbered keypad to pan, having identified this functionality when viewing the map help for a different purpose. Again, however, he had expected to select the map first before being able to use the tool. The implications of this were that the revisions made to the map panning tool, while adequate for its purpose, were still not ideal in terms of its usability (**DP1**). Taking inspiration from the participants' expectations, a potential solution was suggested, concerning panning via 'map click' and crosshair scrolling behaviours (additional to the current tool). This was incorporated into Recommendation 10 along with some additional map behaviours already anticipated for ensuring the layout map's consistency with other maps in the system (**DP4**, **DP13**, **DP25**).

In terms of map content, on the whole the participants were happy with the different map scales – "I think it comes in at the appropriate one"; "the [initial scale is] good so you know how to get there, and then if you're looking for a particular place you can [zoom] in closer. I think that's really good" – and also the changes in detail between each scale – "so each time you go down you can see more things … yeah, that is useful" (**CP1**, **CP8**). Although the initial levels of detail were largely appreciated ("I think if you had more it would be too busy"), participants did have some issues regarding specific features not being present at particular scales. In this respect, one participant sought more navigation-type information at Scale 1 (e.g. railway stations), while he and another participant each sought the display of additional features at Scale 4: namely, emergency services (e.g. hospitals, police stations – "I think maybe that's more important than say … a restaurant or a bar") and the GPO (general post office, "the centre part of the city"), respectively. No changes were recommended in relation to this, however, since such differences in user needs/preferences were the main reason for implementing the ability to hide/display map features during the design revision (discussed below).

While most of the map symbols appeared to be sufficiently self-explanatory ("they're fairly standard – information, hotel, 'P' parking" – **CP3**, **CP10**), some were not immediately clear to all participants ("Not sure what 'H' and 'P' and 'T' [are]"). When prompted as to whether they could determine the symbols' meanings, all participants went in search of a legend/key. With two participants finding the appropriate icon after visiting the *Map Help* (H=2), and the rest managing to identify it without assistance ("there's a little key sign"), each was satisfied that it contained the information they required. There were some reservations regarding this feature, however, with one participant confused by the icon used to access it (**DP20**) – "[the] key to map features is the lock symbol … I wouldn't have expected that … when I actually first saw that lock symbol I thought it was some way of … locking the map to a point" – prompting Recommendation 11 to suggest trialling different icon designs. Additional to this, two participants expressed a desire for the legend information to be present on the same page as the map, although one acknowledged the potentially large number of symbols that could be included, requiring an inordinate amount of scrolling (note, no changes were recommended here for precisely this reason – **DP22**). In terms of the contextual nature of the legend (i.e. its content linked to the features displayed at the current map scale), this was readily understood and highly regarded by all participants (P=5) – "there's less information on this … 'cos [*sic*] it's a high-level map"; "So it only shows you, typically, what's valid on that map … I like that feature" – for this reason recommendation 12 advocates removing the option to configure contextual vs. static legends.

In **Task 2b** participants were asked to view their current location, with none knowing how to do so immediately. Although two participants found the correct option (*Map Feature Display*) while exploring the marginalia icons during the previous sub-task, two others appeared to choose this only after a process of elimination, having first looked around the map page ("I haven't used the eye button, so I'll see what that does"). Moreover, the final participant had to be led to the correct option (H=1), having unsuccessfully searched for a way to view her location both within the map page and the map help. Once on the correct page, however, all participants seemed to readily understand and appreciate its function (**DP1**) – "obviously there's some standard things that I could click on and it would save them for me … they'd come up every time I went to a destination and selected [the map]"; "yeah, that would be handy, so you don't have to do it all the time". Since each participant then successfully added their current location to the map display, no major changes were deemed necessary regarding this functionality. Two potential problems were acknowledged with respect to this, however. The first concerned the design of the icon representing *Map Feature Display* (**DP20**) – "to me … that eye symbol – I didn't really know what that was for … I don't know if that's very intuitive" – with Recommendation 11 amended to address this. The second was based on a comment made by one participant who stated "I think if I selected everything on the [*Map Feature Display*] screen … [the map] would be quite cluttered", prompting the recommendation to limit the number of features able to be displayed on the map at one time (Recommendation 13). Finally, in terms of the display of their current location, all five participants found this to be a useful feature ("It'd be good if you're lost … you can also see what's around you"), particularly appreciating the associated map symbol's animated behaviour (**CP11**) – "I like that it flashes actually … 'cos [*sic*] you might not notice it, you might think it was part of the map"; "it's really clear and easy to see. You don't have to look around for it" – although one participant did note: "whether it's flashing or not is probably not as important if the other things are all different colours". With the potential for multiple map features to use the same colour as the current location symbols (i.e. to keep within recommended colour limits – **DP3**, **DP13**), the dynamism was retained.

In completing **Task 2c**, participants were required to explore the two remaining representation forms and compare these with each other and the conventional map output. Looking first to the text output, here the participants' had mixed feelings. While three found that the text provided useful (geospatial) information, additional to that attainable from the other representations – "I think that's a good description of what's there and it tells you what's available to do"; "It's not just where it is but what's there; what you'll find when you get there" – the other two participants did not see this as particularly relevant, one implying that it provided more a "summary" of the location than conveying its layout – "It just gives kind of a flavour of the place"; "Maybe if that was a bit more structured, under 'places to visit' and 'attractions, 'food' and 'entertainment' …[otherwise] you have to read through it all". Similarly, the image map drew varying responses, with two participants liking it ("it actually works quite well [on the small screen]"; "it's very clear … you can still read all the writing and symbols, which is good"), while the remaining three found it difficult to read ("it's a little too busy for my taste"; "it's harder to see … the actual features; [the conventional map] form simplifies it … [the] colours and highlighting … make it difficult to see"; "the top of a building's not really gonna [*sic*] tell you anything about how to get there"). In terms of clear preferences, all participants preferred the conventional map representation (P=5) – "I went there expecting a map"; "I just find that easier to navigate by" (**DP1**) – with all but one implying that they would never use the image map, even if it were an option. And while all five agreed that the text may be useful to have "in addition" to the map, none seemed particularly committed to using this representation ("I probably would but I'd use the [map] first"; "I think I'd use the map instead"). Based on these findings, Recommendation 14 was formulated to remove the image map, while an addition was made to Recommendation 6 suggesting the incorporation of the text-based output within the textual description on the location summary page (and thus its removal from the *Layout* component).

10.3.1.3 Task 3: Identify & select pursuits / find out the characteristics of each pursuit

Introducing participants to Module 4, Task 3 was concerned with evaluating a variety of input techniques for finding attractions and activities in and around the location of interest, in addition to a number of attraction-related outputs. At this time participants were also encouraged to explore the various shortcuts linking different system components (**ugL**, **DP7**), some of which had already been discovered and occasionally utilised (e.g. the 'Home' link in the page header/footer).

Inputs

A number of different input techniques were trailed as part of **Task 3a**, requiring participants to first navigate to the *Attractions & Activities* component. While two did so using the 'Return to

Fremantle summary' shortcut (one required help to find this), arriving back at the location summary page before selecting the correct item from the *Location Options*, one selected the shortcut *Find things to do here* from within the *Layout* pages, taking him directly to the *Attractions & Activities* search menu. The two remaining participants instinctively selected the 'Home' link and then navigated to the location summary page from the *Main Menu*, before identifying the correct option: "I would assume that it's under *Attractions & Activities*". From here, the first part of the sub-task required participants to select an attraction from a system-maintained list. Whereas the first two participants were directly led to *Most recently viewed* by the task wording (which was subsequently changed – see Section 10.2.3.1), as a result having no issues selecting this and then finding the required attraction, the remaining three each considered their choice carefully before making the correct selections ("[according to the task] I've looked at it before, so it would be under 'Most Recently Viewed'"). Likely due to their experiences during Task 1, all participants expressed an immediate understanding of the list's composition: "it's just a list of the last eight attractions and activities" (**DP4**, **DP13**, **DP25**).

The second input technique involved searching for an attraction by name, with the first two participants again being directly led to the *Search by name* option by the task wording, while the remaining three each gave their choice greater thought – in the process referring back to the task description – with all making the correct selection. Notably, four of the participants initially arrived back at the *Attractions & Activities* search menu via the *Return to Attractions & Activities Menu* shortcut (only one being prompted to do so), with the fifth using the device's 'back' key. This indicated that most participants were becoming more inclined to look for and utilise shortcuts to access the functionality they required (**ugL**, **DP7**). On the *Name Search* page participants were faced with a choice between text and voice input, with two misinterpreting the category dropdown list (E=2) as an additional search technique – "I can search by text or by voice or I can look in *My Categories*" – notably none explored this feature. In response to this, Recommendation 15 suggests the addition of 'on page' instructional text clarifying the category field's purpose as a filter for the search, as well as its default to 'All Categories' to avoid confusion over the results should users not understand the constraint. Returning to the search itself, three participants chose to conduct this 'by text' and two 'by voice', all doing so with ease – not least the result of having performed similar searches during Task 1 (**DP4**, **DP13**, **DP25**).

A third 'set' of input techniques involved hierarchical list-based selection, the first version of which comprised a relatively straightforward series of text-based lists. Upon returning to the *Attractions & Activities* search menu (four out of five using a shortcut to do so), each participant immediately selected the *Browse by category* option and then the category 'Historic Sites' – all largely being led here by the task wording. With each participant quickly realising that the attraction of interest was not on the first page of the category, all navigated directly to the second page using the 'Next 8' link, then finding what they sought. The only issue experienced during this process was one participant's interpretation of the listing within the selected category – "I guess it's given me a list of the top historic sites" – which, despite being wrong (E=1) did not prevent her from successfully completing the task. Of note, a further comment was made at this time by a different participant, supporting the provision of category browsing as an input technique: "so that you don't have 300 attractions that you have to scroll through".

The second in this set of techniques was identical to the first, except that the textual list items were accompanied by photographic thumbnails. Here participants used a combination of shortcuts and 'back' key navigation to return to the *Browse Categories* page, before selecting the required category – 'Museums' (note, the first participant did not evaluate this technique). Immediately noticing the alternative presentation of attractions/activities ("oh cool, so there's [*sic*] pictures too"; "So that's a different display to all of the others"), each participant then readily identified the attraction of interest (one leaning in closer to do so). When asked their opinion of the image-based search, two participants saw benefits in this: "you can tell if you wanna [*sic*] go there by looking at it"; "I think it's easier to find [than text only] 'cos [*sic*] I saw the motor car … whereas before you had to read each line". At the same time, a number of disadvantages were identified by all: "it takes up a bit more room"; "If you're having to scroll through … a lot of pictures it'd … get [difficult]"; "I'm not sure all the pictures are very helpful in that instance, assuming you could go to more detail and get a picture once you were there". Notably, two clear preferences were expressed for having text-only lists rather than incorporating images (P=2): "just [the] text list. Get more onto it, get there quicker". Responding to each of these findings, Recommendation 16 advocates further exploration and evaluation of the image-based input (**ugD**).

The third variation on hierarchical list-based selection involved finding an attraction within a category which was not on the user's initial, personalised list – a task which had previously created difficulties for PDE participants. Again, a combination of shortcuts and 'back' key navigation was used to return to the *Browse Categories* page, upon which each participant was observed to look through the list seeking the required category, 'Walks & Views'. When it was not found, each participant instinctively selected the link to *See more categories*, before navigating to the second page of the *More Categories* list and selecting the category (and then the attraction) of interest. Upon being questioned about the composition of the initial category list, three of the participants conveyed an immediate understanding (**ugK**) – "I'd assume it was *My Categories*" – while the other two made incorrect assumptions as to why the required category was not there (E=2) – "because it's not in the top things that people search on?" and "'cos [*sic*] there's not enough room?" (note, all participants had read a description of *My Categories* on the *My Profile* information sheet at the beginning of their session). The observed errors were not attributed to problems with the feature's usability, however, since: (a) it was expected that had they created the *My Categories* list themselves (as would be the case with a fully functional system) these participants would have recognised the initial category list more readily; and (b) their misinterpretations did not prevent them from completing the task. These findings confirmed that the revisions made to this design component had successfully improved its usability, while additional comments from the participants confirmed its overall usefulness (P=5): "otherwise this list would get way too long"; "that's quite good"; "otherwise you get a whole lot of stuff that you're not really interested in"; "that would save me time" (**ugN**).

Task 3b required participants to explore the final set of input techniques, concerned with searching for attractions/activities *Around an address*. Here there were four options for specifying an address upon which to base their search: *My Current Location (GPS)*, *My Addresses*, *Most recently viewed* and *New address* (note, *Most recently viewed* was not evaluated since the other options provided sufficient coverage of the input representations for this part of the evaluation). Upon being presented with the *Specify Address* menu, most participants either expressed an immediate understanding of the purpose of this component ("you've got a certain address and you're looking at things around that area") or else did not comment. One participant, however, communicated her obvious confusion: "*Around an address*. I'm not quite sure from … how that's worded, as to what that is. The assumption is that it's 'what's around this location?' … I guess I was looking for features around the Fremantle address". From this it appeared that she did not understand that the menu was asking her to input a specific address, with the facilitator compelled to explain the functionality to her so that she could continue the task (H=1). Since none of the other participants experienced issues with this feature, no changes were recommended (the task wording was suspected of contributing to her confusion).

Despite being given free choice over the order in which they evaluated each address entry option, all of the participants approached these in the order that they were listed. Therefore *My Current Location (GPS)* was the first technique to be tested. Upon selecting this option, participants were immediately presented with search criteria enabling them to specify the category(/ies) and distance (from the address) within which to search. At this point two participants demonstrated a lack of understanding over what they were seeing – "I'm not sure. Why would you have *My*

Categories? … I think I was expecting it to give me a map of where I was and the address of where I was". However, while one required explanation of the functionality from the facilitator (H=1), the other eventually managed to determine this without assistance. Furthermore, these two participants also struggled to initiate the attractions/activity search, one exiting the feature in an attempt to do so (E=1, H=1). Upon consideration of these findings, a potential source of the confusion was reasoned to be the appearance of the *Search Criteria* before the (current location) address was determined. Had these occurred in the opposite order, perhaps the *Search Criteria* page would not have been so unexpected (**DP1**, **DP26**). Recommendation 17 addresses this while advocating greater support within the *Search Criteria* page (**ugM**, **DP10**).

Upon initiating the search, the address of the device's current location was calculated and the results of the search presented. This comprised a text-based listing of all attractions matching the search criteria (ordered by straight-line distance from the address – closest to furthest), each of which was linked to the appropriate attraction/activity page. With all five participants conveying an understanding of this output (**ugK**) – "it's telling me where I am in bold, and then there's a number of options … and it tells you how far away they are from the current location and you can select on those and probably see more information" – only one issue was uncovered, whereby a single participant did not recognise 'Paddy Troy Mall' as her current address ("so it's come up with, I guess, the main thing that's around me"). No revisions were deemed necessary in response to this, however, with the data expected to have been the cause of her confusion (i.e. had the address been '3 Market St', for example, she may have recognised its nature more readily). In general, all participants found this to be a useful technique for finding attractions/activities: "that's good. If you're in a location and you're not sure what to look at next or what's around you, that will tell you. It will also tell you how far it is".

The second of the *Around an address* input techniques to be evaluated was *My Addresses*. Having earlier experience with such 'favourites' lists, all participants readily understood the composition of this ("that's what I've saved in there") – **DP4**, **DP13**, **DP25**. Upon selecting the required address, identical selection criteria to the previous search was presented – the same participant who had earlier not recognised her current address again feeling confused: "when I see that *Around an address* I'm thinking it's gonna [*sic*] give me an address'. In an effort to alleviate this issue, and at the same time provide feedback regarding the user's previous selection (**DP5**, **DP28**), Recommendation 17 was updated to add the specified address to the *Search Criteria* page. Whereas the current address search had resulted in text-based output, here the results were in diagrammatic form, which seemed to surprise most participants ("oh!"). After some thought, each participant expressed their opinions of the representation, ranging from complete acceptance ("Like a map. That's really cool") to dismissal in favour of the text-based output ("it's a bit hard to see" … I think the text was easier to read" – **ugJ**). Other comments concerned the lack of geographic context provided by the diagram (e.g. coastlines and physical obstacles), with direction and distance seemingly not providing enough geospatial information for their requirements ("it's good for direction, but it doesn't give you any indication of how to get there") – **ugE**. Furthermore, it was not immediately obvious to participants that the diagram was centred on the specified address ("I've got a circle with, I'm assuming, me in the centre"; "it's giving me, assuming Paddy Troy Mall, Fremantle is in the middle, … the other attractions and activities"). While each participant was able to use the diagram to select the attraction of interest, the value of this representation form for its purpose appeared doubtful. Recommendation for its removal from the design was reserved, however, until the participants' experiences with the final output form were analysed.

When asked to specify a *New address*, the participants encountered no problems typing the street name into the required field using the numbered keypad, initiating the search and then selecting the matching address, having experienced similar input techniques during earlier tasks. Similarly, each readily understood the alert providing an option to save the new address within *My Profile* ("is it going to ask me to save, automatically, if it's something I haven't saved before?"). When then presented with a schematic map showing the location of various attractions/activities around the address, three of the five participants expressed an appreciation for the greater geospatial context it provided (**ugE**), compared with the diagrammatic output ("same as the previous one except I know … where the streets are, which is helpful"; "It shows you where the streets and locations are, compared to each other"). All, however, noted that they could not tell by looking at the map what each of the attraction/activity symbols represented ("I'm not sure about these stars. It probably should be obvious. I guess they're attractions and activities"; "you know that an attraction is nearby but you have no clue as to what it is"; "I guess you have to click on them"). Whilst the selection of an attraction/activity symbol within the map assisted in its identification, this was not considered an ideal technique ("that does make it hard, you're gonna [*sic*] have to click on each of the stars to find out what it is"). Furthermore, the interim 'identification' page that appeared upon selecting a symbol was found to be of little use by at least three participants ("so we've got a [picture] first … and then the information. I like the [attraction/activity page] display better … the detail with the [picture]? … that's already there"). In terms of the actual map design, this was also found to be problematic in certain respects: (1) the approximate scale was difficult to see and therefore caused confusion ("there isn't a scale on this though … it says 'show scale'") – **CP5**; (2) the symbol representing the specified location was not labelled ("if that's the address …?") – **CP10**; and (3) the map's sketched appearance was not appreciated by all ("don't like the map … don't like hand-drawn … comical writing and I'd like to keep a consistent look to the maps throughout"; "bit hard to read the street names … I prefer the [conventional map style]").

While each of the address entry techniques was seen to have a place in the service ("I can see [all] being used"), the participants were split in their preferences regarding the three output forms used to convey the attractions/activities located around the address. While two preferred the use of a map (P=2), two others preferred the text-based list (P=2) and the final participant wondered if these two representations could somehow be integrated (**ugD**). Notably, all were in agreement that the diagrammatic output was not useful. Based on these findings, a number of potential solutions were identified (embodied by Recommendation 18), involving the removal of the diagrammatic output and the combination of the text and map outputs, with the latter designed using the conventional map style.

Outputs

As part of **Task 3a**, participants were also asked to comment on the outputs contained within the various attraction/activity pages. Here, each person appeared satisfied with the information content and structure, particularly appreciating its consistent appearance for the different attractions/activities (**ugO**, **DP4**, **DP25**):

> *"I think that's a good breakdown … tells you where it is, pictures of what it is, what's there, what's it cost, when it's open and who to talk to to get more information … very good layout";*
>
> *"good high-level information. I could make a decision on whether I wanted to go there";*
>
> *"I didn't know it would have that much detail … yeah, that's good";*
>
> *"all the information's the same. I do like that"; and*
>
> *"that's what I'd expect to see, because now I'm used to it".*

Looking to specific output forms, the newly implemented ability to view more/less detail within the text-based description was looked upon favourably by at least four participants, while two specifically expounded their appreciation for the reference information presented below – "I can see very good information there about the facilities – child friendly, I love that"; "I like that it's brief … just in point form". In addition, the changes made concerning the provision of attraction/activity images were well received, with four participants commenting that they liked the presence of a thumbnail image on the main page, with the ability to view "bigger-sized pictures" via a link ("I like that"; "shows you what you'll be seeing when you go there"). One participant particularly appreciated the position of the thumbnail and link below the textual description – “I think that’s really quite good because before, on the [location summary page], it was right down the bottom”. Two improvements to this feature were suggested by participants, however, with one seeking a larger thumbnail image that filled the screen width (presumably so that it could be more clearly viewed – **ugJ**), while another objected to the ‘Close’ link on the additional pictures page, remarking that “on a small device I don’t have the concept of multiple windows … so ‘Close’, as I clicked it I thought … I hope that doesn’t close the application”. Being minor and essentially non-geospatial issues, no recommendations were made on the basis of these comments.

Concentrating finally on the conventional map output, each participant found this useful for identifying where the attraction/activity was located (“that’s showing where it is, in relation to everything else”), with the animated nature of the attraction/activity being particularly appreciated (“absolutely excellent”) – **CP11**. Two participants proceeded to display their current location on the map (using the same technique as for the layout map), commenting that “it’s given me a red tag of where I am in relation to Fishing Boat Harbour” and “it’s good, ’cos [*sic*] then you know where you’ve got to go to get to the new location”. When asked about the map’s initial level of detail, while the participants were mostly were happy with what was presented (“I think that’s pretty good”), one commented that the displayed features did not match the information on the previous page – “it doesn’t tell me where all those [shops, cafes in the picture] were … can’t see where the markets are”. The ability for users to customise the display of map features, however, negated the need to recommend any design revisions based on this. Another participant also suggested that the map could display “maybe a dark line or something showing you the best way to get there” (i.e. a route), before noticing the shortcut below the map: *Find a route to or from here* (“that’d probably do that for you”). Notably, three of the five participants noticed the shortcut to Module 5 (either here or on the main attraction/activity page), believing it to be a particularly useful feature (**ugC**) – “that’s great. I’ve found the attraction, I like it, [the service] know[s] exactly where I am … bang and then up it comes. I reckon that’s great”; “that would be helpful”; “we could sort of plan: we can do 3 activities today because we can … drive to each of them”. Therefore the revisions made to ensure that this link was sufficiently obvious here were considered successful.

10.3.1.4 Task 4: Determine the accessibility of each pursuit

Offering a variety of output representation forms for comparison, Task 4 required users to compare the whereabouts of the attractions and activities on their saved list. Due to the limited time available for each session, most participants were directly led to the correct starting point –

My Attractions/Activities ("a list of the things that I've saved") – from which they then had to determine how to proceed with **Task 4a**. With one participant initially wondering how to compare the attractions' whereabouts "without opening them all up", all quickly identified and selected the option *Compare My Attractions/Activities*. They then each correctly interpreted the resulting page – "it's given me a list of all the attractions I've got in my favourites and the option to select them or not select them" – before proceeding to the *Compare Attractions/Activities* menu with all of the attractions/activities selected.

Given a choice of multiple comparisons (but with only two being functional), most participants opted for the first menu item which was to compare *Relative locations* between the selected attractions/activities. Notably, one participant commented here that she would have expected the menu to comprise "checkboxes … so [you] could … compare more than one or two items at the same time", prompting Recommendation 19 to suggest providing an ability to combine multiple geospatial (and other) comparison options[5] (**DP1**, **ugD**). Upon being presented with the initial, text-based output (comprising the address of each attraction/activity), each of the participants expressed disinterest and/or confusion at this – "it's pretty much giving me their addresses … but it doesn't help me compare"; "this doesn't actually mean a lot to me because I don't know where The Terrace is"; "I'd wanna [*sic*] see some distances from … the address or location that I'm at". Moreover, when asked about the text output's usefulness, three of the participants definitively responded that they did not see a need for it, being able to obtain this information by visiting the associated attraction/activity page. From this it appeared that the textual output added little to the location comparison, with Recommendation 20 thus advocating its removal.

After exploring the page of addresses, each participant moved onto **Task 4b**, opening the page containing a 'chart' of relative distances. While two participants found some benefit in this representation ("that's pretty handy", "yeah, that's quite useful"), a third felt that it added nothing to the comparison ("nah, it doesn't help me") and a fourth sought additional information (I like these charts *on maps* in general … 'cos [*sic*] then I can see how far it is from A to B"). The remaining participant, however, did not understand the chart at all – "so now it's got a map … this makes *no* sense to me … I guess that's distance?" – even after accessing the online help (H=1) – "that's not clear at all". Recommendation 20 addresses this by suggesting that the chart representation should be retained, but only as a secondary output – available to users as required (**ugD**, **ugE**). In terms of the need to rotate the device when viewing the chart, the participants

[5] This essentially reinstated the second half of Design Recommendation 27 from the PDE, which was not addressed during the design revision.

were clearly split, with two finding this disconcerting ("it threw me … the navigation and all is still in portrait mode", "eek! I've gotta [*sic*] turn that side on … not ideal"), while the others had no problems ("that's fine"; "It doesn't bother me"; "that's good, 'cos [*sic*] you can see the information more clearly … rather than having it … in smaller font, or having to scroll down."). No changes were recommended in relation to this, particularly since the chart did not require any manipulation. Continuing Task 4b, participants were directed to explore the conventional map output, which each readily understood ("it shows you where all the attractions are"). While all five participants were able to determine the identity of each attraction/activity on the map by matching their "colour-coordinated [symbols]" with the quasi-legend, there were some misgivings about the need to scroll up and down the page to do so ("it's good but the scrolling up and down probably isn't great") – **DP22**. Furthermore, greater detail was sought within the map by three participants, who requested for it to "at least show a couple of roads" – **DP1**, **CP1**. While any recommendations regarding the quasi-legend were reserved until after the second comparison had been analysed, Recommendation 20 was updated to include more initial detail on the map (keeping in mind that users had the ability to add additional map features at will).

To complete the *Relative locations* comparison, participants were asked to undertake **Task 4c**, requiring them to compare only the attractions/activities located on the mainland. Notably each participant did this from the map page, all having generally dismissed the textual output by this stage. After looking around the page, four of the five participants focused their attention on the quasi-legend, sequentially (and correctly) 'unchecking' the checkboxes next to the two attractions/activities located on Rottnest Island (**DP1**). The fifth participant, however, required help with this task (H=1), having initially tried selecting the map itself. With an alternative technique tested as part of the second comparison, recommendations concerning this UI feature continued to be reserved. Once the two attractions/activities were excluded, all participants became aware of a change in the map scale – "it's taken 1 and 7 away and that's zoomed in more to that area because it doesn't have to show those other places anymore"; "so now it's just giving me a map of the … mainland" – and, with only one exception, each person appreciated the automated behaviour – "I like it"; "everything's a little bit more easier [*sic*] to see where it is"; "I guess the map shows relative to what you've selected … makes sense". The final participant, who had struggled with this sub-task initially, commented "I wouldn't have really thought about doing that … I would've preferred just to use the zoom … to zoom in" (**ugD**). Again, no recommendations were made at this time.

With time again a limiting factor, the participants were led by the facilitator to the alternative comparison option, *Proximity to an address*, upon which each proceeded to easily specify an address for the comparison (having done this before during Task 3b). When presented with the first output form, incorporating text and animated graphics, four of the five participants expressed their approval of the representation – "it shows you how far you've got to walk and it shows you some are probably too far away to go and have a look at"; "that's quite good with the graphic … get a picture straight away of what's closest and what's further away" – while the remaining participant did not find it particularly useful – "it's much the same as before, whether it's got the bar line or not" (**ugD**). Notably, none of the participants initially noticed the animation of the 'bar' graphics and, once having their attention drawn to this, expressed a general feeling that it was largely unnecessary ("maybe it's a bit gimmicky, considering it's such a small screen"; "you've already been told the distance [by the text] and there's no reason why they couldn't just come up as solid blue lines straight away"). Therefore, although the dynamism was considered visually pleasing ("it's a bit more dramatic, more interesting to look at"), Recommendation 21 advocates its removal.

From here, each participant proceeded to view the schematic map output, and while three participants objected to this map 'style' ("I really have a thing against comical maps"; "I don't like the handwritten as much"), all found the representation form to be of reasonably high usefulness, equating it to the conventional map in the previous comparison. With respect to specific feedback, of the two participants who chose to map just the attractions/activities on the mainland, both appreciated the inclusion of major and minor roads at the larger scale ("I can … see that … I could drive from 3 to 5, whereas … 6 to 5 I can't go straight across there"), however they also saw a need for more information ("there's no street names … you will probably need some main street names on there to be able to navigate"; "oh, I don't have the option to zoom in") – **DP1**. To address these comments (and in the interests of consistency – **DP4**, **DP13**, **DP25**) Recommendation 21 suggests that the schematic map representation be redesigned in the conventional map style, with some road labelling also added – **CP1**. When questioned over the relative usefulness of the text/graphics and schematic map representations, three participants expressed a preference for the map output (P=3), but also saw benefit in having access to the alternative. Conversely, the remaining two participants preferred the text/graphics output (P=2), while acknowledging that "[a] map's always useful as well". Responding to this, Recommendation 21 advocates displaying the map output initially, while providing an obvious link to the text/graphics output.

Upon viewing the final, diagrammatic output, each participant immediately expressed an aversion to this representation technique: "I don't like it. I don't like bullseyes"; "I don't really enjoy that";

"okay … I don't like these. The target's the least helpful for me". Their general justification for this surrounded the fact that there was little contextual information within the diagram, compared to the map ("it's good that you can see where they are in relation to each other, but you can't really see anything else"; "it's not showing me the coastline or that's on Rottnest Island or that there's water in between"; "There's not really any advantage to having [this] … if you're gonna [*sic*] have a picture like that you might as well have a map"). Again, participants were asked to compare only the attractions/activities located on the mainland, with a different technique employed here than that used previously. After minimal searching, each participant managed to find and select the link to *Hide or show attractions/activities*, after which they successfully 'unchecked' the required attractions (one participant noting: "now I have to remember it"). When asked to compare the two techniques for hiding/displaying attractions, although one participant preferred this second, 'new page' method ("it actually didn't jump around [like the other method]" – i.e. the map refresh), all others preferred the first technique – involving the quasi-legend below the map – which they felt was faster and easier ("it's saving you time and navigation"; "that's too many steps for not much"; "that's a bit too much clicking – I prefer when it's all on the same page"). Based on these findings, Recommendation 21 suggests the removal of the diagrammatic representation technique from the design. Furthermore, addressing these and several earlier results, it also recommends retaining the quasi-legend below the map (for both comparisons), including its use for hiding and displaying attractions/activities, as well as a number of further investigations relating to this.[6]

10.3.1.5 Task 5: Find out local level detail about the location (weather)

Before being asked to check the weather forecast as part of **Task 5a**, the four participants who completed this task[7] were first directed to return to the location summary page, most finding the appropriate shortcut without assistance. Each participant then scrolled straight to the *Location Options*, selected *Climate & Weather* without hesitation (each having likely seen this during an earlier task) and then, after briefly scanning the resulting page, chose the correct sub-option, *Weather & Forecast*, all appearing satisfied with what was presented: "that's everything you expect to see"; "it's just like it is on the news"; "it's good having an outlook there" (**DP1**).

With most participants reading aloud the various page contents, including the current rainfall text, each was then directed to view the *Rainfall Radar*. Upon being asked to describe what they were seeing, only one participant immediately understood that the representation conveyed

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[6] While it was initially intended to gather opinions on the two different comparison types (i.e. *Relative locations* and *Proximity to an address*), time constraints during the evaluation sessions prevented answers being obtained from each participant. The resulting lack of systematic data collection thus prevented its coverage here.

[7] Recalling that participant 4 did not complete tasks 5 or 6 due to time constraints – see Section 10.2.3.

recent rainfall observations – admittedly having seen similar maps before. The others, however, initially believed the information to be a model of future rainfall (E=3) – "it's showing you where it's going to rain"; "is that where the rain's moving or where it's currently raining?"; "it's got the cloudy bits where it's gonna [*sic*] rain". Whilst incorrect, this interpretation *was* reasonable considering that the time period shown on the animation did not match the current time displayed on the page (an issue related to the use of simulated data). Therefore no changes were suggested with respect to this. Continuing on, three of the four participants failed to see the rainfall legend at first (with this initially situated off the screen, below the map), prompting Recommendation 22 to advise its relocation. Indeed, without seeing the legend, the participants had difficulty interpreting the map – "well the more cloud there is, the more rain I suppose" – but after being directed to it, had no such issues – "that shows me that it's light rain" – demonstrating the importance of having a legend (**DP5**). While all participants expressed some level of enthusiasm for the radar and its animated status ("That would be very useful"; "when it's moving it's easier to see, and it's showing you the timeframe"; "I quite like that it's moving"), one participant – who consistently leaned closer to the screen to read the map – noted that "it's good but it doesn't tell you what light [rain] is and what heavy [rain] is", seemingly seeking access to some quantitative scale of rainfall to correspond with the legend. With all of this in mind, Recommendation 22 was extended to require the expansion of the 'help' content accompanying the map (**ugM**, **DP10**). Of particular note, no issues were observed with the map design itself, indicating that the revisions made here were successful.

Finally, when asked to compare the different rainfall representations (i.e. text vs. animated map), two participants expressed an interest in having access to each ("I like both, definitely, but [the text] first"), while one preferred the text only ("I like just the text. I wouldn't bother to look at the map"). The remaining participant did not comment. With this and the PDE findings in mind, the radar was retained as a secondary option, available to users interested in viewing it (**ugD**).[8]

10.3.1.6 Task 6: Determine what's in the immediate area

Concerned with evaluating those UI components comprising Module 1, Task 6 required participants to employ the system to determine their current whereabouts. To initiate this process (and thus satisfy **Task 6a**), participants had to return to the Main Menu and select the *What's Around Me* button. At this point some problems were encountered, with two participants looking for a way to approach the task within the *Location Info* pages (E=2) and one taking the correct path (having accidentally visited Module 1 before) while admitting "no it doesn't [make sense] …

8 **Task 5b** was included simply to provide context for the weather warning alert in Task 6. As such there were no specific UI components for participants to evaluate, and thus no data to analyse here.

I don't know if it needs to be labelled something different". Whilst the participants' lack of experience with the system may have explained their obvious confusion, it appeared evident that the Main Menu buttons still did not adequately support the user goal 'Obtain overview of location(s)'. In response to this, Recommendation 1 – which already addressed the issue with respect to searching for general information about a location – was updated to additionally target the task of determining what is in the user's immediate area (**ugA**, **DP1**).

Moving on, after eventually selecting the *What's Around Me* button, each participant read aloud the prompt regarding their current location determination, before selecting 'Yes' (i.e. to use GPS) without comment. Looking at the resulting menu and seeming satisfied that "it tells me where I am", each participant then began **Task 6b** by selecting one of the output links situated next to the option *The immediate area* (note, the three options were generally accessed in the order that they appeared). Looking first to the conventional map output, upon seeing this representation, all participants immediately expressed their understanding and approval over its presence, particularly appreciating the initial level of detail shown:

> *"little red symbol is where I am …just showing a few streets around where that is";*
>
> *"it shows me exactly where I am … which is good. It's got all the names of the streets and locations around me";*
>
> *"that gives me a visual straight away and I know exactly where I am";*
>
> *"good old familiar map. Yep, I'm happy with that"; and*
>
> *"I think that scale's quite good it's not too crowded, it's easy to [interpret]".*

With each participant then instructed that certain map features could be 'clicked', all proceeded to scroll to and select the panorama point symbol, one person musing "this is gonna [*sic*] give me a photograph of there" (note, this provided evidence that the icon's design was sufficiently self-describing – **CP10**). Upon seeing the panorama, all participants rotated the device accordingly and conveyed an understanding of what they were seeing ("I can turn around and look up the street and it should look like that to me"), validly explaining how they might use such a representation: "It's showing me a picture looking north-west of the road that I could well be on. So if I can see that then I know exactly where I am"; "you could look at this and you could, sort of, look around you and try and work out which way is best to be heading". One participant, however, was confused upon selecting one of the icons for viewing the next perspective, seemingly having expected this to act like the 'map pan' tool (which used an identical symbol) – i.e. she believed it would display a new photograph of a position further along the street (E=1): "it's given me another view now … hasn't moved up … the same shot form the other way? … I would've thought it'd go further". Although she admittedly did not have a clear understanding of cardinal directions, this finding suggested that the operation of the panorama could be improved and/or made more obvious (e.g. through online help), with Recommendation 23 included to address this (**DP1**, **DP10**, **DP14**, **CP11**, **CP16**).

The panorama's annotated directions and street name labelling appeared to add value to the representation – "I get an idea of which direction is what, so now … if I was standing south-east I'd be looking at that"; "if there's no street signs around here and now you know … 'I'm standing here' and that's what the name is, and then you go back to the map and you know exactly where you are … gives you a direction as well, that's good". Not all participants were entirely happy with the representation, however, with two objecting to the need to rotate the device ("I would prefer not to actually"), while one believed that it would only be useful if the user was standing exactly where the photo was taken and thus considered it "a bit gimmicky". With respect to the latter, since the other three participants felt that the panorama could be "very helpful" and were able to express specific examples of this, it was retained within the design models. Furthermore, the comments made by two participants that the landscape format "gives you a clearer picture" and "[is] better than looking at it the other way – you wouldn't be able to see as much detail", prompted that attribute of the representation to also be preserved (of course, contingent on the final implementation technique). The fact that two participants were observed to lean closer to view the various images, however, led Recommendation 23 to additionally advocate revisions aimed at improving the visibility of the panorama's detail (**ugJ**).

Upon returning to the map, participants were directed to select one of the landmark symbols, which resulted in a page containing: "a picture of what's there on that map" and "what it's called … which street it's on". Whereas previously equivalent output had been considered unnecessary (i.e. the interim identification page that appeared when selecting map symbols while searching for an attraction/activity *Around an address* – Section 10.3.1.3), it clearly held more value for the current task, particularly as a means of self-localisation:

> *"I know I was down here before so the Town Hall's just down the road a bit, so if I end up walking down there and I see that, I know where I am again";*
>
> *if you were lost then you'd just look up and [see it] … it's a landmark so that makes it very obvious … if you were stuck … you could follow [it]"; and*
>
> *"I guess if you could see it, where you were, you might be able to work out where you are in relation to it".*

The ability to access a 'zoomed in' map centred on the landmark was also considered useful for the most part ("you can see where it is in relation to the Mall, and it's showing you more things around that area"), although one participant was somewhat confused by the result after selecting the *Map this location* link which, admittedly, was not part of the original task: "it's put the words in [*i.e. the landmark label*]… but it's taken away where I'm currently standing … it threw me, 'cos [*sic*] it wasn't what I was doing". Once having the functionality explained the participant was more accepting of this, but expressed a valid desire to be able to re-centre the map on his current location (**DP1**, **DP14**). Recommendation 24 was included to address this.

The next output technique for communicating *The immediate area* comprised a text-based representation which was described by participants thus: "it gives me a description of the streets, where they are, and then the landmarks and distances"; "it's sort of emphasising what's around you. This is just a text equivalent of a map". In particular, three participants expressed an appreciation for the ability here to select landmark names and then map and/or find out more information about these (equivalent to the aforementioned 'map click' functionality) – "you can select each of the landmarks for more information"; "If you want to know where something is and how to get there, that's quite good – shows you straight away where it is"; "the text is very, very helpful in this regard" (**DP1**, **DP14**). When asked their opinion about the text output, while two participants doubted its usefulness compared with the map ("it's good to give you a general picture but … a picture speaks a thousand words … a map's a lot easier to navigate from"), all expressed a preference for both (P=4): "I think that's good information. Maybe it could be under … 'more detail' … as an option"; "I like having both … I'd probably use the [map] first but then, the landmarks I would use more [in the text]"; some people can't read maps, so that would be useful for them" (**ugD**, **ugE**). Based on these findings, Recommendation 25 advises retaining the text (in its current form) as a secondary output, which is accessible from the map display.

The final output for the UI component was a schematic map, which excluded the manipulation marginalia and legend included with the conventional map, but incorporated the same 'clickable' landmark symbols – the display of which, in addition to the 'target-like' scale, could be turned on and off. In general, the immediate reaction of each participant to this representation was one of familiarity – "that's just another kind of a map"; "The only difference I'd say is that it doesn't have the names of the attractions on there". When questioned about the difference in the map styles, there were again differing opinions, with one participant tending towards the schematic map (P=1: "I like this layout a bit better … I don't know [why], I just like the look of it better"), while two definitively preferred the conventional map style (P=2: "It's easiest to use"; "the colours break it up a bit – make it easier to see/distinguish between each of the different types … I think the [conventional map] would be easier to navigate with"). In response to this, and for consistency with the other maps in the system, it was again recommended to discard the schematic map style, in favour of the design and functionality of the conventional map output (Recommendation 25). That said, based on these and other results/observations from the previous tasks, an opportunity was seen for offering users a choice of map styles to suit their individual tastes (**ugD**). This resulted in Recommendation 26, which suggests allowing users to select between multiple map appearances (where technically feasible), which would then be applied throughout the system.

Before moving on to the next part of Task 6b, one final recommendation was made relating to the evaluation of an additional representation technique for this task. Prompted by a participant's earlier comment (during Task 2) that image maps "might be good for some things … National Parks, things like that", it was anticipated that having access to imagery containing natural landscape features may be more useful in certain situations than a purely graphical map (**ugE**) – for example, if a user becomes disoriented in a rural area that has few identifying features (e.g. road names, buildings, etc.). As a result Recommendation 27 was formulated to suggest trialling image maps for this task.

The second set of outputs for *What's Around Me* presented a smaller scale of information, under the label *A nearby town or city*. With participants again generally accessing these in the order that they appeared on the page, most began by selecting the 'map' link. When presented with a conventional map "showing all the surrounding towns", each participant seemed satisfied that it provided the information they required – "it shows you where you are in comparison to everything else". Notably two participants instinctively selected the map, then scrolled to and selected 'Fremantle', upon which the location summary page from Module 2 appeared – this behaviour suggesting that consistency between similar representations was indeed beneficial in helping users to anticipate functionality within the UI (**DP4**, **DP13**, **DP25**). When asked about the map's level of detail, one participant commented that "I'd probably zoom in a bit", while another also sought more information at the initial map scale: "maybe a few more place names". Meanwhile a third participant noted that "you can't navigate … from it, but you can certainly see where you are". In general, however, the map served its purpose, offering value-added information to the user: "[If you're flying into Perth] you need to know how to get from Perth to Fremantle … [and] you might suddenly have more time to look around, so you can go down to Rockingham". With users able to hide and display map features at will, the only change suggested here was to increase the number of towns/cities displayed on the map, and within the alternative representations (**CP1**, **CP2**) – see Recommendation 28.

The next output was text-based, with all participants appreciating the level of detail provided, in particular the numeric and diagrammatic distances (**DP1**): "you know how far you have to go to travel and the blue bars are good because it does give you an idea of the scale between each of them"; "it gives you more of an idea of what's close and what's far away"; "visually you can see right away, without having to read … Fremantle's, that close". And when questioned as to its usefulness compared with the map, two of the participants expressed a preference for having access to both (P=2) – "I think you need the map just to get an idea of where things are", however "[with the] map you couldn't really measure how far away you were, but … [the text] shows you the distances … so that's quite handy" – while another emphatically stated (P=1): "I still like the map [only]". Based on this, a similar recommendation to that concerning *The immediate area* was made here, advising the retention of the text (in its current form) as a secondary output, which is accessible from the map display (**ugD**, **ugE**) – see Recommendation 28. Furthermore, an additional feature was also suggested, comprising the application of adaptation to these and similar outputs within the system (e.g. the *Proximity to an address* attraction/activity comparison), whereby the initial representation (i.e. map or text) automatically changes according to recent and/or frequent user behaviours. Based on previous recommendations, this had the potential to reduce the amount of navigation required by users to access the information of interest (**DP1**, **DP23**).

Looking then to the diagrammatic output, this representation was immediately dismissed by all participants, prompting Recommendation 28 to remove it completely from the design:

> *"doesn't really help me – that type of map – 'cos [*sic*] it doesn't show anything … doesn't serve any purpose … [the conventional map] makes a lot more sense";*
>
> *"personally … it doesn't really help me, 'cos [*sic*] there's no landmarks … there's sort of distances, but you have to spend a bit of time looking … I think the blue bars [are] a much better representation";*
>
> *"I don't like it as much as the map … it doesn't really tell me anything, except I guess distance. And it doesn't tell me where I am … I can't immediately see how far away things are. So it's a little bit pointless … for me"; and*
>
> *"I still prefer the traditional [map]".*

A final representation form evaluated by three of the participants concerned the automated weather warning alert which appeared 'randomly' during their completion of Task 6. Not surprisingly, none of the participants had expected this, with two wondering about its cause ("does that just pop up?"), upon which they were reminded of the relevant configuration within *My Profile*. Overall, each participant liked the automated alerting feature (P=3) – "it's telling me wherever you are you're gonna [*sic*] get weather warnings … automatically it's going to tell me what's going on in the area … I think that's good"; "it's like a news update" – however a need was identified to maintain user control over this ("if I'm out in the elements, I wanna [*sic*] know if there's something going to happen, but if I'm in a hotel room I wouldn't care so much"), including a greater level of configuration ("I wouldn't wanna [*sic*] know it's about to rain – maybe you could select what's important [to you]") – **DP1**, **DP14**. In response to this, Recommendation 29 suggests the addition of a finer (optional) level of configuration for weather warning and other automated alerts.[9]

10.3.1.7 Final comments

As with the PDE, three final questions were asked at the conclusion of each evaluation session, serving to broaden the results by gathering participants' subjective opinions relating to the prototype and thus the design as a whole. Beginning with their **overall impressions** of the Holiday Helper service, all five participants were quite enthusiastic – "it's a great concept"; "it's very handy, definitely"; "I think it could be really useful" – placing particular emphasis on the potential convenience and wealth of information offered:

> *"that's something that would be very useful on your mobile, 'cos [*sic*] then you don't have to look it up on the Internet or go to an information centre after hours. It's instant, 24 hours on your phone";*
>
> *"I like the idea of … the ability to search it all. Just a standard GPS just doesn't give you that. It doesn't give you all of the information"; and*
>
> *it's all in one place too … you don't have to go and look in the information centre for pamphlets … [plus] it does everything in comparison to your location, which is very useful … quite good in that it's focused on your location or where you want to go".*

When then asked whether they would **find a fully functional version of the service useful in the future**, the participants were again overwhelmingly positive: "yes, yeah I would"; "I would use it"; "if I could take it with me, yeah, that would be great (rather than a heavy guidebook)". A number of important clarifications were made at this time, however, including one participant's assertion that her use of the service would be intermittent throughout a given holiday ("I'd opt in and out"). Once highlighted, this situation – expected to be common to most users – held important implications for the automated alerting functionality in particular, which could not operate when a user was logged out of the system. Recommendation 29 was amended to address this issue by advocating the use of SMS and/or MMS technology for sending automated alerts to users. Furthermore, a second notable comment came from a different participant who stated "A

[9] While it was initially intended to gather opinions on the two different scales of information provided (i.e. *The immediate area* and *A nearby town or city*), time constraints during the evaluation sessions prevented answers being obtained from each participant. The resulting lack of systematic data collection thus prevented its coverage here.

lot would depend on the cost I think … I imagine it would be very expensive to use … just having the Internet on your phone … I can't imagine it being very cheap" Recalling that similar concerns were also apparent in both the user profiling (Section 5.4.4) and PDE data (Section 8.3.2.6), cost was considered a major deciding factor in the use/non-use of this – and indeed other – mLBS applications. With the design models focused on geospatial information, however, the research could only acknowledge this as an issue for future research.

The final question asked participants if there was any **additional functionality or features** they would like to see included within the system. Here a number of 'already planned' features were highlighted (providing support for the conceptual models/model components not yet incorporated into the design), including:

- *Facilities & Services* (Module 2) – "the closest shopping centre … somewhere that is open", "pubs … places to go out and socialise", "restaurant reviews … bookings";
- *Accommodation* (Module 3) – "accommodation … [would] probably be quite key"; and
- *Routes To, From & Around* (Module 5) – "routes", "I'd like to see travel times …that would really help".

In terms of entirely new ideas, a number of these came from a single participant who suggested, among other things: (1) "some sort of quick video tour" for a given location, as part of the information provided ("just the major highlights and certain things about it"); and (2) the provision of information regarding "altitude[s] … [so I] could see which street's gonna [*sic*] take me up the highest" (i.e. for a bird's eye view of the location). As described, the first item pertained largely to non-geospatial information and so was outside the research scope. It did, however, serve to recall the notion of 'virtual tours' for locations and other features (e.g. buildings), which 34% of the target user group expressed interest in during the user profiling (Section 5.4.4). Based on this it was proposed that such outputs should be trialled in future versions of the design (see Recommendation 30). Looking finally to the second participant-based suggestion, the provision of altitude information was considered a valuable adjunct to the design, with Recommendation 30 therefore advocating its inclusion for optional display within the various system maps.

✧ ✧ ✧ ✧

This completed the analysis and interpretation of the evaluation results, which yielded a vast amount of qualitative information concerning the usefulness of the cartographic UI design models. With the procedures followed for this evaluation being largely equivalent to those employed during the PDE, identical steps were taken here in terms of minimising the effects of sampling problems, participant motivation and demand characteristics and experimenter bias, while endeavouring to maximise the accuracy and rigour of the evaluation procedure and the interpretation of the results. For this reason a separate discussion of the evaluation's overall effectiveness was not deemed necessary here (refer instead to the discussion in Section 8.5). Therefore this chapter concludes by presenting the outcomes from the evaluation process, namely a set of recommendations for further improving the design, while Chapter 10 provides a comprehensive discussion of these and all other results generated throughout the research.

10.4 Design Recommendations

The design recommendations presented below comprise specific courses of action intended to contribute towards improving the usefulness of the cartographic UI design models, in particular their component geospatial information representation, presentation and interaction techniques. While further formal design iterations are beyond the scope of the research, each recommendation *will* be considered when making final revisions to the design models – presented in Chapter 10 – and thus will contribute to the overall results of the study. Once again, with the recommendations being but one interpretation of the evaluation findings, it must be remembered that other valid options for revising the design are entirely possible.

General

1. To ensure greater support for the tasks of accessing general information about a location and determining what's in the user's immediate area, consider each of the following:
    - Rethink the button labelling on the Main Menu (including the icons used) to ensure that each appropriately represents the underlying functionality.
    - Provide more prominent access to Module 2 from within Module 1.

Task 1

2. Add a new option at the top of the Location Info search menu comprising the town/city that is closest to the user's current location – e.g. My current location (Fremantle). Note, this option would only be offered when automated positioning of the device was available.
3. Move the 'state' field to the top of the *Place Name Search* page, replacing the online help with 'on page' instructions regarding its purpose/use.
4. Replace the use of crosshairs for map-based selection with sequential highlighting of map features (e.g. states, regions, towns) when the joystick is moved. Provide 'on page' instructions (potentially replacing the online help) regarding the operation of the map-based selection. If possible, automatically select the map upon loading the page.
5. Implement and evaluate the following enhancements to the Location Info search menu:
    - Adaptively reorder the menu items according to the user's most frequent selections.

- Combine multiple search options into a single technique – for example map-based input and voice recognition.

6. For the textual description on the location summary page:
   - set the initial state to 'truncated', with the user able to change this configuration within *My Profile*. Additionally, implement and trial automatic adaptation of the display state to match the user's recent selections; and
   - integrate the content from the text-based location Layout page.
7. Provide users with an option to configure the font size used for all text-based output (e.g. within *My Profile*).
8. Make the following changes to the voice output for the location summary page and other relevant parts of the system:
   - Voice output is to be accessible only on-demand (i.e. remove the ability to configure automated voice output from *My Profile*).
   - Evaluate voice recognition for the selection of menu items within various parts of the system – e.g. *Location Options*, *Main Menu*, *Location Info* search menu.
9. Retain a single version of the location summary page containing:
   - the link to view images of/from the location on a separate page, positioned below the textual description (i.e. removing it from the *Location Options*); and
   - the location map (with dynamism removed) incorporating a link which, when selected, opens the layout map page.

Task 2

10. Implement and evaluate the following behaviours for the layout map:
    - when a map symbol is selected, offer additional information along with the ability to zoom in on the feature (i.e. identical to the map symbol functionality within *The immediate area* – Module 1);
    - when another area of the map is selected, re-centre the map on this point (a form of pan); and
    - when the crosshairs are scrolled 'beyond' the viewable map boundary, pan the map in the appropriate direction.
11. Evaluate alternative icon designs for the *Key to Map Features* and *Map Feature Display* links.
12. Disregard the anticipated My Profile option for configuring contextual vs. static legends, instead always providing a contextual legend.
13. Determine appropriate thresholds for the number of point, line and area symbols that can be displayed at each map scale in order to maintain map clarity. Implement these limits within the Map Feature Display functionality.

14. Remove the image map representation from the location *Layout* component.

Task 3

15. Move the 'categories' field to the top of the attractions/activities *Name Search* page, adding 'on page' instructions regarding its purpose/use. Set the default value to 'All Categories'.
16. Reduce the size of the thumbnails within the image-based input when browsing for attractions/activities using hierarchical list selection so that each item appears on one line only. Evaluate the usability and acceptance of this (including image visibility) against the text-only list. Consider the potential for adaptable or adaptive techniques with respect to the inclusion/exclusion of images.
17. When searching for attractions/activities *Around an address*:
    - when specifying the address using *My current location (GPS)*, conduct the A-GPS positioning and reverse geocoding prior to presenting the search criteria; and
    - add the selected address to the top of the *Search Criteria* page and provide greater 'on page' support regarding the purpose of the 'categories' and 'distance' fields.
18. Remove the diagrammatic output for the display and selection of attractions/activities around an address. Combine the text and map outputs onto the same page, incorporating the following design revisions:
    - redesign the map using the conventional map style (not including the legend and manipulation marginalia);
    - incorporate the (unchanged) text output below the map;
    - use numbered map symbols to represent the attractions/activities (similar to those employed for Task 4), also incorporating these into the text results as a form of legend;
    - incorporate the symbol representing the specified address into the written address at the top of the page (again as a form of legend); and
    - link each attraction/activity symbol directly to the appropriate attraction/activity page, thus discarding the interim 'identification' pages.

Task 4

19. Trial an alternative method for comparing attractions/activities which enables multiple geospatial (and other) comparisons to be combined.
20. Remove the text-based output for comparing the *Relative locations* of attractions/activities and retain the chart representation as a secondary output, accessible from the map page. Include major roads, freeways, railway lines and ferry routes on the initial map display and link each attraction/activity symbol to the attraction/activity (information) page.

21. Remove the diagrammatic output from the *Proximity to an address* comparison and employ the map as the initial display, from which the text/graphics output is easily accessed. Make the following changes to the remaining representations:

- remove the animation from the text/graphics output;
- redesign the map output using the conventional map style (including all marginalia and functionality), adding road labels where applicable;
- implement and trial automatic adaptation concerning which of the outputs is displayed first, basing this on the user's recent and/or most frequent selections; and
- discard the 'new page' technique for hiding and displaying attractions/activities, retaining the associated functionality within the quasi-legend (for both comparisons) and investigating options to reduce both distraction caused by the map refresh and the amount of scrolling required for comparing the map with the legend.

Task 5

22. Relocate the legend for the animated map communicating the *Latest Rainfall Observations* so that it lies above the map. Additionally increase the online help content to incorporate instructions on how to read the radar, as well as a quantitative rainfall scale that corresponds with the legend. Consider moving some of the help content onto the radar page itself.

Task 6

23. Where technically feasible, incorporate dynamism and interactivity into any panoramas, thus providing a simple form of Virtual Reality. Where not, alter the icons used for scrolling between images so that these are distinct from the map pan icons. Regardless of the technique employed:

- provide information supporting the operation of the panorama, with the most important aspects included on the page with the representation; and
- improve the visibility of the panorama's details by brightening the component images and/or providing the ability to zoom in.

24. Add an option to all maps within Module 1 for instantly re-centring the map on the user's current location (with or without a new position request).

25. For communicating *The immediate area* surrounding the user, employ the conventional map as the initial display, from which the (unchanged) text output can be easily accessed. Discard the schematic map output.

26. Investigate the technical feasibility of offering the conventional, schematic and other map <u>styles</u> as options for users to apply throughout the system, with the same level of functionality maintained for each (i.e. zoom, pan, hide/display features). Where this is possible, allow it to be configured within *My Profile*.

27. Implement and evaluate an image map representation for communicating *The immediate area* (equivalent to that trialled for the location *Layout* component). Trial this in non-urban settings.

28. For communicating *A nearby town or city*, increase the number of towns/cities returned by the results (i.e. by changing the threshold governing what is included in this category), and employ the conventional map as the initial display, from which the (unchanged) text-based output is easily accessed. Additionally implement and trial automatic adaptation concerning which of the outputs is displayed first, basing this on the user's recent and/or most frequent selections. Discard the diagrammatic output for this task.

29. Provide two levels of configuration within *My Profile* for automated alerts (e.g. weather warnings), enabling not only the specification of their overall presence/absence, but also the configuration of particular sub-categories for alerting (e.g. cyclone warnings vs. rain). Send all alerts via SMS and/or MMS, enabling responses (e.g. cancelling the alert) to be sent using the same method.

Future Features

30. Implement and evaluate the following additional functionality and representation forms:

- provide virtual tours of locations and appropriate attractions for Modules 2 and 4, respectively, employing representations such as 3D maps and video (among others); and
- allow users to display altitude on all system maps, e.g. using contours, spot heights and/or other symbology.

10.5 Chapter Summary

This chapter has described the process by which the revised and expanded cartographic UI design models were evaluated. The box below summarises the major steps and outcomes involved, leading to the successful achievement of the defined aims. Specifically, the collection of both qualitative information and quantitative measures served to identify a number of usability problems relating to various aspects of the design – evaluation aim (a) – including particular representation, presentation and interaction techniques. While many of these comprised new issues that were introduced by the recent design additions, a small number were considered to be pre-existing, the redesign having failed to rectify their negative impacts (note, the evaluation results also highlighted areas within the UI where usability had been improved). In addition to this, the relative usefulness of the various alternative representation, presentation and interaction techniques was also determined – evaluation aim (b) – based on both the usability-related findings as well as (qualitative and quantitative) user preference data relating largely to the utility of each technique. This led to the removal, or recommendation for redesign, of a number of representation forms not deemed appropriate for certain tasks. In the next chapter, a final iteration of the cartographic UI design models is presented (incorporating the recommendations made above), along with a discussion of their implications to the research and the design of mLBS applications overall.

- The aims for the evaluation were established to be:
  - **(a)** identify usability problems within the cartographic UI (both pre-existing and new) along with their causes; and
  - **(b)** trial and compare the usefulness of alternative representation, presentation and interaction techniques employed for particular tasks.
- Informal empirical usability testing was again selected to collect the evaluation data, comprising a combination of assessment testing and formative evaluation, along with a degree of comparison testing for contrasting alternative cartographic representations.
- The evaluation took place in a specialist usability laboratory, with five participants and one pilot test subject selected from the target user population through a process of purposeful random sampling. During each evaluation session, an individual user completed realistic tasks using the prototype system, while 'thinking aloud' about their experiences and answering questions posed by the facilitator.
- The observational and verbal data resulting from the evaluation sessions provided qualitative information and quantitative measures, each of which were qualitatively analysed and interpreted.
- The end result comprised a set of 30 new recommendations aimed at improving the usefulness of the cartographic UI design models.

11 Research Results and Analysis

11.1 Introduction

The previous chapter documented the second and final evaluation of the cartographic UI design models, thereby signalling the completion of the UCD methodology adopted by the research. From this a final (high-level) revision of the design models was undertaken, incorporating only those representation, presentation and interaction techniques considered to offer maximum usefulness in their communication of geospatial information to users. Embodying the culmination of the research, this chapter therefore begins by presenting and describing the final cartographic UI design models for a DHR travel mLBS application (Section 11.2.1), including the relative utility and usability attributed to each of the UI components, as well as instances where alternative representation techniques were deemed unsuitable. Accompanying this, a detailed analysis is provided (Section 11.2.3), discussing the models' strengths, limitations and application beyond the research, as well as their satisfaction of the research aims. Following on, the effectiveness of the UCD methodology is discussed, in terms of the value offered by each of the major phases and their component methods and techniques (Section 11.3), with several potential improvements proposed. Comprising the final component of the chapter (Section 11.4), the research concludes with a number of more general recommendations for design that are intended to assist researchers and developers concerned with communicating geospatial information through mLBS applications.

11.2 Cartographic UI Design Models

Satisfying the main aim of the research, the primary purpose of this chapter is to present and discuss the set of cartographic UI models developed for communicating geospatial information to non-expert users in a useful manner through mLBS. These models – described below – are largely the result of a comprehensive UCD methodology which enabled the early specification of users' needs and use contexts, followed by an iterative cycle of design and evaluation involving real users in order to test, assess and improve the models' usefulness (i.e. utility and usability). Any interpretation of the design models must be mindful of a number of qualifications, however, established prior to and/or during their development. These are summarised as follows:

- **Application-specific concepts** – to control the scope of the research and enable effective UCD, an early decision was made to focus the design model development on a specific application area and group of users. In this way, the design models are considered most useful as a starting point for those working in the field of DHR travel mLBS applications, while offering insight for more general, mostly industry, application.

- **The components of useful communication** – in the context of the design models, this refers to the utility and usability with which the cartographic UI and its component representation/presentation forms and interaction techniques are able to convey required geospatial information to users. Where utility is concerned with whether the UI or given representation addresses the user's goals and information needs, usability relates to how effectively and efficiently the user can employ the UI/representation to achieve their goals, as well as their satisfaction with its use. Refer to Section 2.5.1 for more information.
- **A focus on non-expert users and uses** – the design models are solely focused on communicating geospatial information to 'novice' users who generally lack detailed knowledge, training and experience in its representation and use (i.e. as opposed to geospatial scientists and professionals). Furthermore, the tasks supported by the models relate to 'everyday'-type geospatial information needs, rather than expert geospatial uses. Both of these factors were supported by the selection of the DHR travel application area and an associated non-expert user group. Refer to Sections 2.5.2 and 5.2 for more information.
- **Relevant technologies** – with their focus on communicating geospatial information through mLBS, the design models were developed around the associated enabling technologies (as described in Section 2.3.1): positioning; handheld devices; wireless networks; the mobile Internet; geospatial and application platforms. In terms of the models' evaluation and extent, however, these were limited by the specific technological platform selected for the prototype development, which centred on a single handheld device and mobile Internet browser/data protocol (see Section 7.3.4), while simulating and/or assuming the remaining technological components (i.e. A-GPS positioning, 3G wireless network, appropriate geospatial and application processing).
- **Conceptual design status** – being a research project and not a commercial product, the UCD methodology did not endeavour to develop a fully functional system, instead finishing early in the development cycle after an intensive process of conceptual design, which served to satisfy the defined aims and objectives by way of providing a proof of concept for improving usefulness within the DHR travel application. It is for this reason that the design models demonstrate the presence of, without incorporating detail for, certain 'out of scope' UI components.

11.2.1 Presentation of models

This section presents the final cartographic UI design models for the research. Governed by an overall cartographic UI structure, the design models are the culmination of a comprehensive UCD methodology, being based on extensive user profiling and user task analysis data and having had their usefulness validated through a process of iterative design and evaluation.

11.2.1.1 Cartographic UI structure

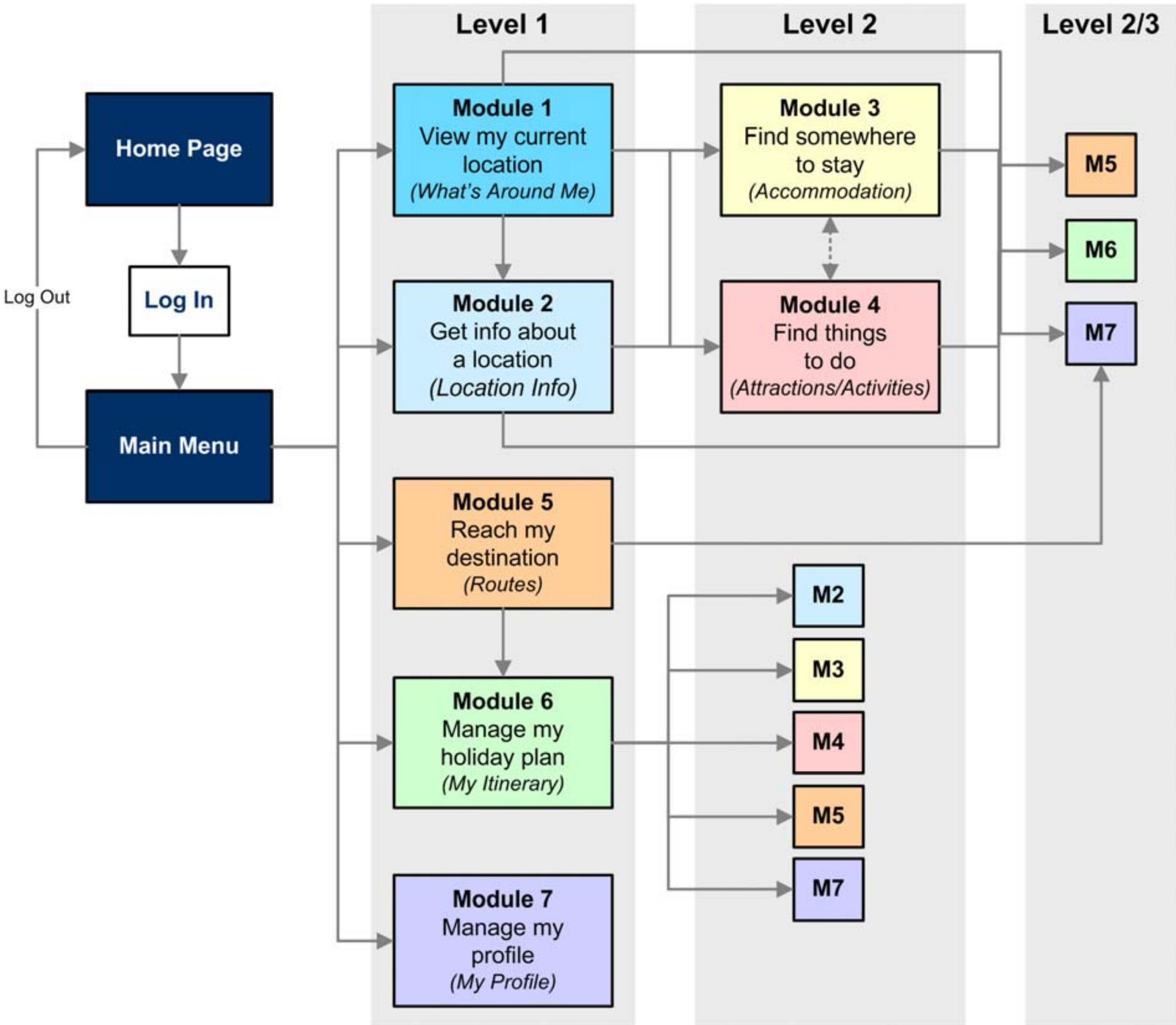

Figure 11.1 The final cartographic UI structure.

Formalising a complete conceptual model of the target user group's goals, tasks and geospatial information requirements, the cartographic UI structure presented in Figure 11.1 describes the relationships between seven major Modules underlying the design models. This was formulated from the user profiling and user task analysis findings and validated through two iterations of evaluation. The purpose and function of each Module – only some of which are covered by the detailed design models[1] – is described below:

- **Module 1: View my current location** – (Figure 11.16) based on the high-level user task 'determine what's in the immediate area' and contributing to the goal 'obtain overview of location', Module 1 provides information about the user's immediate geospatial situation, such as their current location and orientation relative to objects (e.g. places, landmarks) in the surrounding environment. Links directly to each of the other Modules.
- **Module 2: Get info about a location** – (Figure 11.2, Figure 11.5 and Figure 11.7) based on the high-level user task 'find out local-level detail about the location' and contributing to the goal 'obtain overview of location', Module 2 allows users to search for and access various geospatial and non-geospatial information about known/unknown locations (e.g. physical attributes, facilities and services, etc.). Links directly to Modules 3, 4, 5, 6 and 7.
- **Module 3: Find somewhere to stay** – (*not in detailed models*) based on the user goal 'find suitable accommodation', Module 3 allows users to search for, access and compare geospatial and non-geospatial information about various accommodation in and around a location; note, the user's personal criteria may be used to filter the search. Links directly to Modules 5, 6 and 7, and indirectly to Module 4.
- **Module 4: Find things to do** – (Figure 11.9, Figure 11.13 and Figure 11.14) based on the user goal 'find things to do / of interest', Module 4 allows users to search for, access and compare geospatial and non-geospatial information about various attractions, events and activities in and around a location; note, the user's personal criteria may be used to filter the search. Links directly to Modules 5, 6 and 7, and indirectly to Module 4.
- **Module 5: Reach my destination** – (*not in detailed models*) based on the user goal 'determine route', Module 5 provides the ability to plan different routes to or from a location and compare these according to personal criteria and other geospatial/non-geospatial information (e.g. length estimates, route qualities, transportation modes, costs, etc.). Links directly to Modules 6 and 7.
- **Module 6: Manage my holiday plan** – *(not in detailed models*) allows users to create, manage and follow itineraries based on information from Modules 2 to 5.

[1] In an effort to control the scope of the research and provide greater focus for the development of the design models, certain UI Modules were excluded from the detailed design and development efforts, for the following reasons:

- Module 3 – involves similar sequences of action and cartographic representation forms to Module 4 (having largely equivalent geospatial tasks and information requirements).
- Module 5 – a considerable body of research already exists relating to representation, presentation and interaction techniques for route selection and guidance using mobile devices (see Chapter 3).
- Modules 6 and 7 – not directly concerned with the physical representation/presentation of, or interaction with, geospatial information.

- **Module 7: Manage my profile** – (*not in detailed models*) allows users to configure personal preferences and requirements relating to various aspects of the UI (e.g. automated alerts), while storing and providing the ability to manage various 'favourites' lists created while accessing Modules 2 to 5.

With the overall structure now in hand, the remainder of this section describes the detailed design models, divided according to a number of high-level user tasks identified during the pre-design phases of the research. Primarily represented as a series of flow diagrams, each model is accompanied by a brief description identifying the UI components and representation forms that were/were not considered useful for each task, as well as specific features not able to be included within the figures. Cross-references to sample interface implementations (used for evaluation) are also incorporated to demonstrate functionality and interaction sequences. For the purposes of presenting definitive outcomes only, the models do not explicitly include any 'new' representations/components recommended by the research for future trial and evaluation. Many of these, however, are highlighted at the conclusion of each model description.

11.2.1.2 Task: find out local level detail about the location

For the purposes of presenting the design models, this task was divided into three sub-tasks: Location Overview, Location Layout and Location Weather, each of which is discussed below.

Sub-task: Location Overview

Depicted on the left-hand side of Figure 11.2, the first component of the Location Overview sub-task concerns searching for/specifying a location about which to find out geospatial (and other) information. To this end, the models offer six alternative options for input, each of which was seen to offer utility in differing contexts.

- **Places around me (*list-based selection*)** – automatically determines the user's current location (e.g. via A-GPS), using this to calculate and return a list of nearby locations (regions/towns/cities), ordered by proximity (closest to furthest away). Refer to Figure 9.3a and b (Chapter 9) for the interaction sequence. Provides utility:
  - when the user is currently at or nearby the (known) location of interest.

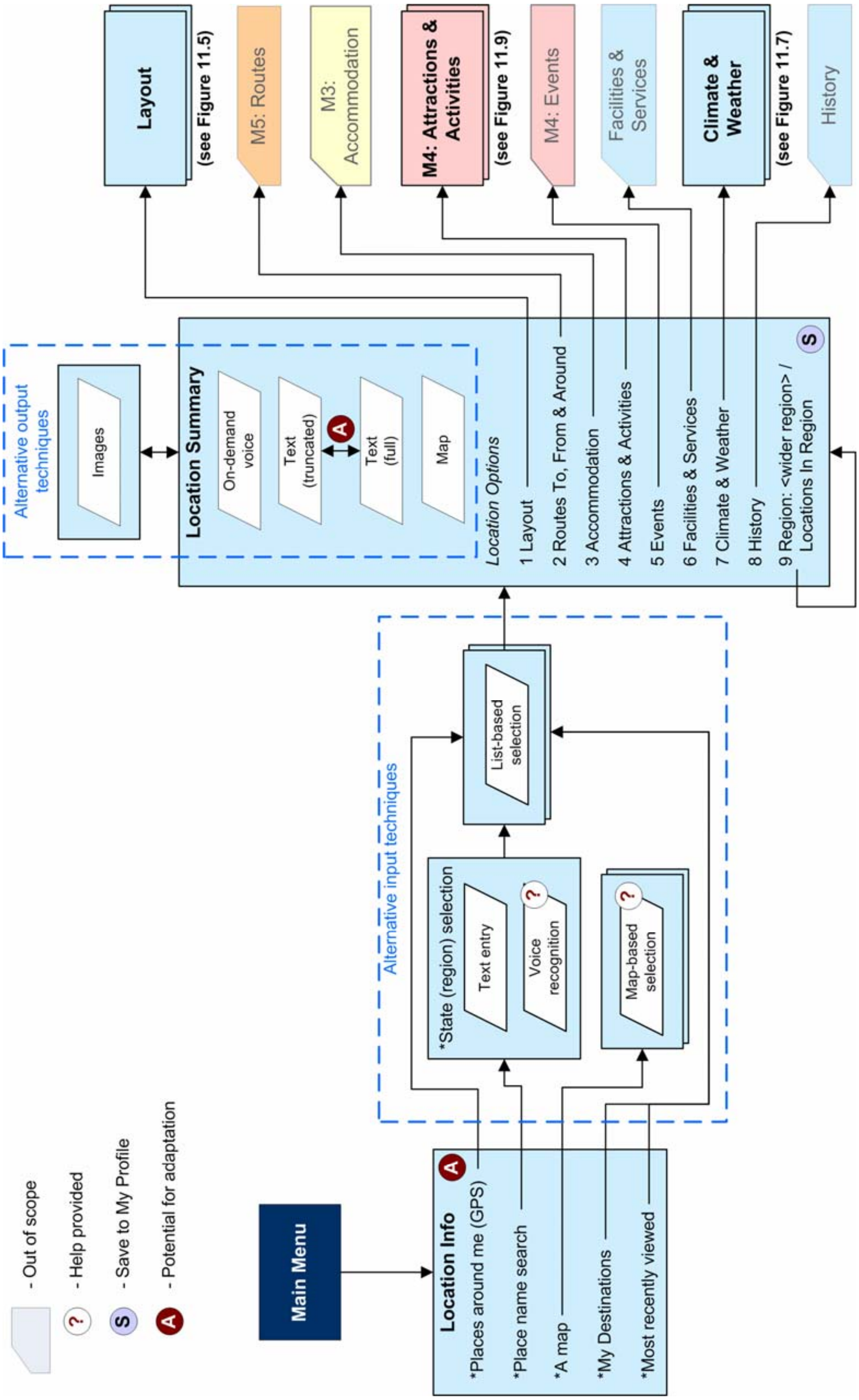

Figure 11.2 Components of the cartographic UI design models related to the sub-task 'Find out local level detail about the location – Location Overview' (including areas for which adaptation techniques are recommended).

- **Place name search (*text entry*, *list-based selection*)** – allows the user to type in the name (or part thereof) of a location using the device's keypad and select from a list of results matching the input; allows optional filtering for the search through the specification of a state[2]. Refer to Figure 11.3a and b. Provides utility:
  - when the location name (and spelling) is known, but not necessarily its whereabouts.
- **Place name search (*voice recognition*, *list-based selection*)** – allows the user to speak aloud the name of a location (into the device's microphone) and select from a list of matches generated by the voice recognition software; allows optional filtering for the search through the specification of a state[2]. Refer to Figure 11.3a and c. Provides utility:
  - when the location name (and pronunciation) is known, but not necessarily its whereabouts;
  - in quiet, private settings;
  - as an alternative to multiple keypad presses;
  - for users with vision problems; and/or
  - when the situation prevents the user's primary visual attention from being directed towards the UI (e.g. when driving).
- **A map (*map-based selection*)** – allows the user to specify a location using a series of ('clickable') hierarchical maps, involving: (1) selection of a state or capital city; (2) selection of a region (when a state was selected in (1)); and (3) selection of a town/city[3]. Refer to Figure 9.5 (Chapter 9) for the interaction sequence. Provides utility:
  - when the location's whereabouts are known;
  - when exploring a general area (as opposed to looking for a specific location); and/or
  - for users who prefer interacting with graphics (e.g. over text).
- **My Destinations (*list-based selection*)** – allows the user to select a location from their saved list (i.e. 'favourites'), which is stored and maintained within *My Profile*. Refer to Figure 7.9 (Chapter 7) to see an example of this functionality. Provides utility:
  - when the user has previously accessed and saved the location of interest (i.e. a 'shortcut').
- **Most Recently Viewed (*list-based selection*)** – allows the user to select a location from the eight they most recently accessed using the service. Refer to Figure 9.3c (Chapter 9) to see an example of this functionality. Provides utility:
  - when the user has previously (and recently) viewed information about the location of interest.

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2 Applicable to the Australian context – refers to the eight administrative states and territories making up the continent (equivalent to regions, territories, counties, etc. in other parts of the world).

3 Within the research prototype the map-based selections were performed using the device's joystick by scrolling the centre of a set of 'crosshairs' over the state/region/town/city of interest and then 'clicking'.

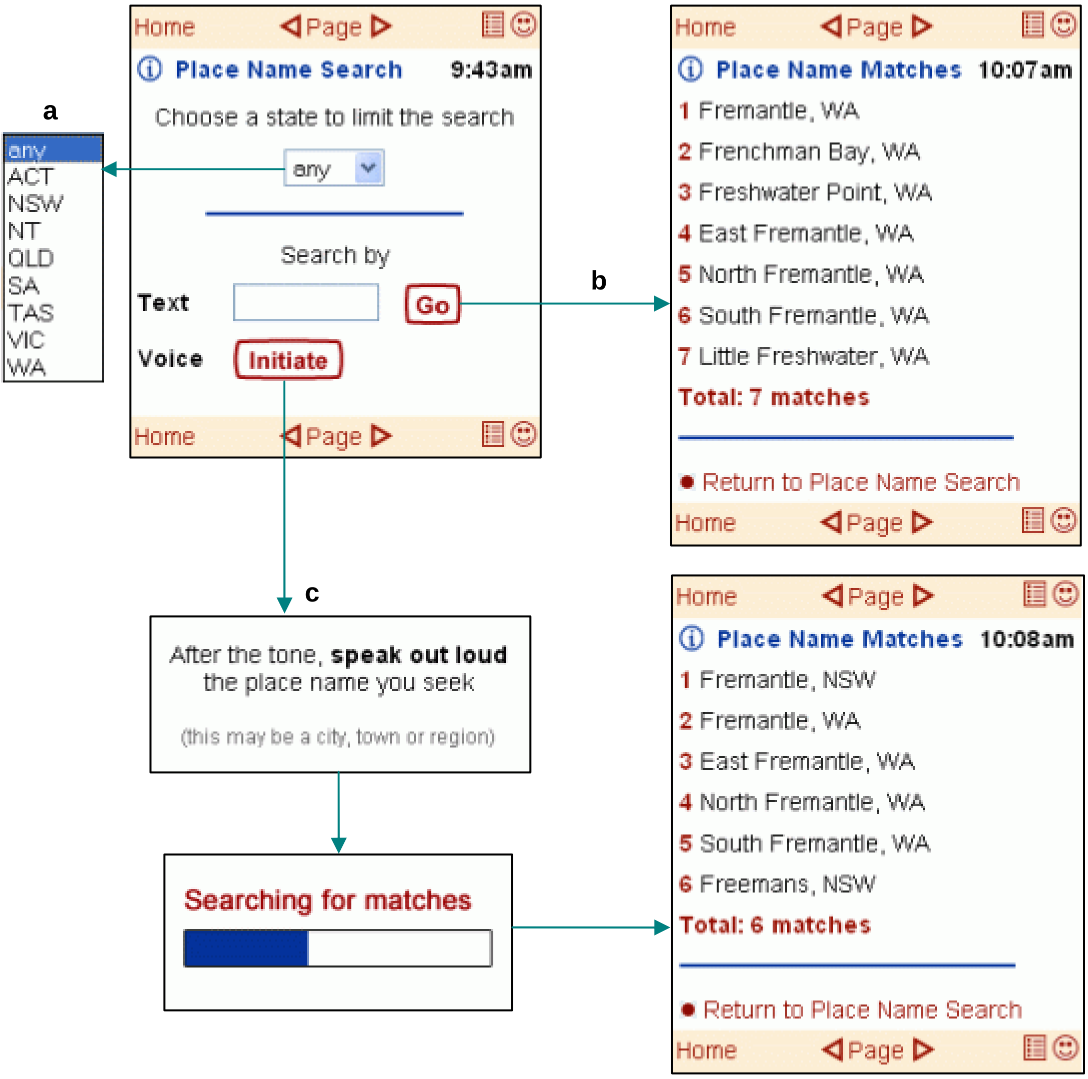

Figure 11.3 Searching for a location by place name, showing (a) the state-based filter, (b) input by text-entry and (c) input by voice recognition.

As indicated above, four different interaction techniques were incorporated within the input options, three of which proved highly usable while the other was considerably less so, for most users. Specifically, *text entry* caused no issues, with *voice recognition* encountering equivalent ease of use, although users were less trusting of the effectiveness of this technique (potentially leading to its avoidance). Similarly, the operation of the widely employed *list-based selection* proved immediately usable in all instances. In contrast, *map-based selection* demonstrated poor usability, being non-intuitive to initiate, while slow and cumbersome to use. This input option/interaction technique was retained within the design models, however, based on its anticipated utility (see above), coupled with the knowledge that the identified usability issues were largely tied to the technological limitations of the prototype platform (e.g. the need for substantial scrolling to select the location of interest) and thus could potentially be alleviated through changes to the development platform (subject to further evaluation). Notably, no trialled input options/interaction techniques were excluded for this sub-task as a result of the evaluation outcomes.

Looking then to the right-hand side of Figure 11.2, the second component of this sub-task concerns the output of overview geospatial (and other) information about a particular location. Here a number of alternative representation and presentation techniques were trialled for the 'location summary page', resulting in the following inclusions (and certain exclusions) for the final design models:

- **Truncated text description** – comprising the first three lines of a paragraph summarising the main features of the location; able to be expanded to the full text view; refer to Figure 9.6 (Chapter 9) for the interaction sequence.
    - Largely considered more useful as the initial display state than the **full text** view since it enables 'more important' page content to be initially visible (e.g. the *Location Options* – links to more detailed location information), while allowing the text to be easily expanded/contracted, as required.
- **On-demand voice output** – comprising a 'clickable' link at the top of the page, shown in Figure 11.4a, which plays – or stops, once playing – audible voice output communicating the content of the text description (full text display only) and the *Location Options* (including the keypad numbers that could be used to select these).
    - Considered useful (throughout the service) when the situation prevents the user's primary visual attention from being directed towards the UI and/or for sharing the information with travel companions. **Automation** of voice output was rejected, being variously considered unnecessary, annoying, ineffective and potentially socially intrusive in particular contexts (e.g. public places, noisy environments).
- **Link to images** – (in text form) situated below the text description; when selected opens a new page containing multiple tourism-style photographs of the location (e.g. aerial views, major landmarks, typical scenes); see Figure 11.4b.
    - Considered more useful than a **single image** on the location summary page itself (which provided mainly aesthetic benefits), while making space for the location map.
- **Location map** – conveying the location within its wider regional context (i.e. its position with respect to the largest town/city within the same region); incorporates minimal symbology and 'view-only' functionality; see Figure 11.4c.
    - Considered useful for providing immediate geospatial context for the location, with **animation** of the location label (e.g. 'blinking') found to be largely unnecessary due to this already residing at the highest visual level (e.g. larger, bold style font).

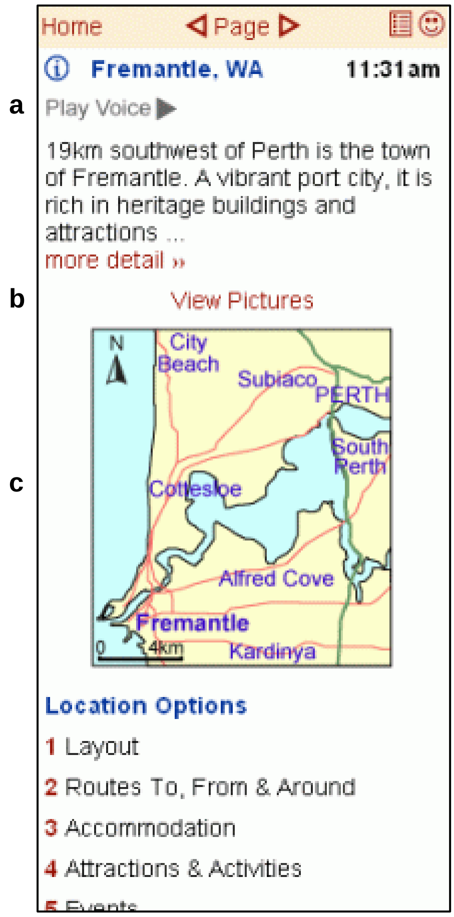

Figure 11.4 The location summary page incorporating (a) a link to play voice output, (b) a link to view images of the location and (c) the location map.

Finally, a number of new UI components and/or representation, presentation and interaction techniques were recommended for future investigation regarding their usefulness for this sub-task. These include:

Inputs

- A new option on the *Location Info* search menu which links directly to the location summary page for the town/city that is closest to the user's current position (e.g. *My current location: <town/city>*). Note, this would only be available where automated positioning of the user's device is enabled.
- A different interaction technique for map-based selection, replacing the need to physically scroll the centre of a set of crosshairs over the entity of interest before selecting (as implemented in the prototype). Ideally this would involve the sequential highlighting, and associated selection, of individual map features (i.e. states, regions, towns/cities) upon moving the device's joystick – e.g. scrolling left to right on the first map in Figure 9.5 (Chapter 9) would highlight WA, then NT, then QLD, and so on.
- Adaptive reordering of the *Location Info* search menu options according to the user's past selection behaviour – e.g. their most frequently used option is moved to the top of the list,

while the least frequently used is placed at the bottom. Refer to the A symbol in Figure 11.2 for the applicability of this to the design models.

- Combined and potentially multimodal *Location Info* search menu options – e.g. voice recognition (auditory) combined with map-based selection (visual, gestural), with the former used to input the location name while the latter enables (optional) simultaneous specification of the relevant state. As discussed by Hurtig (2006), such use of complimentary techniques has the potential to improve the usability with which users can input (and obtain access to) geospatial information by increasing the "intelligibility of dialogues and robustness of interaction" while providing flexibility over the choice of input technique (p.251). For these reasons this was considered to be an avenue worth exploring in the future.

Outputs

- Adaptively switching between the truncated and full text descriptions on the location summary page, according to the user's past and/or recent viewing behaviour – e.g. the most recently viewed state is maintained; if the user consistently chooses to view one more than the other (e.g. always opts to view the full text), this becomes the initial state; or, if the user has not previously viewed the location it defaults to the full text state, otherwise it is truncated). Refer to the A symbol in Figure 11.2 for the applicability of this to the design models.
- An option within *My Profile* for users to increase (or decrease) the font size for all text output within the system. This would potentially accommodate those users with visual problems that affect their reading of fine detail.
- Voice recognition for menu item selection, both here (e.g. for the *Location Info* search menu and *Location Options*) and elsewhere in the system (e.g. the *Main Menu*), so as to provide more options, as well as greater continuity and thus utility, for non-visual interaction with the system. In this way, for example, a user could operate the service with minimal use of their vision by employing their voice to (a) select the 'Location Info' Module from the *Main Menu*, (b) select *Place name search* from the *Location Info* search menu and (c) input the name of the location of interest, before (d) listening to voice output describing the location and then (e) using their voice to make a selection from the *Location Options*.
- 'Virtual tours' of a location making use of 3D, video and/or other representation techniques (e.g. a 3D fly-through around the main city centre).

Sub-task: Location Layout

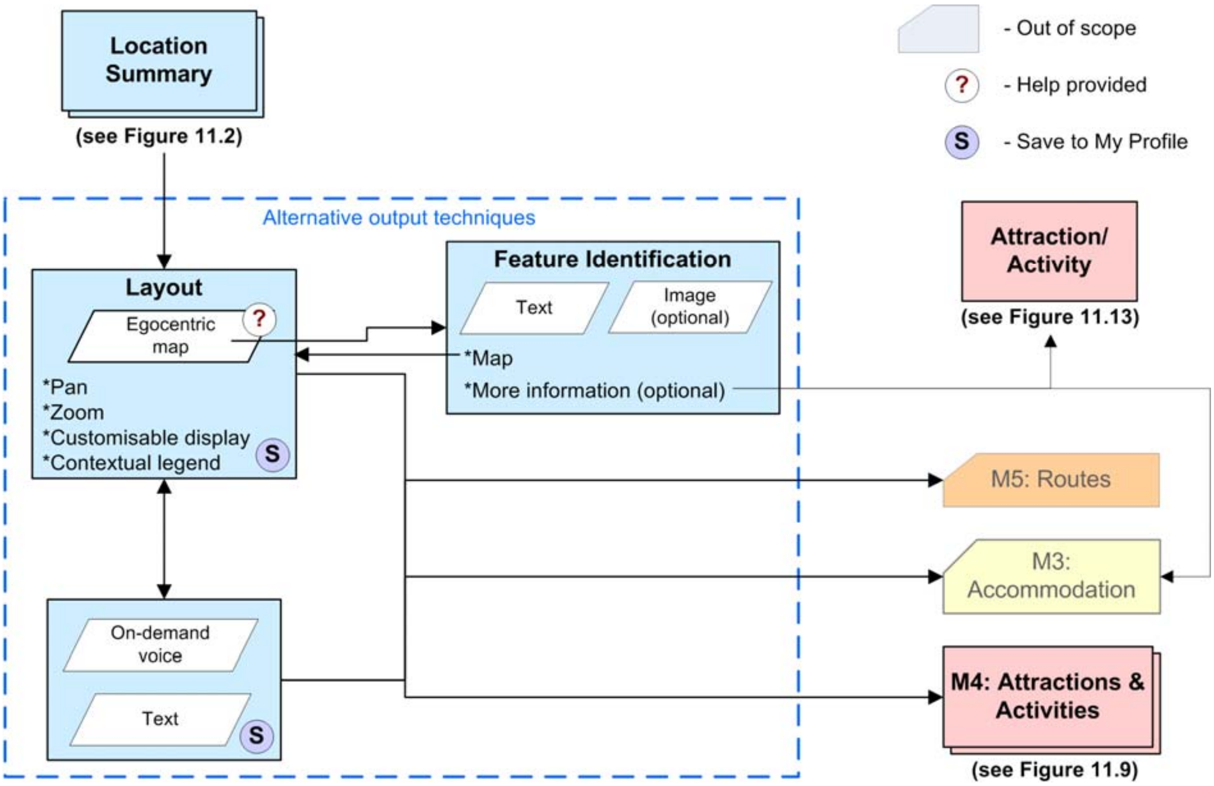

Figure 11.5 Components of the cartographic UI design models related to the sub-task 'Find out local level detail about the location – Location Layout'.

As shown in Figure 11.5, the Location Layout sub-task concerns the output of information conveying the geospatial arrangement of a particular location and its features. Here a number of alternative representation and presentation techniques were trialled, resulting in the following inclusions (and certain exclusions) for the final design models:

- **Egocentric map** – intended to depict geospatial information from the user's perspective (i.e. catering to their goals, interests, abilities, preferences, activities, etc.); conveys the location at four different scales (ranging from suburb to street level); able to be panned and zoomed in/out; provides functionality for displaying and hiding map features, including the user's current location and their saved attractions/activities; comprises the initial view upon accessing the *Layout* option and therefore functions as the primary representation and interaction device; see Figure 11.6.
  - Attributed high utility and (overall) usability by most users, particularly when compared with an **image map** (Figure 9.11, Chapter 9), which was found to be comparatively less usable and was thus rejected. Particular features of the interactive, egocentric maps employed throughout the design models include the following:
    → **Simple, intuitive design** – comprising a high degree of generalisation, low level of detail (with the initial feature display appropriate to the map purpose) and familiar

and/or self-describing map symbols (the latter having embedded identification information – see 'feature identification' below); based on general cartographic design principles (appropriately adapted to the mobile medium).

→ **Pan** – (Figure 11.6e) utilising two alternative interaction methods: (1) selection of individual 'pan' icons positioned around the map boundary (using the device's joystick in the prototype); or (2) selecting numbers on the device's keypad corresponding to the eight common cardinal directions; considered of high utility with users commonly seeking access to such functionality, but low usability (as implemented within the prototype) with the interaction techniques not always being immediately evident.

→ **Zoom** – (Figure 11.6c) enabling two alternative interaction methods (each employing the device's joystick in the prototype): (1) selection of individual scales for display; or (2) incrementally increasing/decreasing the scale by selecting the icons positioned at the extremities of the tool; considered of high utility and usability with most users possessing a strong need/desire to view the map at different scales, while finding the available interaction techniques sufficient for this.

→ **Customisable display** – (Figure 11.6d) enabling users to personalise the display of map features at individual scales (e.g. show bus stops at Scales 3 and 4 only; show tourist information at all scales; show public parking at Scale 2 only); selections are maintained by the system for subsequent use and are specific to the map purpose (e.g. *Layout* map settings are different from *The immediate area* map settings); allows the request and **animated** display (e.g. 'blinking') of the user's current location – seen to offer particularly high utility by drawing the user's attention to their position within the location.

→ **Contextual legend** – (Figure 11.6b) adaptive to the current display of map features; considered highly useful.

→ **Feature identification** – (Figure 11.6a) consisting of 'hidden' information that appears on selection of appropriate map symbols; offers text and (optional) image outputs and the ability to (1) access additional information (where available) and (2) map the feature at a large scale; considered of high utility, but only moderate usability (as implemented within the prototype) due to the information being presented on a new page after a map symbol is selected; greater usability is anticipated whereby the information appears as a 'tool tip' (i.e. displaying on the same page as the map) – note, the prototype platform did not support such functionality.

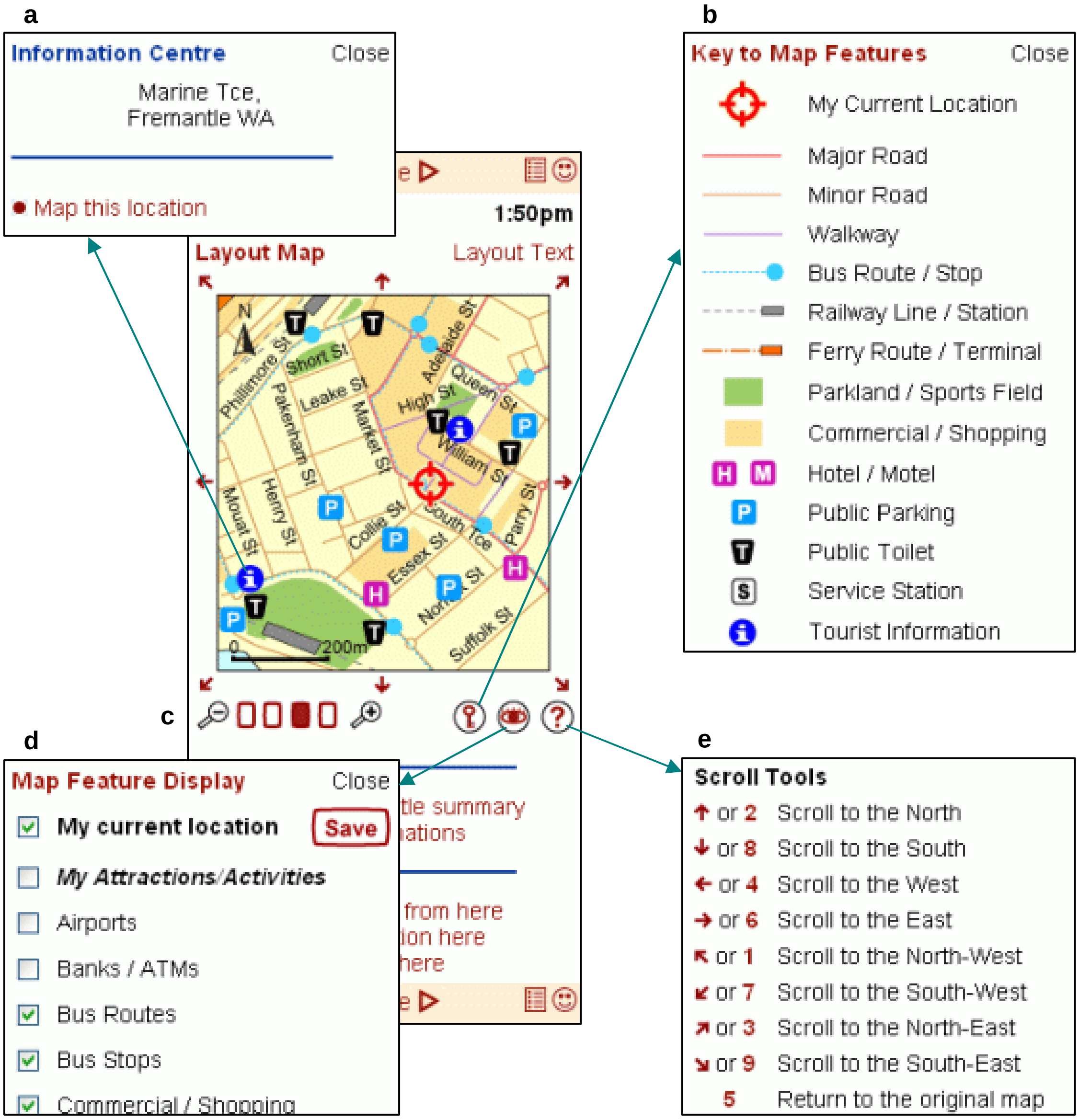

Figure 11.6 The egocentric map output for communicating a location's layout incorporating (a) feature identification, (b) contextual legend, (c) map zoom tools, (d) customisation of displayed features and (e) map pan tools.

- **Text-based output** – accessible from the map page; comprises a detailed geospatial description of the arrangement of the location (e.g. according to physical features and cardinal directions); incorporates major streets and landmarks, as well as tourist-style information; refer to Figure 9.9a (Chapter 9).
    - Considered moderately useful, along with the associated **on-demand voice output**, due to its provision of descriptive geospatial information not immediately apparent within the map – such as thematic zoning within the location (e.g. "To the south-west is the harbour-filled waterfront around which many historical sites are found as well as nightclubs, pubs, cafes and restaurants.").

Additional to this, a number of new UI components and/or representation, presentation and interaction techniques were recommended for future investigation regarding their usefulness for this sub-task, including:

- An ability for users to define and display the location of their own, custom map features (e.g. "my hotel", "my favourite Italian restaurant", etc.).
- An alternative interaction technique for map panning – e.g. by scrolling the device's joystick towards the edges of the map (ensuring that this does not conflict with other map behaviours).
- Re-centring of the map display on the point where the user has 'clicked' (not including clicking on map symbols for which additional information is available), as another alternative, yet more precise, method of map panning.
- Setting appropriate upper limits on the number of point, line and area symbols that can be displayed at each map scale using the *Map Feature Display* functionality, with the definition of these being application-specific and non-configurable within the final product. Note, the definition of such limits is not a simple matter and will likely comprise a detailed study in itself.

Sub-task: Location Weather

Described in Figure 11.7, the Location Weather sub-task concerns the output of information conveying the current (and forecasted) weather – in particular the rainfall distribution and current warnings – for a particular location. Again, a number of alternative representation and presentation techniques were trialled, resulting in the following inclusions for the final design models:

- **Text-based output** – conveying a brief description of the current rainfall situation, as well as current weather measurements and forecast conditions (e.g. temperature, humidity).
  - Considered of high usability in terms of the easily interpretable rainfall description, but of only moderate utility by some users due to its low level of detail.
- **Animated map** – accessible from the text output; conveys rainfall radar observations, at 10 minute intervals, covering the past 40 minutes; accompanied by a legend for interpreting the rainfall symbolisation; refer to Figure 9.28b (Chapter 9).

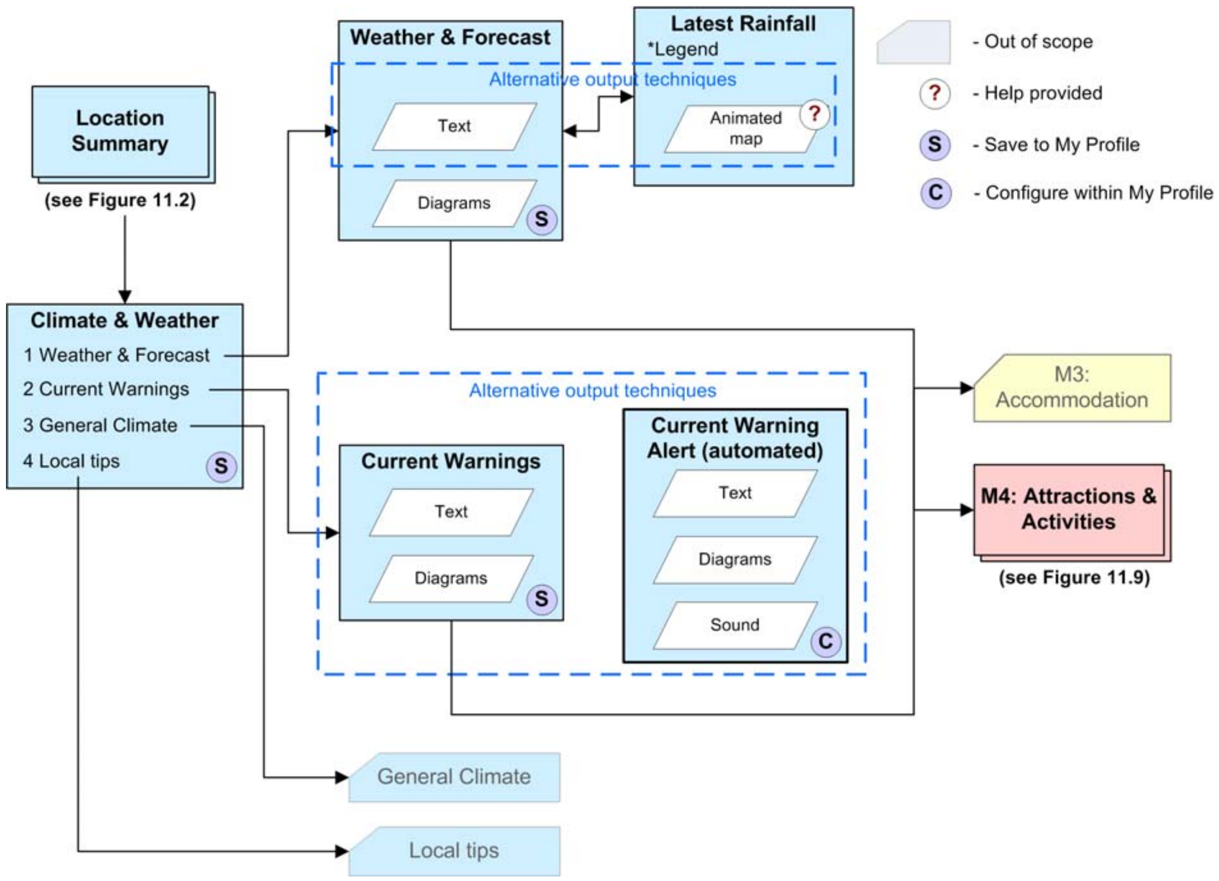

Figure 11.7 Components of the cartographic UI design models related to the sub-task 'Find out local level detail about the location – Location Weather'.

- The high level of detail communicated (i.e. location and intensity of rainfall), along with the use of animation (conveying rainfall movement), were considered to offer high utility to users; usability, however, was considered only moderate with the map not being immediately intuitive to all and as a result required some learning for its interpretation, specifically in terms of the rainfall's intensity – greater usability is anticipated here by placing the legend above the map (making it immediately visible without the user having to scroll) and potentially providing interpretation instructions on the same page.

- **Diagrams** – conveying the forecast weather conditions described in the text (e.g. rain, wind, sun).
  - Considered of high utility and usability for conveying the forecast information (in conjunction with the associated text), particularly through their use of familiar/conventional symbology.
- **Automated weather alert** – conveying weather warning information (e.g. gale force winds) through text and illustrative graphics; pushed to the user based on their current location (i.e. where their position is coincident with that covered by the warning) and time (i.e. only when the warning is relevant); refer to Figure 11.8.

- Offered in addition to the ability to request such information through the UI; considered highly useful, but only where user-configurable (i.e. able to be turned on/off); the use of abstract sound appeared to offer additional utility through drawing the user's attention.

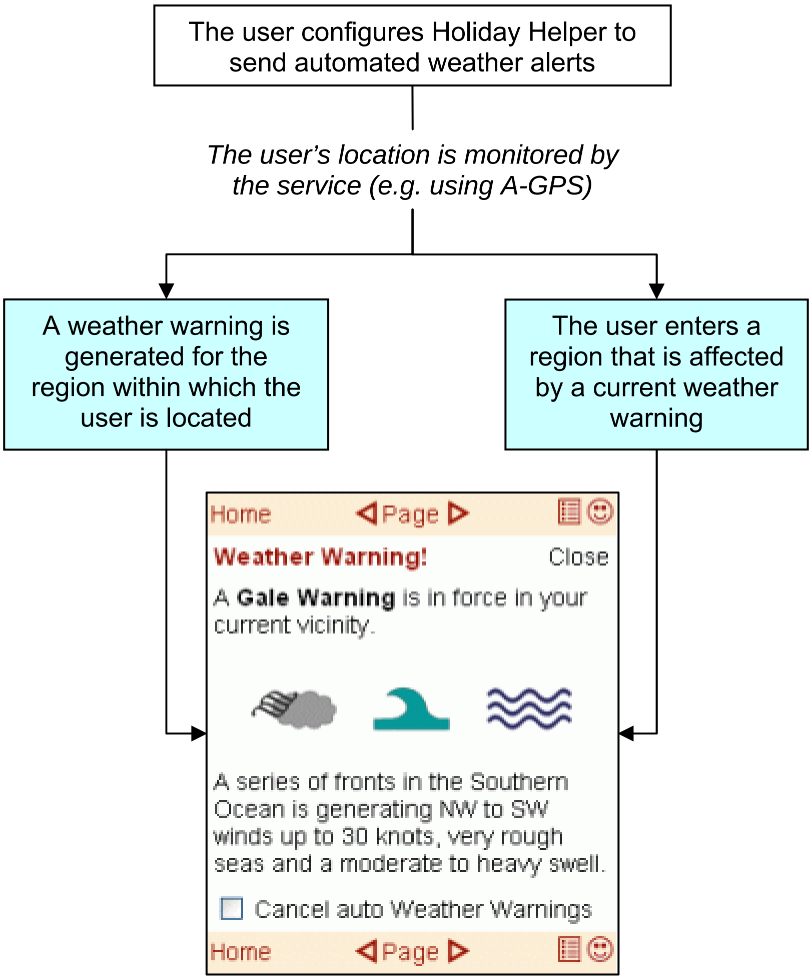

Figure 11.8 The conditions under which an automated weather alert is sent to a user.

Notably, no trialled output representation forms were excluded for this sub-task as a result of the evaluation outcomes. A single addition to the UI was recommended, however, for future investigation regarding its usefulness for this task, comprising:

- The sending of automated alerts (e.g. the aforementioned weather warnings), and user responses to such, through SMS and/or MMS so that this (configurable) functionality is available even when the user is not logged in to the service.

11.2.1.3 Task: identify & select pursuits

The task 'Identify & select pursuits' (depicted in Figure 11.9) concerns searching for attractions/activities situated in and around a particular location. To this end, the models offer six alternative options for input[4], encompassing a range of different interaction techniques.

[4] A seventh input option – Local recommendations – is not included here since it was outside the research scope.

Discussed together, varying levels of usefulness were attributed to the different input options/techniques, as described below.

- **Browse by category (*hierarchical list-based selection, with/without images*)** – allows the user to browse attractions/activities based on the categories into which they fall (e.g. 'Historic Sites', 'Museums') – refer to Figure 9.13a (Chapter 9); attraction/activity lists may or may not include thumbnail images (subject to further evaluation) – Figure 9.14; the initial list of categories comprises those that the user has added to their 'preferred' list (*My Categories*) – stored and maintained within *My Profile*; an option provides access to attractions/activities within the complete category list – Figure 9.13b; selection of a particular attraction/activity takes the user to information about that entity.
  - Considered to offer high utility when one or more attractions/activities of a certain type are sought, as opposed to a particular attraction/activity.
  - The provision of a category-based hierarchy provides usefulness by preventing the need to scroll through long lists of attractions/activities.
  - Initial tailoring of the category list to the user's stored profile offers utility through increasing the relevance of the search and saving time, with the ability to expand the search seen as an additional benefit.
  - Hierarchical list-based selection demonstrates high usability, including the selection of categories not on the initial (personalised) list.
  - The inclusion of images within the attraction/activity lists variably offers high and low utility, depending on the user; equivalent usability appears to be offered regardless of the presence of images.
- **Search by name (*text entry*, *list-based selection*) –** allows the user to type in the name (or part thereof) of an attraction/activity using the device's keypad and select from a list of results matching the input (taking them to information about that attraction/activity); allows optional filtering for the search through the specification of a particular category.
  - Considered to offer high utility when a particular attraction/activity is sought (and its name known).
  - Largely equivalent to the text-based *Place name search* described in Section 11.2.1.2, thus also offering a high level of usability.
- **Search by name (*voice recognition*, *list-based selection*) –** allows the user to speak aloud the name of an attraction/activity and select from a list of matches generated by the voice recognition software (taking them to information about that attraction/activity); allows optional filtering for the search through the specification of a particular category.

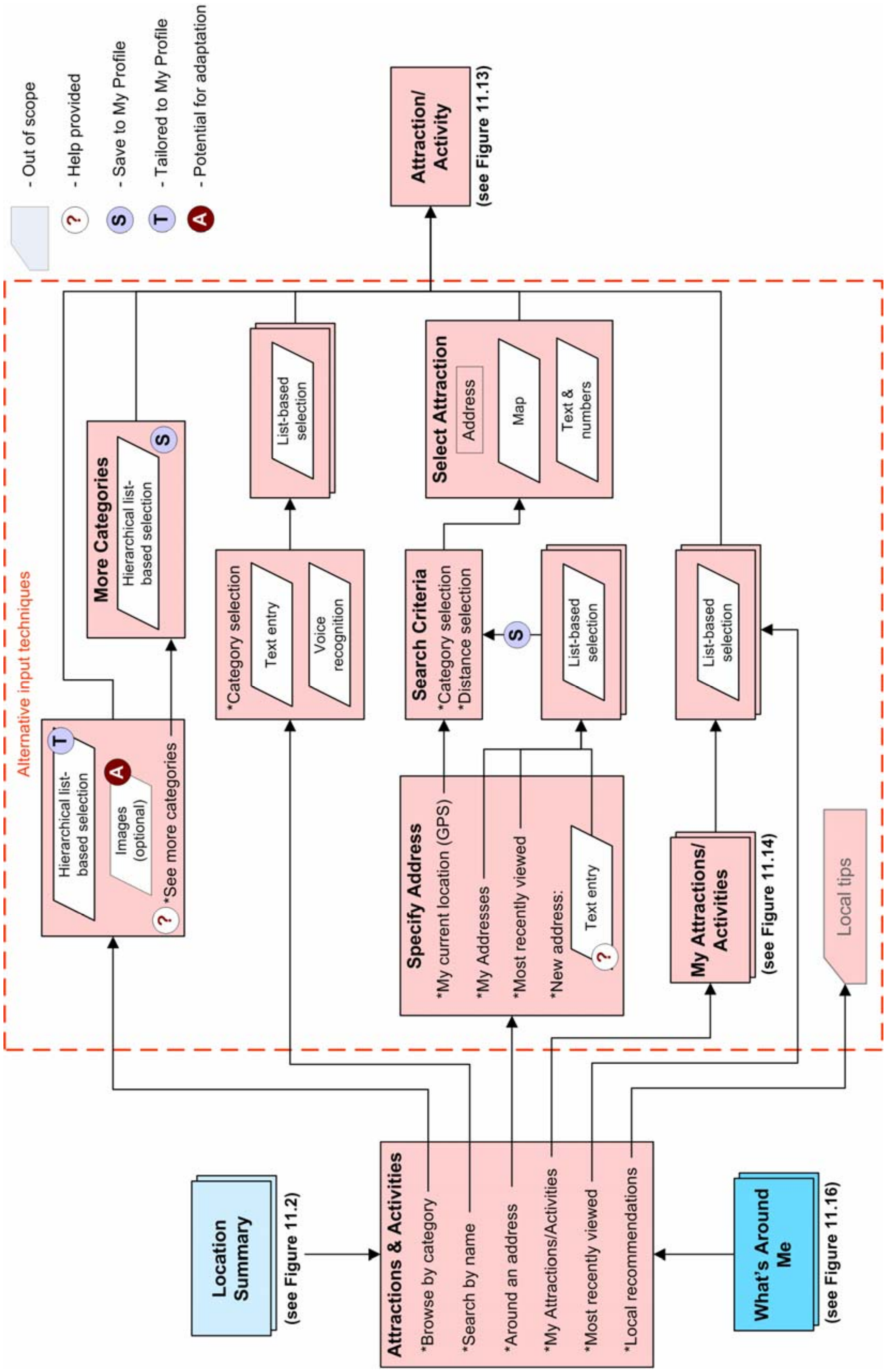

Figure 11.9 Components of the cartographic UI design models related to the task 'Identify & select pursuits' (including areas for which adaptation techniques are recommended).

- Considered to offer high utility when a particular attraction/activity is sought (and its name known), in similar contexts to those described for the voice recognition-based *Place name search* in Section 11.2.1.2.
- Largely equivalent to the voice recognition-based *Place name search* described in Section 11.2.1.2, thus also offering a high level of usability.

- **Around an address** – allows the user to search for attractions/activities proximal to a specific location. See discussion below.
- **My Attractions/Activities (*list-based selection*) –** allows the user to select an attraction/activity from their saved list (taking them to information about that attraction/activity), which is stored and maintained within *My Profile*; also includes functionality for comparing saved attractions/activities (refer to Section 11.2.1.5).
  - Whilst not explicitly evaluated, this was attributed the same high utility and usability as the *My Destinations* search described in Section 11.2.1.2 – in this case being useful when the user has previously accessed and saved the attraction/activity of interest.
- **Most recently viewed (*list-based selection*) –** allows the user to select an attraction/activity from the eight they most recently accessed using the service (taking them to information about that attraction/activity).
  - Offers the same high utility and usability as the *Most recently viewed* search described in Section 11.2.1.2 – in this case being useful when the user has previously (and recently) accessed the attraction/activity of interest.

The input option 'Around an address' requires separate treatment due to its structure which comprises two levels of information input. Here, numerous alternative representation, presentation and interaction techniques were trialled, resulting in the following inclusions (and certain exclusions) for the final design models:

- <u>Specification of an address around which to search for attractions/activities</u>.
  - **My Current Location (*automated search*)** – determines the position of the user (e.g. via A-GPS) and reverse geocodes this into a street address around which to search; allows (subsequent) filtering of attractions/activities returned by the search, through the specification of a particular category and/or a search radius (applicable to all interaction techniques). Refer to Figure 11.10 for the interaction sequence.
    - Offers high utility when the user is currently at the address around which they seek attractions/activities.
    - Offers high usability through minimal interaction.

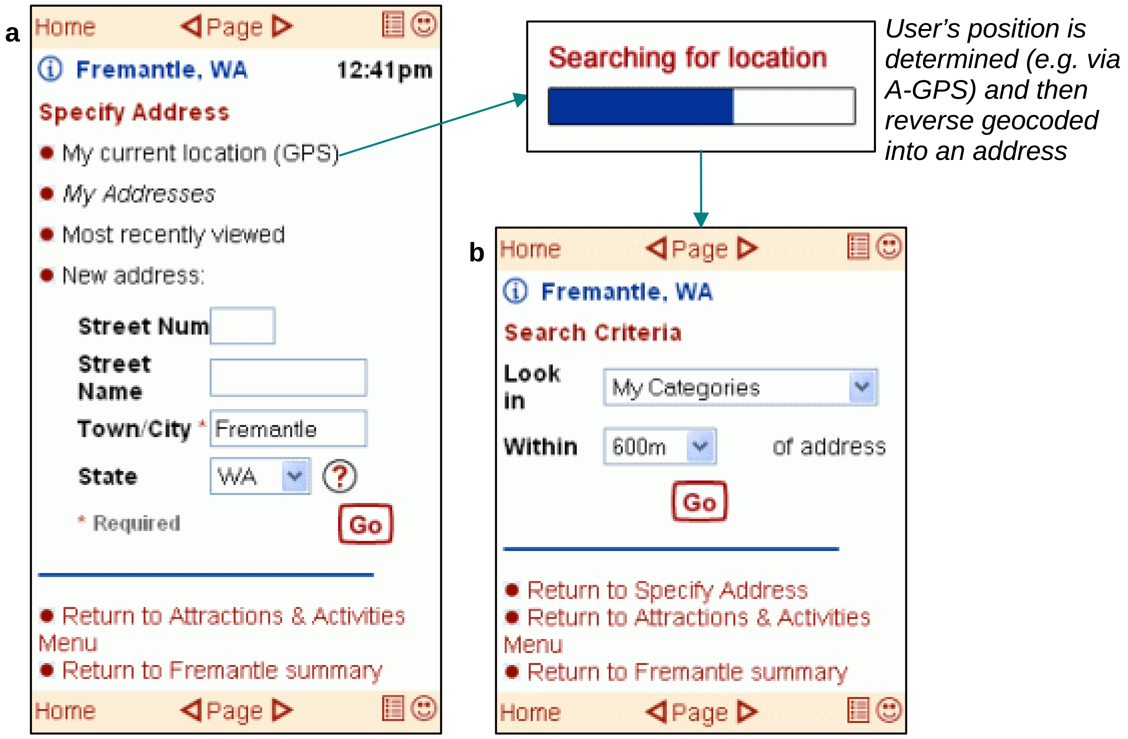

Figure 11.10 (a) Using the automated 'current location' option to specify an address around which to search for attractions/activities, and (b) criteria for filtering the search results.

- **My Addresses (*list-based selection*) –** allows the user to select an address around which to search from their saved list, which is stored and maintained within *My Profile*. Refer to Figure 9.16a and b (Chapter 9) for the interaction sequence.
  - Offers the same high utility and usability as the *My Destinations* search described in Section 11.2.1.2 – in this case being useful when the user has previously saved the address of interest.
- **Most recently viewed (*list-based selection*) –** allows the user to select an address around which to search from the eight most recently geocoded by the service. Refer to Figure 9.16a and c (Chapter 9) for the interaction sequence.
  - Whilst not explicitly evaluated, this was attributed the same high utility and usability as the *Most recently viewed* search described in Section 11.2.1.2 – in this case being useful when the user has previously (and recently) utilised the address of interest.
- **New address (*text entry*, *list-based selection*)** – allows the user to manually enter an address around which to search (using a combination of typing and dropdown list selection to specify the number, street name, town/city and state) and select from a list of results matching the input. Refer to Figure 9.16a and d (Chapter 9) for the interaction sequence.
  - Offers high utility when the (distant) address around which attractions/activities are sought is known, but has not previously been utilised or saved.

- The required interaction is largely equivalent to the text-based *Place name search* described in Section 11.2.1.2, thus also offering a high level of usability.

- <u>Selection of an attraction/activity from those returned following the initial input</u>.
  - **Map-based** – comprising a map containing symbols representing the address and each attraction/activity located around it (which also satisfy the filter criteria, where specified); refer to Figure 11.11a; selection of a particular attraction/activity symbol takes the user to detailed information about that entity.
    - Attributed high utility (overall) by most users, particularly when compared with a **diagrammatic output** (see Figure 9.18b in Chapter 9), which was found to be comparatively less useful (lacking the map's superior provision of geographic context) and was thus rejected.
    - Low utility was attributed in two cases: (1) with respect to the original **schematic map** style (Figure 9.19a), which was rejected in favour of the conventional style used for the Location Layout map (Section 11.2.1.2), additionally adding consistency to the UI; and (2) in terms of the **feature identification page** that had appeared upon selecting an attraction/activity, which was considered largely unnecessary within this context – being an extra, redundant step between the map and the attraction page, that provided no new information – and was therefore removed.
  - **Textual list-based** – incorporating each attraction/activity around the address (which also satisfy the filter criteria, where specified), along with their straight-line distances from the location; ordered by proximity (closest to furthest away); refer to Figure 11.11b; selection of a particular attraction/activity takes the user to detailed information about that entity.
    - Considered to have high utility by certain users through the provision of distance information.
    - Demonstrates high usability, equivalent to other list-based selection techniques within the UI.

a

b

Figure 11.11 An example of combined (a) map- and (b) text-based outputs for representing/selecting attractions and activities around a specific address.

Additional to this, a number of new UI components and/or representation, presentation and interaction techniques were recommended for future investigation regarding their usefulness for this task, including:

- The use of smaller thumbnail images within the hierarchical list-based selection so that more attractions/activities appear on the screen at one time (see example in Figure 11.12).
- Adaptation techniques for including/excluding images from the hierarchical list-based selection, for example:
  - adaptable – allow users to configure the presence/absence of images within *My Profile*; or
  - adaptive – provide an option within the lists to hide/display images (similar to the automated voice output links) and either maintain the most recently viewed state or, if the user consistently chooses to view one more than the other (e.g. always opts to view images), this becomes the initial state.

Refer to the 

symbol in Figure 11.9 for the applicability of this to the design models.

Figure 11.12 An example of hierarchical list-based selection incorporating smaller thumbnail images.

11.2.1.4 Task: find out the characteristics of each pursuit

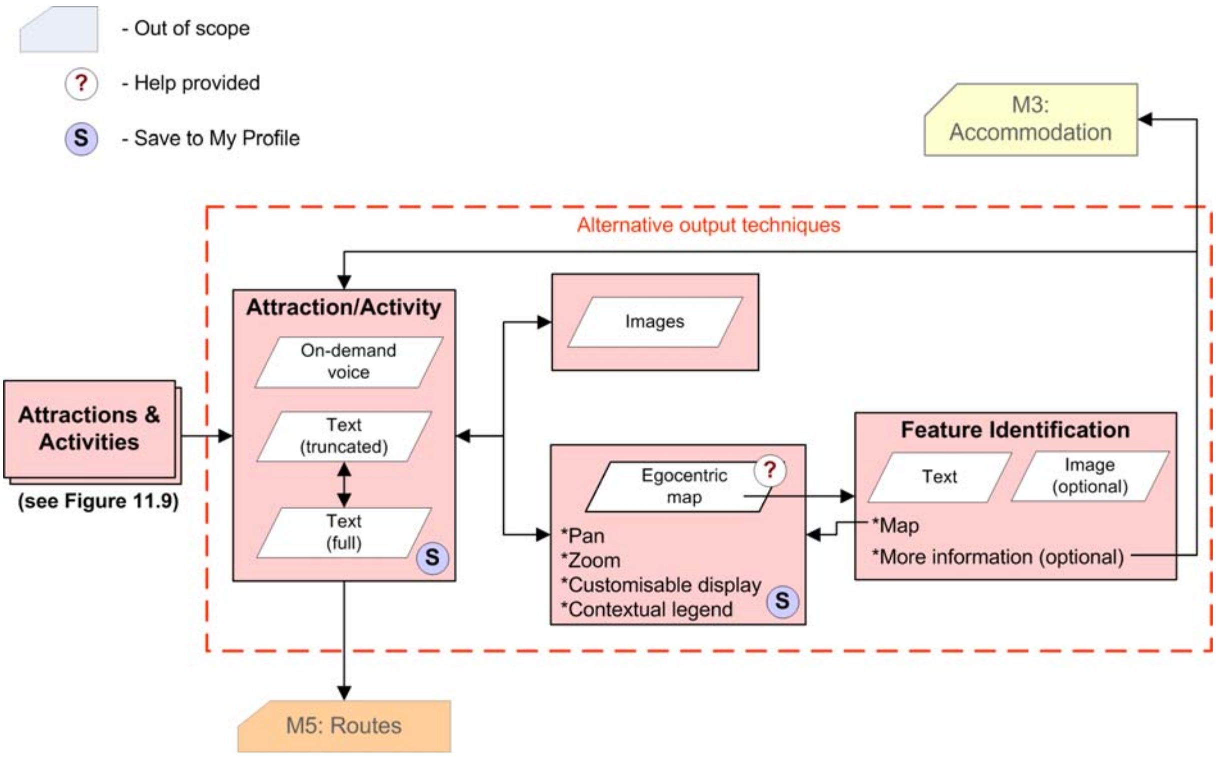

Figure 11.13 Components of the cartographic UI design models related to the task 'Find out the characteristics of each pursuit'.

Depicted in Figure 11.13, this task concerns the output of geospatial (and other) information about a particular attraction/activity. Here a number of alternative representation and presentation techniques were trialled for an 'Attraction/Activity' page, resulting in the following inclusions (and certain exclusions) for the final design models:

- **Truncated text description** – comprising the first three lines of a paragraph describing the attraction/activity; able to be expanded to the full text view; refer to Figure 9.20a (Chapter 9).
  - Considered useful as the initial display state for the same reasons as those given for the Location Layout output (Section 11.2.1.2), with 'reference' information presented below the description (e.g. facilities, cost, opening hours) attributed a higher level of usefulness than the **full text** display.
- **On-demand voice output** – comprising a 'clickable' link at the top of the page, shown in Figure 9.20a, which plays – or stops, once playing – audible voice output communicating the content of the text description (full text display only).
  - Considered useful for the same reasons as those given for the Location Layout output (Section 11.2.1.2), with **automation** of voice output again rejected.
- **Link to images, incorporating image thumbnail** – situated below the text description (see Figure 9.20a); when selected opens a new page containing multiple, larger format photographs of the attraction/activity.
  - Attributed high utility (and usability) by certain users, who appreciated the additional information conveyed, and low utility by others, who saw the images as unnecessary for the task; generally considered more useful than a **single image** on the Attraction/Activity page.
- **(Link to) egocentric map** – conveys the location of the attraction/activity within the surrounding area – see Figure 9.20b (Chapter 9); the characteristics and functionality of this map are consistent with those of the egocentric map included in Figure 11.5 (Location Layout).
  - Considered of high usefulness, particularly the **animation** (i.e. 'blinking') of the attraction/activity of interest.

In closing, a number of new UI components and/or representation, presentation and interaction techniques were recommended for future investigation regarding their usefulness for this task, including:

- Alternative representation forms for conveying the geospatial distribution of appropriate attractions/activities – for example a diagrammatic cross-section and/or 3D terrain model representing the grade/path of a bushwalk.
- 'Virtual tours' of individual attractions/activities making use of 3D, video and/or other representation techniques (e.g. a 3D walk-through of the interior of an historical building).

11.2.1.5 Task: determine the accessibility of each pursuit

As shown in Figure 11.14, this task concerns the comparison of particular attributes between multiple attractions/activities on the user's 'favourites' list. With the design models focused on geospatial information, this comprises two location-related comparisons: *Relative locations* and *Proximity to an address*. A number of alternative representation and presentation techniques were trialled for each, resulting in the following inclusions (and certain exclusions) for the final design models:

- Relative locations – comparison between the physical locations of selected attractions/ activities (from the user's saved list), relative to one another.
  - **Egocentric map** – conveys the location of each attraction/activity, with all initially visible (see Figure 11.15a); the characteristics and functionality of this map are largely consistent with those of the egocentric map depicted in Figure 11.5 (Location Layout), except for the **feature identification page** which appears here only for map symbols not representing an attraction or activity (instead these are linked directly to the attraction/activity information page); additionally incorporates a *quasi-legend* below the map (distinct from the standard contextual legend), which provides rapid interpretation of the attraction/activity map symbols while enabling users to easily display or hide each, with map scale changes made automatically in response to this (see Figure 11.15b).
    - Considered highly useful due to its provision of the full geographic context for the included attractions/activities, particularly in comparison to output comprising **text-based addresses** which, being considered of low to moderate utility, was rejected (with such information easily obtained elsewhere if/when required). Offers high usability through the presence of the interactive quasi-legend, with the associated map scale changes offering high utility by removing irrelevant information from the user's view – note, the ability to zoom in/out augments any reductions in usability resulting from this by providing added control over the scale.
  - **Diagram** – comprising a chart conveying the linear distance between each attraction/ activity, based on the major road and/or ferry networks; refer to Figure 9.23b (Chapter 9).
    - Considered to have moderate utility (and usability) by certain users through its provision of 'quick reference' distance information.

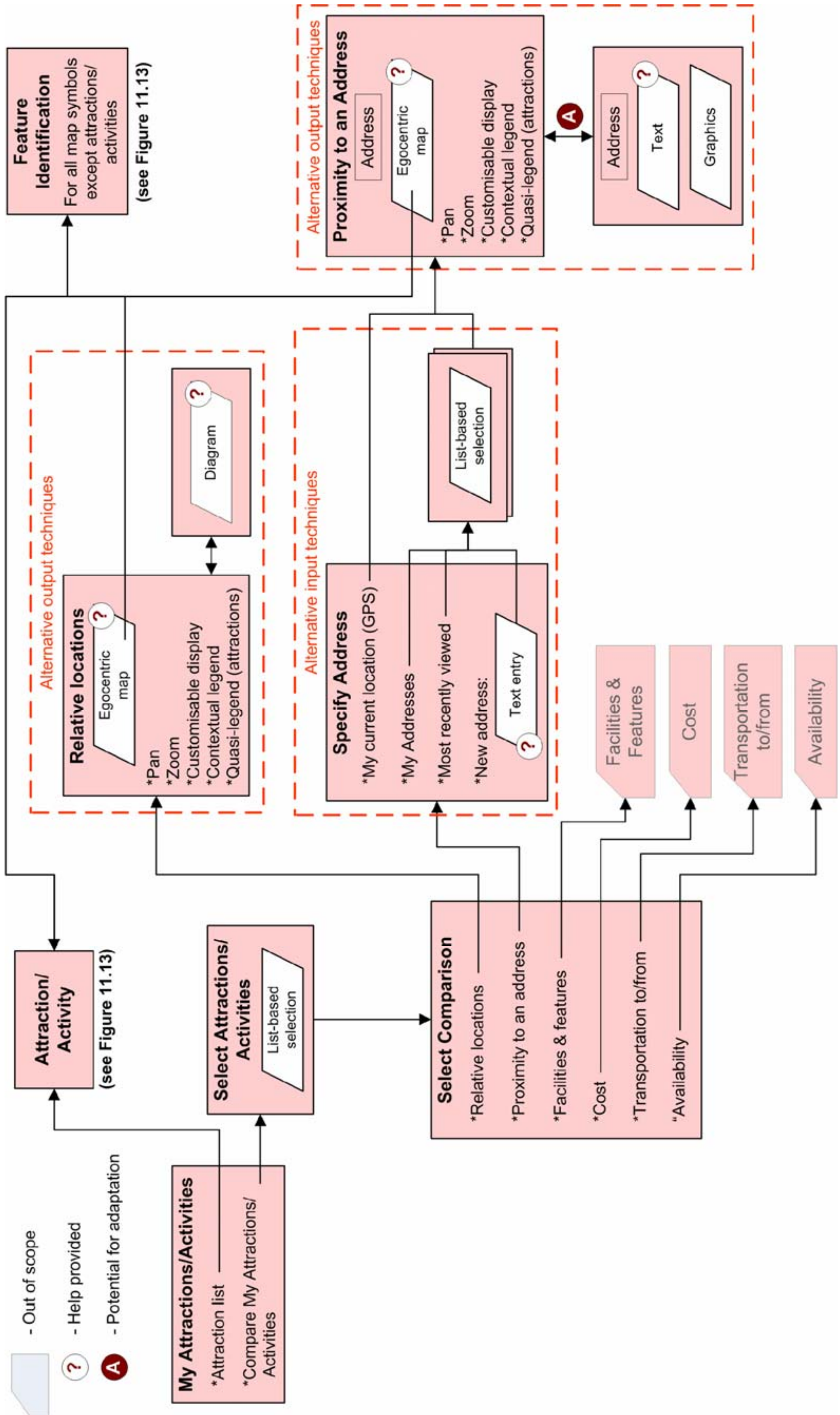

Figure 11.14 Components of the cartographic UI design models related to the task 'Determine the accessibility of each pursuit' (including areas for which adaptation techniques are recommended).

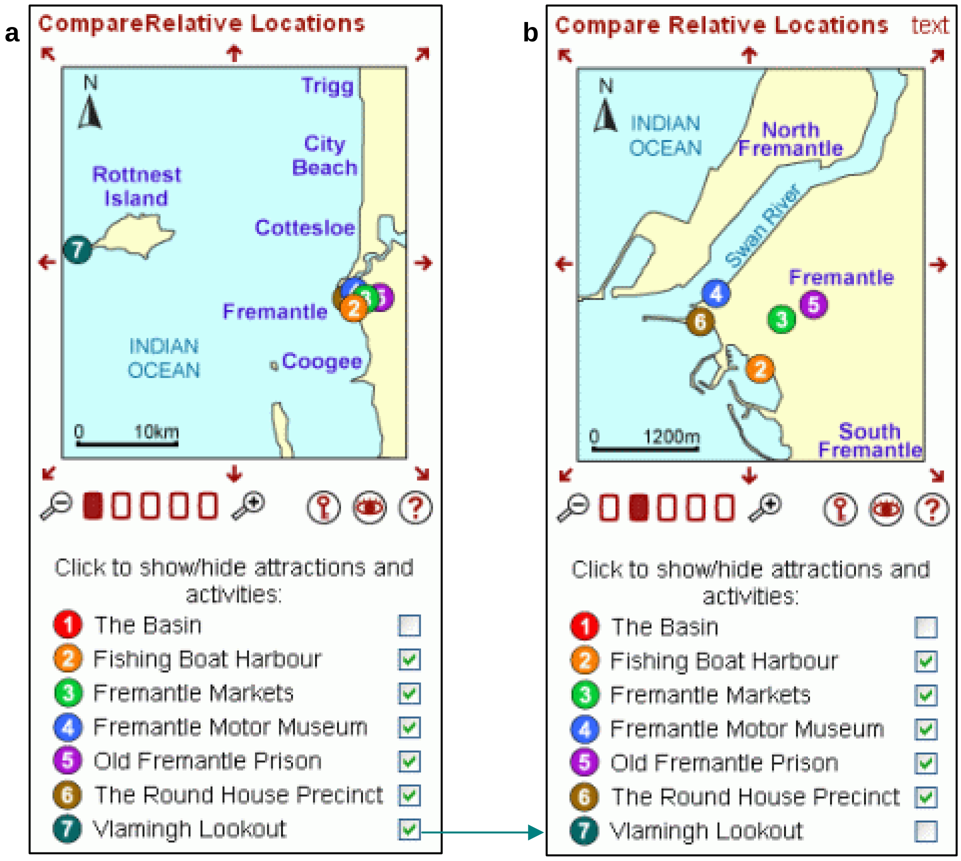

Figure 11.15 The map-based output for comparing the relative location of selected attractions/activities, showing (a) the initial map scale and (b) that following the removal of a feature from display (performed using the quasi-legend).

- Proximity to an address – comparison between the physical locations of selected attractions/ activities (from the user's saved list) and a specific location.

  Inputs

  - **Reference address** – allows the user to specify an address with which to compare the location of each attraction/activity; equivalent to the first level of input described in Section 11.2.1.3 with regard to specifying an address around which to search for attractions/activities (excluding the filter criteria).

  Outputs

  - **Text with graphics** – conveying the name of each attraction/activity and their respective distances from the specified address (based on the major road and/or ferry networks); notably, the distances comprise both text and 'bar'-like graphics, the length of the latter corresponding to the distance between each given attraction/activity and the specified address; Figure 9.25 (Chapter 9) provides an example of this.
    - Considered to have high utility and usability by most users through the inclusion of the graphics, which enabled instant recognition of those attractions/activities closest to or furthest from the address. Having no obvious utility, **animation** of the graphics – whereby the bars 'grew' from the left-hand side of the page – was rejected.

    Approximately half of the users found this representation sufficient (in terms of usefulness) for the task.

- **Egocentric map** – conveys the location of each attraction/activity, with all initially visible, along with the specified address; the characteristics and functionality of this map are consistent with those of the egocentric map described above for the *Relative locations* map (e.g. quasi-legend, pan, zoom, hide/display features).
    - Considered highly useful due to its provision of the full geographic context for the specified address and attractions/activities, particularly in comparison to a **diagrammatic output** (see Figure 9.26 in Chapter 9) which was thus rejected. Low utility, however, was attributed with respect to the original **schematic map** style (refer to Figure 9.27) which was again rejected in favour of the conventional style used for the Location Layout map (Section 11.2.1.2). Particular usability and utility were seen in the *quasi-legend* for displaying and removing attractions/activities from the map (along with the resulting scale changes), which was considered largely more usable than an alternative method requiring access to a 'new' page. Approximately half of the users found the egocentric map representation sufficient (in terms of usefulness) for the task.

Additional to this, a number of new UI components and/or representation, presentation and interaction techniques were recommended for future investigation regarding their usefulness for this task, including:

- Combined geospatial (and other) comparisons, for example enabling users to simultaneously compare both proximity and cost for a selection of attractions/activities. Note, it is likely that additional representation techniques will be required for this.
- Adaptive reordering of the initial output display (map vs. text with graphics) for the *Proximity to an address* comparison, according to the user's past and/or recent viewing behaviour – e.g. the most recently viewed representation is maintained or, if the user consistently chooses to view one more than the other (e.g. always opts to view the map), this becomes the initial representation. Refer to the A symbol in Figure 11.14 for the applicability of this to the design models.

11.2.1.6 Task: determine what's in the immediate area

The final task 'Determine what's in the immediate area' (depicted in Figure 11.16) concerns the output of information conveying the geospatial arrangement of features surrounding the user (or another location), which is presented at two scales: *The immediate area* (large scale) and *A nearby town or city* (small scale). A number of alternative representation and presentation techniques were trialled for each, resulting in the following inclusions (and certain exclusions) for the final design models:

- The immediate area
  - **Egocentric Map** – conveys the immediate area around the user's current (or other specified) location, at four different scales (defaulting to street level) – see Figure 9.32 (Chapter 9); the characteristics and functionality of this map are consistent with those of the egocentric map depicted in Figure 11.5 (Location Layout).
    - Considered of high utility for determining the user's location with respect to their surrounds, and demonstrating high usability through the level of detail provided and the functionality offered. This was favoured over an alternative **schematic map** output (refer to Figure 9.36a) which offered considerably less functionality (and appeal) and was thus rejected. Particular utility was seen in the map **feature identification pages** (Figure 9.33b), with the included images supporting users' self-localisation. High utility was also attributed to the **panoramas** linked to the map (Figure 9.34), which additionally assisted in self-localisation through the provision of feature identification and directional information – allowing users to match their position on the map with that in the real world.
  - **Text description** – comprising a detailed geospatial description of the arrangement of features around the user's current (or other specified) location; divided into three categories – streets, landmarks and coastline – and incorporating distances and cardinal directions; refer to Figure 9.35a (Chapter 9).
    - Considered highly useful (as a secondary output) due to the ability to select feature names included within the text (e.g. attractions/activities, landmarks), with additional information then made available via the aforementioned feature identification page.

- A nearby town or city
  - **Egocentric map** – conveys the towns and cities located within an expanded radius of the user's current (or other specified) location, at four different scales (defaulting to regional level) – see Figure 9.37a (Chapter 9); the characteristics and functionality of this map are consistent with those of the egocentric map depicted in Figure 11.5 (Location Layout).

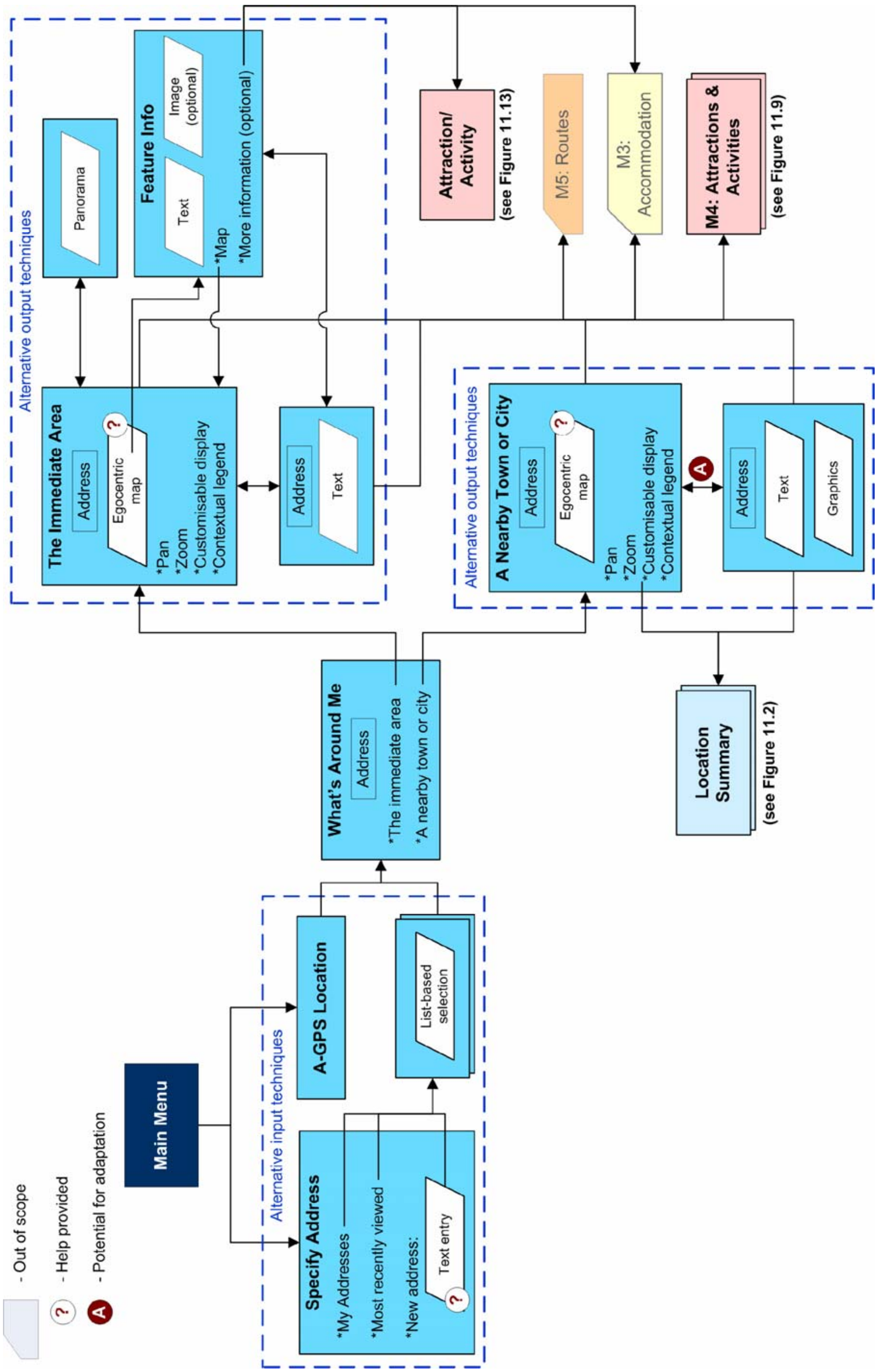

Figure 11.16 Components of the cartographic UI design models related to the task 'Determine what's in the immediate area' (including areas for which adaptation techniques are recommended).

  - Considered of high utility for determining the user's location with respect to towns/cities within the wider region, and demonstrating high usability through the level of detail provided and functionality offered. This was favoured over a **diagrammatic** output (see Figure 9.37c) which was found to be comparatively less useful – lacking the map's superior provision of geographic context – and was thus rejected. Particular utility was seen in the ability to select the town/city names, which provided direct access to relevant information within Module 2.
- **Text with graphics** – conveying the name of each town/city located within an expanded radius of the user's current (or other specified) location; also communicates the distance to each using both text and 'bar'-like graphics, the length of the latter corresponding to the distance between each given town/city and the (user's) location – refer to Figure 9.37b (Chapter 9).
  - Considered to offer high utility and usability through the inclusion of graphics and numbers explicitly conveying relative distances, which enables instant recognition of those towns/cities closest to or furthest from the user (without the need for interpretation).

Additional to this, a number of new UI components and/or representation, presentation and interaction techniques were recommended for future investigation regarding their usefulness for this task, including:

- An alternative technique for viewing panoramas, incorporating dynamism and interactivity (where feasible with the technology platform) to create panorama movies which "provide the viewer with a continuous 360° panoramic image, which may be tilted 180° above and below the camera's horizontal line of view" (Schwertley 2003, p.374) – e.g. using Flash, QuickTime VR, etc. This has the potential to increase the panoramas' usefulness by providing users with greater control over their interaction with the geospatial content.
- An option within *My Profile* for users to select from a range of different map styles (e.g. traditional, schematic, different cultural/regional conventions, etc.) to be applied throughout the system. Note, this is not a simple matter, however, and will likely comprise a detailed study in itself. Considerations here include the data formats involved (with vector data likely to be required), the ability and feasibility of generalising the map data 'on-the-fly' (e.g. to produce a schematic map compared with a precisely scaled map), the need for/maintenance of separate databases (i.e. where on-the-fly generalisation is not possible) and the implementation of different rules for symbolisation.

- An image map representation (i.e. satellite/aerial orthophotos overlaid with map elements) as an output option for *The immediate area*, potentially offering greater utility to users, especially in non-urban settings where few to no man-made landmarks may exist – i.e. users can instead identify natural features within the landscape and match these to the image in order to orient and localise themselves.
- Adaptive reordering of the initial output display (map vs. text with graphics) for *A nearby town or city*, according to the user's past and/or recent viewing behaviour – e.g. the most recently viewed representation is maintained or, if the user consistently chooses to view one more than the other (e.g. always opts to view the text with graphics), this becomes the initial representation. Refer to the A symbol in Figure 11.16 for the applicability of this to the design models.

11.2.2 Summary of techniques

Having described the cartographic UI design models in detail, it is useful to provide a high-level summary of the information presented above. To this end, Table 11.1 draws together the various input and output techniques embodied by the models for representing, presenting and interacting with geospatial information. Furthermore, it highlights those alternative techniques which were additionally evaluated and excluded from the design.

Table 11.1 Summary of the cartographic representation, presentation and interaction techniques included within and excluded from the final UI design models.

Sub-task/ Component	Input options	Excluded	Outputs	Excluded
Task: Find out local level detail about the location (Section 11.2.1.2)				
Location Overview (Figure 11.2)	• List-based selection • Text entry/list-based selection • Voice recognition/list-based selection • Map-based selection	No exclusions made	• Text description (truncated/full) • On-demand voice • Location map • Images (new page)	• Automated voice • Single image (same page)

Location Layout (Figure 11.5)	N/A	N/A	• Text description
			• On-demand voice
			• Egocentric map
			  • Pan
			  • Zoom
			  • Customisable display
			  • Contextual legend
			  • Feature id page
				• Automated voice
				• Map feature animation
				• Image map

Table 11.1 (cont.) Summary of the cartographic representation, presentation and interaction techniques included within and excluded from the final UI design models.

Sub-task / Component	Input options	Excluded	Outputs	Excluded
Location Weather (Figure 11.7)	N/A	N/A	• Text • Animated map • Diagrams • Automated alert	No exclusions made
Task: Identify & select pursuits (Section 11.2.1.3, **Figure 11.9**)			**Task: Find out the characteristics of each pursuit** (Section 11.2.1.4, **Figure 11.13**)	

	• Hierarchical list-based selection
	  • With images
	  • Without images
	• Text entry/list-based selection
	• Voice recognition/list-based selection
	• List-based selection
			• Text description (truncated/full)
			• On-demand voice
			• Images (new page)
			• Egocentric map
			  • Pan
			  • Zoom
			  • Customisable display
			  • Contextual legend
			  • Feature id page
			  • Animated attraction symbol
				• Automated voice
				• Single image (same page)

Specification of an address around which to search	• Automated search • List-based selection • Text entry			
Selection of an attraction/ activity around the specified address	• List-based selection • Map-based selection	• Diagram • Schematic map		
Task: Determine the accessibility of each pursuit (Section 11.2.1.5, **Figure 11.14**)				

Relative locations	N/A	N/A	• Egocentric map
			  • Pan
			  • Zoom
			  • Customisable display
			  • Contextual legend
			  • Feature id page
			  • Quasi-legend
			• Diagram
				• Text-based addresses

Proximity to an address	• Automated search
	• List-based selection
	• Text entry
		No exclusions made	• Text with graphics
			• Egocentric map
			  • Pan
			  • Zoom
			  • Customisable display
			  • Contextual legend
			  • Feature id page
			  • Quasi-legend
				• Animated graphics
				• Schematic map
				• Diagram

Table 11.1 (cont.) Summary of the cartographic representation, presentation and interaction techniques included within and excluded from the final UI design models.

Sub-task / Component	Input options	Excluded	Outputs	Excluded
		Task: Determine what's in the immediate area (Section 11.2.1.6, **Figure 11.16**)		

The immediate area	N/A	N/A	• Egocentric map
			  • Pan
			  • Zoom
			  • Customisable display
			  • Contextual legend
			  • Feature id page
			• Panoramas
			• Text description
				• Schematic map

A nearby town or city	N/A	N/A	• Egocentric map
			  • Pan
			  • Zoom
			  • Customisable display
			  • Contextual legend
			  • Feature id page
			• Text with graphics
				• Diagram

N/A – Not applicable to the sub-task/component

11.2.3 Model analysis

Representing the main outcomes of the research, the cartographic UI models presented above identify the range of tasks and geospatial information requirements associated with users of a DHR travel mLBS application, focusing on the provision of useful representation, presentation and interaction techniques that are suited (or adaptable) to individual users and their changing use contexts. The following sections discuss certain aspects of the models' effectiveness, beginning with those factors that distinguish them from existing research, before moving onto their limitations and opportunities for improvement and concluding with their satisfaction of the research aims and applicability outside the study.

11.2.3.1 Strengths and differentiating factors

A number of factors can be identified which highlight the strengths of the cartographic UI design models while differentiating these from existing research and knowledge within the field of mLBS:

- **The design models are among the first of their kind to provide extensive treatment of the cartographic aspects of a mLBS application UI.**

Recalling the discussion of related research in Sections 3.3.1 and 3.3.2, previous work in this area has largely concentrated on designing and evaluating the overall UI of a given mLBS application (with little emphasis on its geospatial components) and/or specific cartographic representation forms (generally maps), for a limited number of tasks (predominantly guiding users along a route). In contrast, the cartographic UI design models presented above provide both greater focus on cartographic communication issues within mLBS – through their emphasis on the delivery of geospatial information (to non-expert users) – and broader attention to such – by offering alternative techniques for useful input/output of, and interaction with, geospatial information, and through their coverage of a range of geospatially-related tasks common within a travel setting[5]. In this way the models are well placed to cater to the highly variable use contexts that characterise mobile settings, as well as the range of individual geospatial information needs and abilities invariably present within a user population.

- **The design models are supported by a comprehensive UCD methodology.**

Although other researchers have previously implemented UCD techniques for designing and evaluating complete mLBS applications and/or individual representation forms (see Section 3.3.1.3), this appears to be the first time that a comprehensive UCD methodology has been applied to the empirical collection of data forming the basis – along with existing research knowledge – of the development of a set of cartographic UI design models for the medium. In particular, where undertaken at all, little other research has focused the pre-design specification of user tasks and requirements on general geospatial information needs, concentrating instead on overall system requirements and/or user needs relating to specific cartographic representation forms (e.g. maps). Moreover, where the evaluation of design solutions has been made a priority, this has seldom focused on the geospatial content, or otherwise alternative methods of communicating geospatial information have not been involved. In contrast, this research involved UCD techniques at each stage in the development of the design models, as a means of both informing and evaluating the design of a comprehensive cartographic UI incorporating multiple alternative geospatial representation, presentation and interaction techniques.

- **The design models are grounded in the goals, needs and characteristics of real users.**

A major strength of the cartographic UI design models is their basis on data collected directly from intended users of the proposed mLBS application (i.e. those expected to benefit from the communication of geospatial information), as opposed to existing knowledge and/or new theoretical hypotheses. Specifically, this is the first time that research of his nature has studied a group of non-expert, general population users in such a comprehensive manner – i.e. through user profiling, task analysis and two iterations of prototype evaluation. Although the results of the data collection in itself cannot be generalised to the wider population (through the research focus on qualitative, rather than quantitative analysis – see Section 4.4), valuable insight into the

[5] Notably, navigation and wayfinding were purposefully omitted from the design models due to their expansive coverage by existing research and a resulting desire to focus the design efforts elsewhere.

geospatial goals, requirements, representation/interaction preferences and abilities of real-world users was gained and applied to the developed models. In this way, the usefulness of the models was maximised, catering directly to those people who would eventually use the system, along with their anticipated use contexts.

11.2.3.2 Limitations and opportunities for improvement

As with any research outcomes, the cartographic UI design models possess what can be considered limitations and/or areas for improvement. While many of these derive from the research focus on developing a proof of concept/conceptual design, as opposed to a fully functional system, others may be considered limitations of the research plan which, although minimised wherever possible through the selection and conduct of individual methods, still impact on the overall findings.

- **Sample sizes** – during the user task analysis and iterative evaluation phases of the research in particular, relatively small numbers of users were selected for participation using purposeful sampling techniques (see Sections 6.3.2.3, 8.2.2.3 and 10.2.3). Although justifiable through the depth of information gathered from each participant and subsequently rich, thick description and detailed analyses, the use of small (non-probability) samples introduced the risk that important data not present within each sample was excluded from the design models. Therefore, assuming access to greater resources (e.g. time, personnel, facilities), the usability of the design models could potentially be improved by: (a) conducting a second iteration of the user task analysis involving more users, selected via probability sampling; and/or (b) involving larger numbers of users in the evaluation of future design model refinements, while at the same time collecting additional data to augment the user task analysis results and thus inform further on the models' utility.
- **Pre-design data collection** – similar to the previous point, the design models may omit important task and user information due to the pre-design's reliance on collecting data through users' recall of past travel experiences, as opposed to direct observations of them conducting real tasks in the real world. While the impacts of this were minimised during the user task analysis phase through the use of the Critical Incident technique to enhance user recall (see Section 6.3.2), the utility of the design models could potentially be improved by: (a) conducting a second iteration of user profiling and user task analysis, this time involving observation[6]; and (b) collecting additional observation data concerning users' geospatial goals, tasks, information requirements, interests and preferences during field-based evaluations of future model refinements (note, this would require a certain level of free-form prototype use, as opposed to task-based testing).

[6] Although this presents additional limitations, as discussed in Section 6.3.1.1.

- **Evaluation setting** – while the importance of testing design solutions for mobile systems in 'field' settings was recognised, the design models were exclusively evaluated within a laboratory setting, thus impacting on their relation/ability to be generalised to the real world (Kjeldskov & Graham 2003b). Although the controlled laboratory evaluation environment was acceptable for the conceptual purposes of the design model development (see Sections 8.2.2.1 and 10.2.1), it is expected that their continued development, expansion and overall usefulness will benefit from testing within real world settings, particularly through incorporating the changing environmental factors inherent in dynamic, mobile contexts (e.g. light, noise, distractions, power, network communication, weather, etc.). For this to be feasible, however, high-fidelity prototypes are required.
- **Prototype fidelity** – the two prototypes used to specify and evaluate the design models remained of relatively low-fidelity, comprising mainly simulated functionality and data (Sections 7.3.3 and 9.2.1). While sufficient for the research, which was largely concerned with conceptual design activities rather than the technical feasibility of developing a fully functional system, this limited the ability to test technological components of the usage context, set objective (quantitative) usability goals, and constrained the freedom with which users could explore the design during evaluation. With this in mind, it is envisaged that improvements to the usability of the design models will be possible through the development and (field-based) evaluation of increasingly higher-fidelity prototypes, incorporating real functionality/data and live network connections, so that quantifiable factors ranging from request and download efficiencies to task completion rates and time spent in errors may be accurately measured and acted upon.

One final opportunity exists for improving the design models, which is not in response to any identified limitations but instead represents an extension of the current research. This comprises continuing the process of iterative design and evaluation, eventually expanding the scope of the design models to full coverage of the cartographic UI structure described in Figure 11.1, and at the same time trialling further techniques for representing, presenting and interacting with geospatial information in different contexts. This should logically begin by addressing the recommendations for future investigation generated by the final evaluation phase of the research (Section 10.4) – many of which are highlighted throughout Section 11.2.1 – and should continue to take advantage of existing and emerging knowledge in the field of mLBS.

11.2.3.3 Satisfaction of objectives

The main aim of the research was to develop cartographic UI design models for the useful communication of geospatial information to non-expert users through mLBS, with an underlying objective of comparing and evaluating alternative cartographic representation, presentation and interaction techniques for mLBS applications. Acknowledging the impossibility of achieving such aims for mLBS applications and users in general, the research chose to focus on a particular (and popular) application area – domestic holiday-related (DHR) travel – and an associated non-expert user population, with the final design models (presented in Section 11.2.1) being largely specific to these.

While the design models' formulation made use of existing research and knowledge from the fields of Cartography, mobile systems, mLBS, mobile cartography and VNS, as discussed above the key to maximising their usefulness lay in the UCD methodology employed to inform their development and, specifically, the involvement of real users throughout this process. In particular, the utility of the overall cartographic UI was optimised by consulting members of the user group prior to developing any design solutions – through the activities of user profiling and user task analysis – in order to understand and specify their goals, tasks and geospatial information requirements for a DHR travel mLBS, as well as individual differences in their geospatial knowledge, experience, training, habits, preferences and abilities. Moreover, the utility and usability of the UI and that within/between alternative representation forms and interaction techniques were assessed and improved through iterative evaluation of design solutions by the users themselves. In this way, a set of cartographic UI design models was established, incorporating a range of *appropriate* representation, presentation and interaction techniques and offering increased utility and usability to the non-expert users for whom they are intended.

11.2.3.4 Application beyond the research

The UCD approach taken for informing the development of the cartographic UI design models was predominantly qualitative, involving purposeful (non-probability) sampling of participants from the target user group, the collection of both qualitative and quantitative user data and in-depth analysis using qualitative techniques to identify themes, patterns, understandings and insights within the data. While this meant that the results could not make use of inferential statistics from probability theory[7], and thus could not be generalised beyond the general study area, that was never the intention of the design models, their purpose instead being to provide a conceptual foundation for those working in the field of DHR travel mLBS applications and to offer insight for more general, mostly industry, application.

With this in mind, it is anticipated that the design models will be of primary relevance to researchers and developers seeking to produce (useful) cartographic UIs for tourism/travel-

[7] Generally associated with quantitative research strategies, concerned with collecting and analysing statistical data to test theories or hypotheses.

related mLBS applications having largely non-expert users. Whether comprising the main project aim, or simply being a contributing factor, benefits are expected to be gained in this respect by employing the design models as a starting point for development activities, using them as guidance for the UI structure as well as those cartographic representation, presentation and interaction techniques offering utility and usability in particular contexts. Remaining mindful that the UCD data used to inform the design models was largely specific to the user group under study, it is important to note that where these are to be employed elsewhere (within the same application area) a small amount of additional investigation is recommended, both to validate their appropriateness for the project and determine any major differences with respect to users and usage environments that need to be taken into account before beginning full scale development. This may comprise cut-down user profiling and/or user task analysis activities involving members of the intended user group (e.g. employing the questionnaire and interview questions presented in Appendices A.3 and B.5), or even user-based evaluation(s) of an early, low-fidelity prototype (e.g. paper-based) produced from the design models. Where deviations are evident, the design models should be adapted accordingly.

Further to this, any application of the cartographic UI design models should consider the recommendations for future investigation and refinement generated by the final evaluation phase of the study (Section 10.4), which are not explicitly part of the models – although many were summarised throughout Section 11.2.1. Of particular importance here is the need for expanding the design models' scope and investigating additional areas of the UI (including specific representation forms) where *adaptation* to user-based contextual parameters has the potential to maximise the relevance of the geospatial information communicated and/or to simplify the interaction process[8]. And finally, to maximise the usefulness with which the end product communicates geospatial information, the iterative process of evaluation and redesign commenced here should be continued throughout the development process, employing prototypes of increasingly higher-fidelity along with user-based testing within realistic field settings.

Looking then to more general application of the design models, this can be seen in two respects. The first of these concerns the models' identification of typical DHR travel tasks (albeit specific to the user group studied) along with knowledge about which mLBS-based cartographic representation forms and interaction techniques are/are not suitable for each, accounting for various user-related contexts. Such information, while not strictly generalisable, is expected to

[8] Note, additional guidance should be sought here from the emerging field concerned specifically with adaptation in mobile cartography (Reichenbacher 2007; Sarjakoski & Nivala 2005; Reichenbacher 2005b).

contribute to the growing body of "empirical research … to find mappings from typical activities to most commonly used information types and presentations" (Reichenbacher 2004, p.153). Secondly, the UCD methodology used to inform the design models is broadly applicable, having the potential to generate cartographic UI design models offering high utility and usability for a vast array of mLBS application areas, thereby assisting in the development of widely useful (and ultimately successful) mLBS products. The following section discusses this in more detail.

11.3 User-Centred Design Methodology

Despite similarities in the technologies involved, individual mLBS applications possess inherently different contexts – i.e. situations, environments, information and, most importantly, *users*. Therefore what may be considered useful within one application (in terms of UI structure and geospatial representations) will not necessarily be directly useful for another, unrelated mLBS application. It is generally accepted that in order to establish and assess usefulness within a given product, the associated users (including their needs) must first be understood and then actively involved in design and evaluation. UCD is a methodology directed at achieving this, and was adopted by the research to inform the development of cartographic UI design models for a DHR travel mLBS application, in the process determining which techniques for representing, presenting and interacting with geospatial information were/were not considered useful within different contexts. The following sections discuss the contribution of each of the major UCD research phases to improving the usefulness of the design models. As part of this, the individual (predominantly qualitative) methods employed by the research are considered in conjunction with some of the other high-level techniques available (including the potential for conducting quantitative analysis). From here recommendations are made concerning changes to the UCD methodology which may improve the usefulness of the results, while being potentially applicable to other mLBS studies.

11.3.1 User profiling

As described in Section 4.2, there are four main activities of UCD with the first two comprising: (1) *understanding and specifying the context of use* for the intended product; and (2) *specifying the user and organisational requirements*. In accordance with commercially accepted practice (Mayhew 1999; Nielsen 1993), two phases of the research together contributed to investigating these factors, the first of which was 'user profiling'. Undertaking data collection through the distribution of a questionnaire to members of the target user population, the user profiling sought to define the characteristics of the users, including their: demographics; geospatial knowledge, skills and experience; travel habits and related geospatial information requirements; preferences for a DHR travel mLBS application; and capabilities and experience with respect to relevant technologies. The end result was a comprehensive User Profile (Table 5.6) based on a qualitative analysis of the data (involving some degree of quantification), that described the range of physical characteristics, relevant use contexts and information/usage preferences present within the target user population, including the implications of each for the development of cartographic UI design models.

While the evaluation of a completed design (with or without the involvement of users) may be sufficient for identifying issues with, and providing information to help improve its usefulness, the added value of undertaking user profiling early in the UCD process lies in the associated acquisition of knowledge about the target users and use contexts of a product, so that optimal design decisions can be made (i.e. to maximise usefulness) from the beginning. Without such input – along with that from a 'user task analysis' (see below) – the design process will likely proceed in an ad-hoc manner, based largely on researcher/developer beliefs about end user needs, which may be biased and/or incorrect. This can in turn lead to major problems with the conceptual models underlying the design, requiring considerable redevelopment effort later on – wasting time and money. In the same way, the value of involving real users in any user profiling activity (a key aspect of UCD) cannot be overestimated. Indeed, without making direct contact with those people who will ultimately use the models/system, any definition of their characteristics, preferences and requirements can only be based on assumptions and second-hand evidence. Here it must be remembered that no two user populations are necessarily the same – even when similar application domains are considered – which prevents the transference of a user profile established for one context directly into another. For these reasons it is the researcher's contention that many of the insights into the target user population gained from the user profiling process would not have been obtained without taking a UCD approach. Examples in this respect include: the high proportion of new destinations visited by users (compared to familiar travel); an overriding interest in using the DHR travel mLBS application 'on-trip' (with comparatively little interest for 'pre-trip' research and planning); the widespread desire for locally-informed knowledge – i.e. assistance and suggestions – about a location (e.g. secluded swimming spots, unmarked bushwalking tracks); a general preference for 'all-in-one' device access to the service (i.e. integrating mobile communications with the required computing and positioning functionalities); and a base need for the support of decision-making activities (as opposed to a 'travel guide'-style application).

For each phase of UCD, there are numerous methods and techniques available for their implementation, with the final selection and combination being dependent on the particular product under design, and the resources available. This was certainly the case for the methods and associated data collection and analysis techniques employed throughout the research, with each specifically chosen to suit the DHR travel application domain (as well as limitations on time, budget and personnel), and carefully implemented in such a way as to maximise the credibility of the outputs (which were fed directly into the design model development) – see Chapters 5, 6, 7 and 8. Looking specifically to the user profiling, the use of a **questionnaire** distributed to users (and its subsequent qualitative analysis) proved extremely successful in achieving the required aims, providing a wealth of detailed information about the characteristics, use contexts and preferences of the target user population, which was used as a foundation for the user task analysis as well as directly informing the development of the cartographic UI design models. While **probability sampling** (involving a much larger user sample) would enable the results of the user profiling to be quantitatively analysed and thus more confidently generalised beyond the target user population employed by the research, high value is seen in the questionnaire as a data collection technique, particularly in its gathering of information directly from the users themselves. Indeed the other techniques available for user profiling (see Figure 11.17) are not considered to offer any major improvements over the questionnaire, with **interviews** (Mayhew 1999) and/or **focus groups** (Rubin 1994) conducted with parties knowledgeable about the user population seen to be of most benefit when access to an appropriate user group is difficult. Based on this, minimal changes are recommended for the user profiling component of the UCD methodology employed by the research (refer to Figure 11.20).

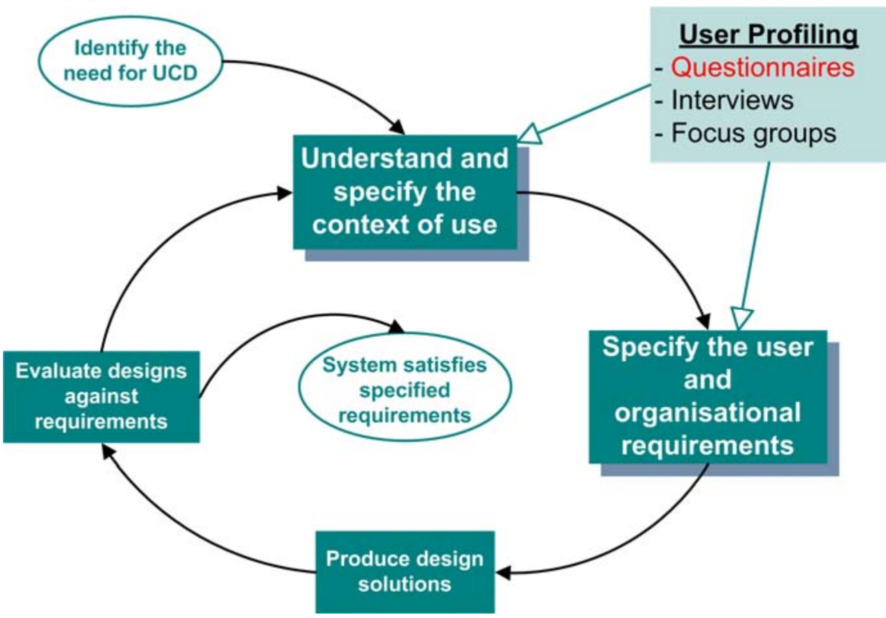

Figure 11.17 Alternative methods and techniques available for user profiling, with those employed by the research highlighted in red.

11.3.2 User task analysis

The second stage of the research was a 'user task analysis'. This continued and completed the investigation of the first two UCD activities which began with the user profiling. Here, data was collected through (Critical Incident) interviews with representative users to elicit details about their DHR travel goals, tasks and information requirements. A goal-driven modelling technique was then employed (Section 6.4.2), with the associated data analysis producing a number of qualitative outcomes – each of which was fed directly into the development of the cartographic UI design models. These comprised: personas describing the major user types present within the target population, including their motivations and characteristics with respect to DHR travel (Section 6.5.3); scenarios covering the most common usage episodes anticipated for the mLBS application (Section 6.5.6); and a set of hierarchical models describing the users' (action-based) travel goals, the high-level tasks undertaken to achieve these and their associated geospatial (and other) information requirements (Figure 6.4 to Figure 6.9, inclusive).

Similar to the user profiling phase, particular value is found in conducting a user task analysis as part of the pre-design activities of a UCD methodology, enabling the goals and requirements of the target user population (and their potential usage environments) – all of which need to be supported by the design – to be clearly identified and understood prior to making any design decisions. Without this step, including its involvement of representative users, the design activities will again be based on biased and/or incorrect assumptions and second-hand evidence, and likely result in a design that does not address any real user needs. Particular insights into the target user population gained from the user task analysis, which the researcher believed would not have been obtained without taking a UCD approach include: the presence of four specific user 'types' (described by the research personas); the definition of, and relationship between, three distinct categories of DHR travel goals (motivational, value-based and action-based); specific geospatial information requirements while travelling (current and anticipated), including their relationship to particular goals and high-level tasks; and major geospatially-related problems encountered by users during DHR travel.

The methods and techniques employed by the research in conducting the user task analysis provided valuable inputs for the design, in particular informing the conceptual models upon which the cartographic UI structure was based. Some potential for improvement is seen, however, involving the application of various alternative techniques for the initial data collection (see Figure 11.18 for the range of methods and techniques available). Overall, the design and conduct of the Critical Incident (user requirements) **interviews** was considered successful in gathering detail related to specific user travel experiences, in a systematic manner. It was unavoidably limited, however, by a reliance on participants' memory/recall of past events, with important information likely being lost through omission, forgetfulness and/or distortion. Although sufficient in the context of the research it is therefore recommended that, given access to greater resources, the Critical Incident interviews should be replaced (or at least supplemented) by any/all of the following alternatives[9] (this is reflected in Figure 11.20):

- **Focus groups** involving multiple users to identify and discuss goals, tasks and requirements relevant to the design; most useful in conjunction with other techniques due to minimal behavioural data generated (due to the non-natural environments involved) and the potential for group dynamics to limit the variety of responses obtained; expected to prompt greater information through user interaction (Hackos & Redish 1998; Maguire 2001).
- **Contextual Inquiry** comprising observations of users in their natural environment as they undertake the tasks the design is intended to support; generally also involves in-context interviewing to gather broader, non-observable data; considered important for identifying and providing maximum familiarity with 'real' tasks, information requirements and usage contexts (Raven & Flanders 1996; Mayhew 1999; Holtzblatt & Beyer 1996).
- **Diary keeping** to provide a comprehensive record of 'real' user behaviours, in their natural environment, over time; particularly useful where observation of users is difficult or inappropriate, as was the case with the research (Maguire 2001).

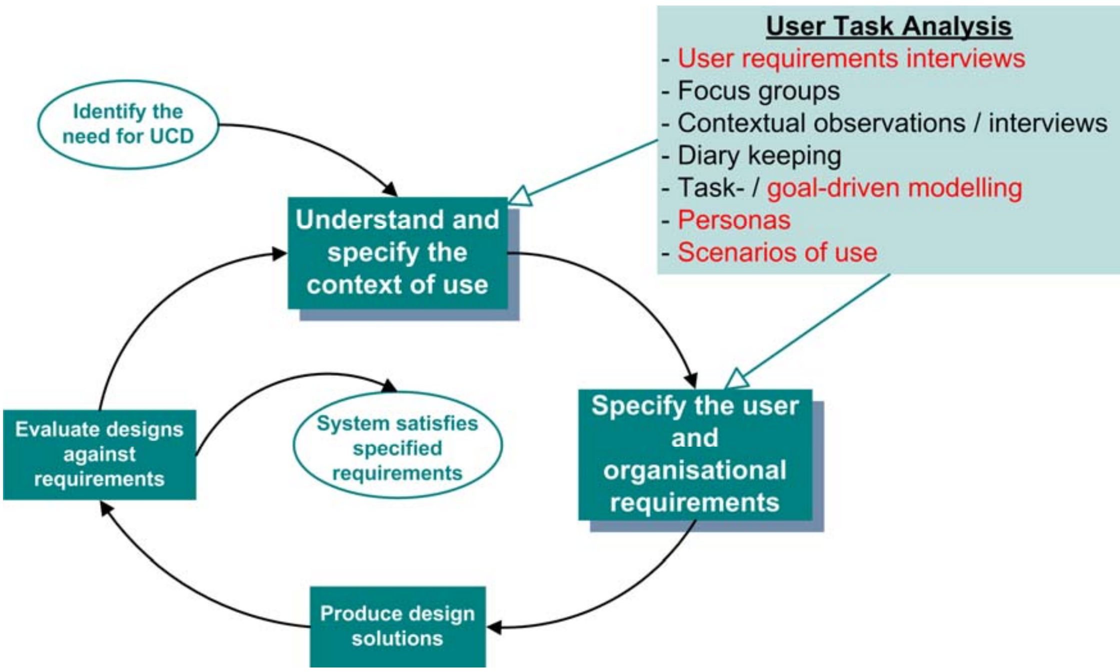

Figure 11.18 Alternative methods and techniques available for user task analysis, with those employed by the research highlighted in red.

Given the ill-defined and open-ended problem-solving nature of users' goals in tourism environments, the qualitative **goal-driven modelling** approach taken for the user task analysis is upheld as the most appropriate means of analysing the user requirements for the DHR travel

[9] Note, the combination of multiple data collection techniques will also increase the ability to generalise the user task analysis results to a larger population, through the associated involvement of more users.

mLBS application. Indeed the alternatives to this – any one of a range of **task-driven** approaches (Bolchini & Mylopoulos 2003; Hackos & Redish 1998; Kirwan & Ainsworth 1992) – were generally considered non-feasible in the context of the research, given the absence of fine-grained and precisely defined user tasks and actions within the user data. In addition to creating the goal-task models upon which the conceptual design was based, the goal-driven modelling provided additional value in its development of associated user **personas** and **scenarios of use**, with the former focusing the design activities firmly on the target users, while the latter drove the entire design process (see below). For each of these reasons, no changes are recommended for the modelling component of the user task analysis undertaken by the research (refer to Figure 11.20).

11.3.3 Iterative design and evaluation

Two phases of design and evaluation were conducted as part of the methodology for the research, together contributing to the final two activities of UCD – (3) *produce design solutions* and (4) *evaluate designs against requirements* – in the process developing and refining the set of cartographic UI design models. At the beginning of the design process, a comprehensive set of qualitative usability goals was established to guide the design efforts, drawn from the results of the user profiling and user task analysis. At the same time a list of accepted UI and cartographic design guidelines and principles was compiled, upon which design decisions would be founded. The design then proceeded using a scenario-based approach, employing a low-fidelity prototype (incorporating simulated functionality and data) for the models' specification. An evaluation of the design models in a 'preliminary' form was then undertaken through (exploratory) usability testing, involving a small sample of representative users undertaking realistic tasks with the prototype in a laboratory setting. During this process, qualitative data was collected pertaining to the usefulness of the cartographic UI, including comparisons between an initial selection of alternative representation, presentation and interaction techniques. Subsequent (qualitative) data analysis and interpretation yielded recommendations for improving the design, most of which were implemented as part of a design revision aimed at extending and enhancing the usefulness of the existing low-fidelity prototype. A second evaluation phase was conducted in a slightly more formal manner than the first, again involving representative users operating the prototype in a laboratory setting, with qualitative (and some quantitative) data collected relating to the overall usefulness of the UI as well as that of a range of alternative representation, presentation and interaction techniques. New design recommendations were then qualitatively generated from this, with many incorporated into the final set of cartographic UI design models presented in Section 11.2.1.

While design is obviously a necessary activity, some may question the value of iterative evaluation and redesign, particularly when considerable pre-design effort has gone into maximising a design's usefulness (e.g. through user profiling and user task analysis). The answer to this lies in the need to validate all design decisions and so ensure that the final design satisfies the specified requirements (regardless of whether these were based on empirical research or assumptions), while providing utility and usability to users. Indeed, without this form of 'checking' – which should be an ongoing process from early design through to full scale development – the risk of a non-useful end product is high, potentially requiring costly re-development after release to improve its acceptability to users. This is no less relevant for the cartographic UI design models produced by the research, with cycles of iterative evaluation and subsequent design revision successfully serving three purposes: (1) validation of the conceptual models of users' goals, tasks and requirements that resulted from the pre-design activities and their embodiment by the cartographic UI; (2) assessment of the relative usefulness of alternative techniques for representing, presenting and interacting with geospatial information, for users within different contexts; and (3) improvements to the usefulness of those techniques deemed appropriate for the DHR travel mLBS application.

Evaluation does not always involve real users. In fact, a range of alternative methods exist which largely take place in their absence. Included in Figure 11.19 under the label **usability inspections** (Nielsen & Mack 1994), these generally comprise the evaluation of a design by one or more usability and/or subject matter experts, in order to identify potential problems that users may face. This may variously include heuristic evaluation (i.e. based on established guidelines and principles), design walkthroughs and consistency assessments, among other things. While the research methodology may be improved by the addition of one or more usability inspection methods (reflected in Figure 11.20) – with several of the evaluation findings likely to have been identified in this way (e.g. the need for consistency between the style and functionality offered by the different maps in the system) – the value of conducting empirical **usability testing** with representative users is undeniable: "it provides direct information about how people use [technology] and what their exact problems are with the concrete interface being tested" (Nielsen 1993, p.165). In fact, numerous insights impacting on the usefulness of the design models were obtained through the two usability tests conducted by the research, which are unlikely to have been identified by usability inspection alone. Examples of these include: users' general desire to see maps of a location, even when they admittedly do not have specific need for such representations; the influence of both task-based context and user preferences on the need to provide multiple options for the input and output of geospatial information; and users' apparent willingness to configure and maintain a personal profile in order to simplify their interaction with the product.

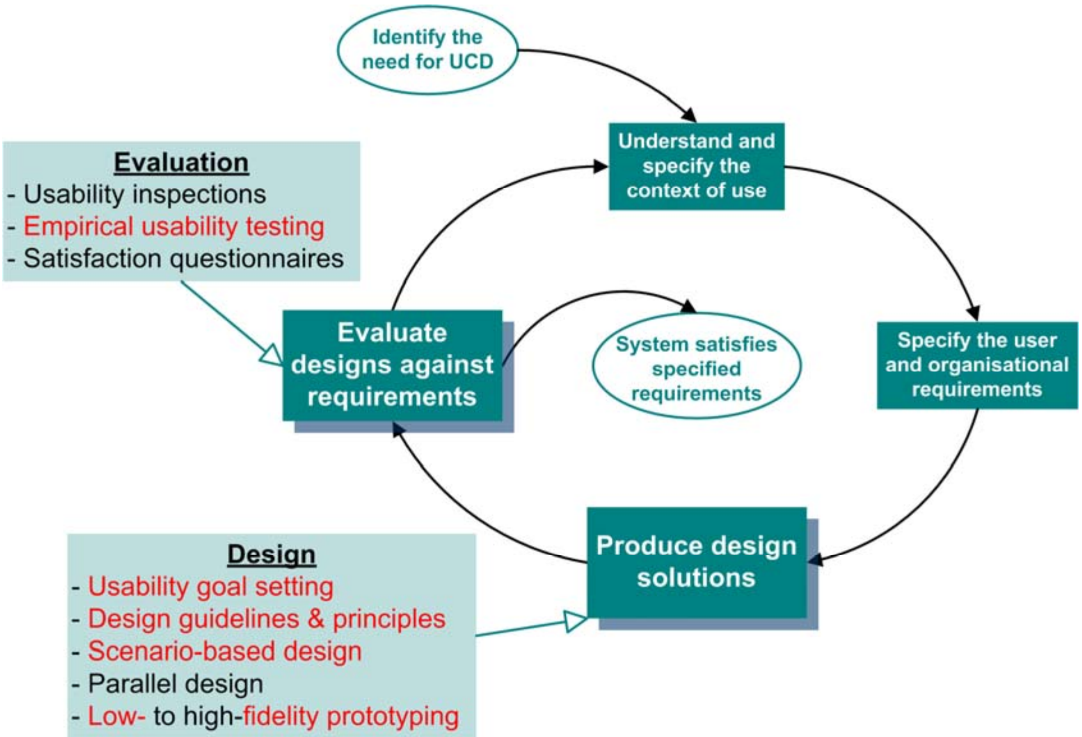

Figure 11.19 Alternative methods and techniques available for iterative design and evaluation, with those employed by the research highlighted in red.

In spite of these benefits, however, potential improvements to the usability testing component of the UCD methodology employed by the research are seen. As discussed in Section 11.2.3.2, the usefulness of the design models is expected to be maximised through: increasing the number of users involved in the evaluations by way of **probability sampling** (thus allowing the results to be quantitatively analysed and so more confidently generalised to a larger population); increasing the functionality/**fidelity** of the prototypes employed and so enabling quantitative assessments of usability against objective **performance goals** (e.g. time to complete a task, proportion of errors successfully corrected); and conducting **field-based testing** to evaluate the prototype under real world conditions (Kjeldskov & Graham 2003b). Furthermore, additional value is seen in the administration of **satisfaction questionnaires** (Lund 2001; Harper *et al.* 1997; Maguire 2001) following user evaluation of high-fidelity prototypes, in order to capture users' subjective impressions of the design in a more formal and quantifiable manner. Each of these recommendations is captured in Figure 11.20.

As a final note, it is difficult to assess the methods and techniques employed for the design component of the UCD methodology due to the fact that there is no 'right' way to approach the design activity. Particular value was seen, however, in the **scenario-based** approach taken, as well as the initial setting of qualitative **usability goals** and reference to established **design guidelines and principles** – each of which served to guide the development of the cartographic UI design models. While 'alternative' design approaches do exist – such as **parallel design**, involving multiple groups of designers working independently on the same design aspects (Nielsen 1993) – no real potential is seen in this respect for improving the design process that was undertaken. As discussed above and in Section 11.2.3.2, however, the development of increasingly **higher-fidelity prototypes** (Nielsen 1992; Dix *et al.* 1998), and the related setting of **quantitative usability goals** against which performance can be assessed (Mayhew 1999; Nielsen 1993), are seen to offer additional benefits. These are therefore included in Figure 11.20.

11.3.4 Proposed methodological changes

Although the effectiveness of the UCD methodology employed by the research is evidenced by the success of each method/technique employed (see individual discussions in Chapters 5, 6, 7 and 8), as well as the final models presented in Section 11.2.1 (the usefulness of which was established through user-based evaluation), there is always room for improvement. Discussed throughout the preceding sections, a number of recommendations can be made regarding changes to the methodology which may prove useful to other mLBS application researchers and developers. These are summarised within Figure 11.20.

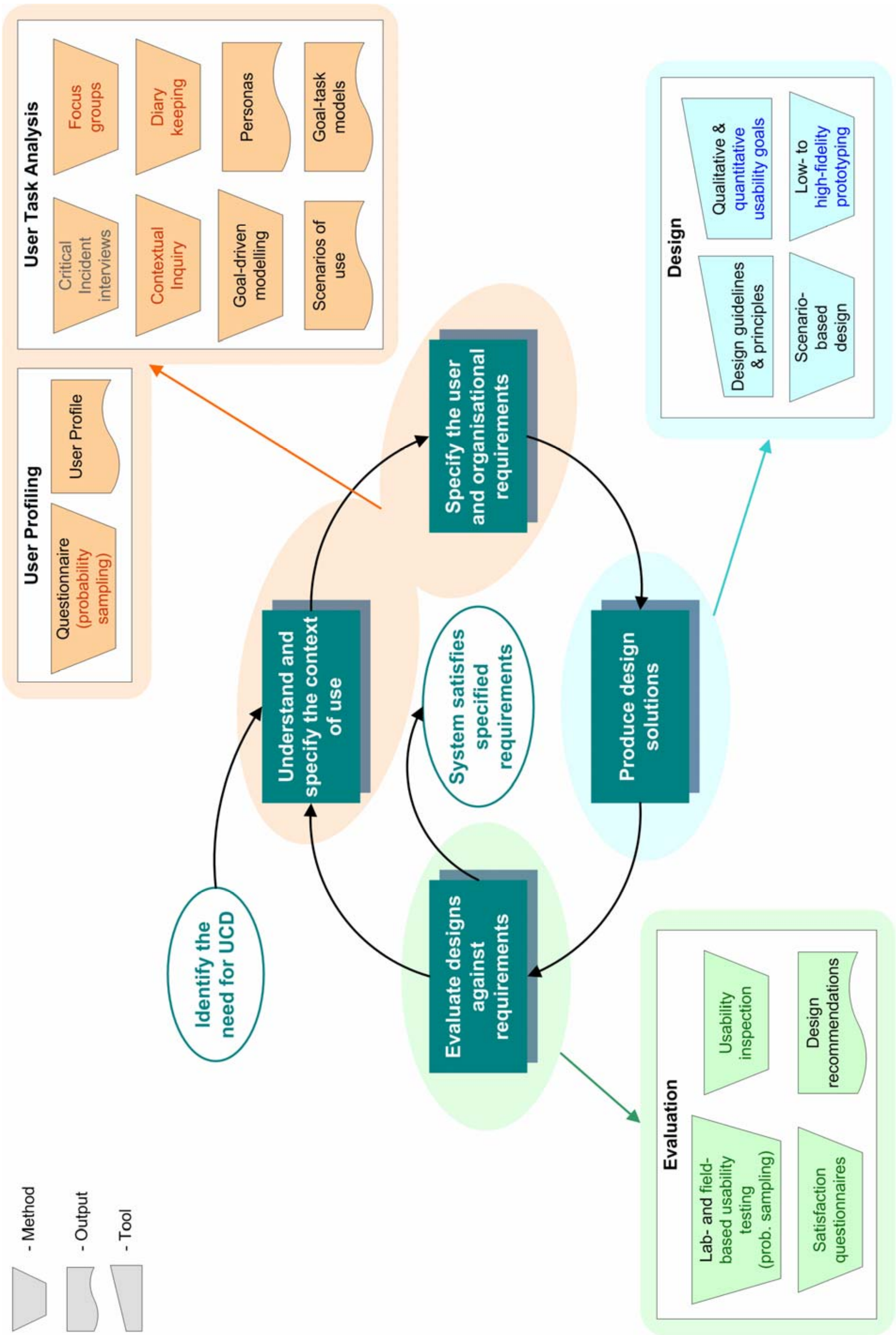

Figure 11.20 Recommended changes to the UCD methodology for the research, with the coloured text denoting methods and techniques additional to those employed by the research.

11.4 General Recommendations

Although focused on the development of cartographic UI design models for a specific mLBS application, a number of more general recommendations were generated by the research findings, which are applicable to both the design of useful cartographic UIs and that of individual representation, presentation and interaction forms used to communicate geospatial information via mLBS. Whilst several of the recommendations overlap with existing research findings, they are considered valuable as a means of supporting and/or validating these – particularly with respect to non-expert users – hence their inclusion here. Expected to be of most relevance to industry developers working on new and existing mLBS applications, the recommendations discussed below may also hold value for researchers striving to define guidelines for mobile cartographic design.

11.4.1 Specific representation forms

As a major component of the research, a range of alternative representation, presentation and interaction techniques were evaluated for different geospatially-related tasks, in the context of a DHR travel mLBS application. From the user-based findings, a number of insights were obtained resulting in the following broad recommendations regarding the usefulness of individual and combined representation forms:

- **Maps are important to mobile users.**

Validating the claims of other cartographic researchers working in the realm of mLBS application design (e.g. Zipf & Richter 2002; Uhlirz 2001), the research found that maps offered significant value and appeal to the target users of a DHR travel mLBS (e.g. "I like to see maps, I like to get an understanding") – even, apparently, when they did not have an explicit need for such representations (e.g. "I'd probably only use [the rainfall map] in rare circumstances … [but] text and the option for the [map] would be good"; "I guess it's probably more useful to see a map [on the location summary page]"). In general, the maps' high degree of utility was attributed to their ability to convey full geographic context for the information of relevance (e.g. location layout, attraction location, relative locations of multiple attractions), including distances, directions and physical features within the landscape. In comparison, the alternative techniques under evaluation provided considerably less context, and as a result lower utility – seen particularly in the communication of proximity to/from a location – with 2D (target-style) diagrams found to omit important physical impediments (e.g. coastlines, rivers), while text-based distances and 1D bar diagrams lacked both this as well as directional information. Furthermore, users found added benefit in the maps' potential for providing wayfinding assistance, even with the knowledge that a comprehensive Routing Module would be available in the final product. Notably they did not strictly seek *guidance* here, but moreso an idea of the *accessibility* of particular entities (often with respect to other entities), taking into account the major transportation networks (e.g. "I can … see that … I could drive from 3 to 5, whereas … 6 to 5 I can't go straight across there"). This was especially evident for maps that contained minimal transportation network information, for example: "if I'm staying in a hotel here and I want to go to that attraction, it's not showing me how to get there"; "if you wanna [*sic*] know how to get there, you need more detailed maps"; "at least show a couple of roads"; "you will probably need some main street names on there to be able to navigate".

- **Mobile map design should be egocentric as well as application- (and task-) specific.**

Although the design and development of map-based representation forms for mLBS applications was not the focus of the research, user feedback was inevitably gathered with respect to the maps employed. While several independent insights were obtained here and used to improve the maps' overall usefulness – including the rejection of a 'sourced' map that was originally designed for an unrelated mLBS application – a particular theme emerged offering support for the claims/findings of others working in this field. This concerned the high level of usefulness offered through the application-specific design of highly generalised, egocentric maps which depict geospatial information from the mobile user's own perspective, thus catering to their individual goals, interests, abilities, preferences, activities, etc. (Reichenbacher 2005a; Meng 2005a). Involving maps which "accommodate … only the information that is instantly needed and effortlessly comprehensible" to the mobile user in their current context (Meng 2005b, p.7), this may be achieved through task-specific design as well as adaptive and/or adaptable techniques (refer to Section 11.4.3). Looking in particular at the cartographic UI design models for the research, a high level of appreciation was expressed by the target users over the custom-designed, task-specific maps employed, and their respective (default) levels of detail, which served to increase the relevance of individual maps according to the purpose for which they were intended (e.g. land use types were included at certain scales of the *Layout* map but not at all on the attraction/activity comparison maps). Further to this, even greater usefulness was attributed to having the ability to personalise the maps (per task) by choosing which features to display at each of the scales offered, with particular value seen in the proposed maintenance of these customisations (i.e. per task and scale), thus preventing the need to re-enter the same selections each time a particular map is accessed. With respect to the behaviour, functionality and general style of the maps employed for each task, however, it proved important for these to remain consistent (e.g. "I'd like to keep a consistent look to the maps throughout") – this is discussed further in Section 11.4.4.

- **Multimedia and multimodality can enhance the usefulness of individual cartographic representations.**

In Chapter 2 it was identified that the combination of multiple media allows for double encoding and the use of complementary information to produce more realistic and intuitive representations of geographic space, support knowledge construction and ultimately ensure efficient communication and dissemination of the underlying data (Buziek 1999; Cartwright & Peterson 2007). Extending this, the added benefits of multimodality were highlighted in Chapter 3, comprising: communication and interaction that better resembles natural human behaviours; emphasis of important information and thus encouragement of its storage in users' long-term memory; avoidance of overloading a single sense while providing insight into complex geospatial data; support for double encoding of information (e.g. in both the visual and verbal stores) for increased memorability and thus more efficient learning; improvements in the accessibility of information for diverse users and usage contexts; and provision of greater flexibility in accessing and interacting with geospatial information (Oviatt & Cohen 2000; Slocum *et al.* 2001; Dransch 2000; Buziek 1999). While such specific cognitive benefits resulting from the use of multimedia and multimodality were not investigated by the research, the (subjective) user evaluation data confirmed the value of these for representing and presenting geospatial information within mLBS applications. In fact many of the output techniques considered most useful within the cartographic UI design models combined multiple media and (to a lesser extent) modalities, as illustrated by the following examples:

- An <u>animated</u> current location symbol able to be displayed on most egocentric <u>maps</u> served to draw the user's attention to their position within the context of the map (e.g. "[if it wasn't animated] you might not notice it") – see example in Figure 11.6.
- <u>Images</u> and <u>panoramas</u> associated with particular points/features on a <u>map</u> of the user's *immediate area* supported both self-localisation – assisting users in matching their position on the map with that in the real world – and the identification of features within the surrounding environment (e.g. "if you were lost you'd just look up and [see the landmark] … you could follow [it]") – refer to Figure 9.33b and Figure 9.34 (Chapter 9) for examples.
- One-dimensional bar <u>diagrams</u> (of variable length) included alongside <u>numbers</u> conveying the user's proximity to a series of *nearby towns and cities* supported instant recognition of their relative distances, without the need to read the text (e.g. "[you] get a picture straight away of what's closest and what's further away") – see example in Figure 9.37b (Chapter 9).

- Voice output for various pages enabled users to access the desired information while using their vision for other tasks and/or to share the otherwise text-based output with travel companions (e.g. "you can actually hear what's being said while you're looking at other things [on the page]") – refer to Figure 11.4a for an example of this.

- **Any automation of auditory outputs should be carefully considered.**

There is an inherent need within mobile usage situations for the user's visual attention to remain with their surrounding environment. As such there are benefits to be gained from including auditory outputs as an alternative to visual representation forms within mLBS applications, with the research findings indicating their particular usefulness: for ensuring the user's safety while interacting with the service (e.g. when driving or walking); as a means of sharing information with travel companions; and/or to simply avoid looking at the device's screen (e.g. "if it's hurting my eyes too much I can go to 'Play Voice'"). The evaluation data also revealed, however, that there are certain situations within mobile usage environments that can make audio representations highly unsuitable – such as in public places, when there is a lot of background noise and where distractions may impinge on the user's safety (e.g. "if you were outside somewhere, it might be a struggle to hear it, and concentrate as well"). The implication of this was that in such cases it would be inappropriate to have sounds played aloud, unless they were specifically requested by the user. Indeed, users generally preferred to *always* have control over the mLBS application's auditory outputs, being able to play and stop such representations at will.

11.4.2 Options, flexibility and control

One of the most obvious and important findings from the evaluation of alternative representation, presentation and interaction techniques was that no 'optimal' method existed for communicating geospatial information through the DHR travel mLBS application for any given user or task, resulting in the following recommendations:

- **Users should be provided with multiple options for the input and output of geospatial information.**

Leading to similar conclusions as Gartner & Radoczky (2007), who found that "redundancy reveals to be one of the most important properties a navigation system should consist of and therefore various presentation forms should be used simultaneously" (p.374), the research indicated that due to differences between users' needs, preferences and current contexts, representation techniques used in isolation only ever had limited usefulness. Indeed, this was observed many times during the evaluations and resulted in the ultimate provision of multiple input options and output techniques for various tasks, thereby offering flexibility and improving the overall usefulness of the information access. Specific examples of this within the design models include:

- The six alternative input options (incorporating four different interaction techniques) for specifying a location about which to obtain detailed information (see Figure 11.2); and
- The two alternative output options (map vs. text with graphics) for conveying the towns/cities nearby a user's current location, and the distance to each (see Figure 11.16).

- **Users should maintain at least some degree of control over the content presentation.**

Related to the previous recommendation, it was found that providing users with control over which representation technique was employed for a particular task, and/or the characteristics of an individual representation, offered added utility by allowing them to further tailor the communication of geospatial information to their individual needs (beyond what is possible with adaptive techniques – see below). This was again evidenced throughout the research, with the most important findings in this respect including: the target users' general preference (expressed during the user profiling) for a decision support system, as opposed to a 'step-by-step' travel guide; their aforementioned rejection of any automation of voice output, in favour of always being able to request this on-demand; their high degree of satisfaction with the ability to personalise the display of map features; their explicit need for control over the delivery of 'pushed' information (e.g. weather warnings, advertisements); and, as discussed above, their variable needs for alternative representations of the same geospatial information.

11.4.3 Adaptation within and between techniques

Existing research has highlighted the importance of adaptation within mLBS applications to improve the relevance and overall usefulness of the information presentation, in response to diverse user needs and abilities as well as the potential for these factors to change over time (Reichenbacher 2004; Jiang 2006). While not directly investigating adaptation as an area of study, the current research acknowledged the benefits it offered, as a result trialling various adaptation options for the cartographic UI design models – such as the ability for users to save/configure 'favourite' entities, which can then be used elsewhere in the system for rapid information input (e.g. *My Destinations* and *My Categories*; see Sections 11.2.1.2 and 11.2.1.3, respectively). Like most efforts concerned with adaptation in mobile cartography (e.g. Nivala & Sarjakoski 2005; Reichenbacher 2005b), the research only directly evaluated techniques for adapting the characteristics of *individual* representations (e.g. the ability for users to personalise the display of map features), with the target users generally responding positively to these (e.g. "otherwise you get a whole lot of stuff that you're not really interested in"). Certain findings, however, prompted the following recommendation, concerned with expanding the focus of adaptation research for mLBS applications:

- **Adaptation *between* alternative representation techniques requires greater attention.**

Expected to involve the use of largely adaptive[10] (and potentially adaptable) techniques for determining the most appropriate representation/presentation form(s) to offer users in their current context, this relates directly to the provision of options for, and user control over the geospatial content presentation, as recommended in Section 11.4.2. In this way, a mLBS application could (theoretically) present the user initially with the representation option considered to be of most relevance/usefulness to them in their current situation (e.g. based on their preferences and past interaction behaviours), while providing access to alternative options. Any selection of alternatives would then provide additional input into the adaptation algorithm, potentially changing the initial representation for the next usage event.

While considerably more research is required here regarding the contextual parameters that are relevant to adapting between representation forms, as well as general and individual user acceptance of this, a number of areas were identified within the cartographic UI design models which may potentially benefit from the addition of such adaptive/adaptable techniques to determine initial input/output states. These are identified throughout Section 11.2.1 and summarised below:

- Adaptive reordering of the *Location Info* search menu options (e.g. the user's most frequently used option is moved to the top of the list) – Section 11.2.1.2 (Figure 11.2).
- Adaptive switching between the truncated and full text descriptions on the location summary page (e.g. maintenance of the most recently or frequently viewed state; display of the full text only for locations not previously viewed) – Section 11.2.1.2 (Figure 11.2).
- Adaptation techniques for including/excluding images from the hierarchical list-based attraction/activity selection (e.g. allowing users to explicitly configure the presence/absence of images; adaptive maintenance of the most recently or frequently viewed state) – Section 11.2.1.3 (Figure 11.9).
- Adaptive reordering of the initial output for the *Proximity to an address* comparison (e.g. maintenance of the most recently or frequently viewed representation) – Section 11.2.1.5 (Figure 11.14).
- Adaptive reordering of the initial output for *A nearby town or city* (e.g. maintenance of the most recently or frequently viewed representation) – Section 11.2.1.6 (Figure 11.16).

[10] Adaptive techniques are generally automated and involve the system 'sensing' the user's context. Adaptable techniques require explicit user interaction. See Section 3.2.2.3 for full definitions of these terms.

11.4.4 Intuitiveness and consistency

Intuitiveness within, and consistency across a UI are two of the most important principles governing the usability of computer-based systems, and are of particular relevance to the design of mobile UIs, which must support specific and immediate goals within often unpredictable environments. Not surprisingly, these factors proved to be equally important to the design of the cartographic UI developed by the research, prompting the following recommendation:

- **Attention must be paid to the design of consistent and intuitive cartographic representation, presentation and interaction techniques.**

While it is acknowledged that such advice does not offer new insights beyond those already expounded by the usability literature, its inclusion here serves to reiterate the importance of ensuring consistency and intuitiveness in mLBS application design – in particular the design of individual representation, presentation and interaction techniques. To provide some specific examples, firstly it was found that the target users expected individual input and output techniques to be immediately usable, looking for affordances and interaction cues within the representations in order to determine their content and functionality, while generally avoiding any additional help offered by the UI. This was most evident for the map-based input technique used to specify a location (Section 11.2.1.2), whereby users had a great deal of trouble initiating the task due to the provision of poor visual cues for selecting the map. Secondly, the content that was initially visible on the screen (i.e. without scrolling down the page) was of particular importance, with users demonstrating a general unwillingness to look beyond this. Because of this, users did not always experience the full range of geospatial information and options available during the evaluations – note, this was the primary purpose for providing the ability to truncate the text description on the *Location Summary* and *Attraction/Activity* pages (see Sections 11.2.1.2 and 11.2.1.4) i.e. so that the most important content and options would be evident upon opening the page. And finally, a need to maintain consistency within specific representation forms used for multiple tasks was also recognised, particularly with respect to the maps employed, with certain differences in their style (e.g. conventional vs. schematic), behaviour (selectable vs. not selectable) and functionality (e.g. zoom tools vs. no zoom tools) causing particular difficulty and frustration for many of the target users (e.g. "oh, I don't have the option to zoom in … I think, just [keep] it consistent").

11.5 Chapter Summary

Addressing the original aims and objectives set out for the research, this chapter has drawn together the major outcomes that were produced by the study (summarised in the box below). First and foremost, the chapter presented and discussed a set of cartographic UI design models for the useful communication of geospatial information to non-expert users through a DHR travel mLBS application. In doing so, it identified the cartographic representation, presentation and interaction techniques that were/were not considered appropriate for different users and tasks, while making various recommendations for future investigations aimed at further improving and extending the models' usefulness. Second, the effectiveness of the UCD methodology employed by the research was discussed, with the relative merits of each major phase (i.e. user profiling, user task analysis and iterative design and evaluation) assessed in terms of its value for informing the development of useful design models. As part of this a revised research methodology was proposed, offering potential improvements to the final results. Finally, while the design models themselves were highly specific to the DHR travel application area, the research findings served to generate several more broadly-applicable insights. To this end, the chapter finished with a number of general recommendations made for ensuring useful mLBS applications.

Completing this thesis, the following chapter presents the main conclusions for the study, reiterating how each of the initial research questions and objectives have been addressed. Additional to this it also presents a number of important avenues for future research in the area of mLBS applications.

- The final cartographic UI design models are governed by an overall structure incorporating seven major functional modules, three of which were included in the detailed models.
- The detailed design models, comprising cartographic representation, presentation and interaction techniques considered useful for the communication of geospatial information via a DHR travel mLBS, are divided according to a number of high-level user tasks:
  - Find out local level detail about the location (overview, layout, weather).
  - Identify & select pursuits (attractions/activities).
  - Find out the characteristics of each pursuit.
  - Determine the accessibility of each pursuit.
  - Determine what's in the immediate area.
- The following strengths and differentiating factors were identified for the design models:
  - among the first of their kind to provide extensive treatment of the cartographic aspects of a mLBS application UI;
  - supported by a comprehensive UCD methodology; and
  - grounded in the goals, needs and characteristics of real users.
- Various limitations and related opportunities for improvement were discussed with respect to the design models, concerning the sample sizes, pre-design data collection techniques, evaluation settings and prototype fidelities employed by the underlying UCD methodology.

- The main purpose of the design models was to provide a conceptual foundation for those working the field of DHR travel mLBS applications and to offer insight for more general, mostly industry, application. Further to this, they are expected to be of broader appeal in their identification of typical DHR travel tasks, along with the cartographic representation forms and interaction techniques considered suitable for each. Moreover, the UCD methodology which informed the models' design is widely applicable to a vast array of mLBS application areas.
- Through the active involvement of real users, the UCD methodology adopted by the research served not only to inform the design of a DHR travel cartographic UI (based on the results of user profiling and user task analysis phases), it was also instrumental in improving the usefulness of the resulting design models' (following two phases of iterative design and evaluation). For all its benefits, however, potential areas for the methodology's improvement were identified.
- Taking a broader view, several recommendations were derived from the research findings, applicable to both the design of useful cartographic UIs and that of individual representation, presentation and interaction forms used to communicate geospatial information via mLBS applications:
  - Maps are important to mobile users.
  - Mobile map design should be egocentric as well as application- (and task-) specific.
  - Multimedia and multimodality can enhance the usefulness of individual cartographic representations.
  - Any automation of auditory outputs should be carefully considered.
  - Users should be provided with multiple options for the input and output of geospatial information.
  - Users should maintain at least some degree of control over the content presentation.
  - Adaptation between alternative representation techniques requires greater attention.
  - Attention must be paid to the design of consistent and intuitive cartographic representation, presentation and interaction techniques.

12 Conclusions and Future Directions

12.1 Conclusions

Geospatial information is becoming increasingly available to non-expert users through mLBS applications designed to support everyday geospatial tasks. Largely comprising the general public, such users commonly lack specific knowledge and training for interpreting and interacting with cartographic representations, compared with domain experts. Therefore, maximising the usefulness – utility and usability – with which mLBS applications communicate geospatial information is of paramount importance if they are to be accepted by their intended user populations and ultimately experience commercial success. While early research into mLBS was mostly technology-driven, concentrating on the physical constraints of the medium, the need for more user-focused studies has been steadily gathering momentum. Thus far, however, efforts to improve the usefulness with which geospatial information is communicated through mLBS applications have been limited. In general terms, the existing research has been overly focused on the design of single representation forms (predominantly maps) for a limited range of tasks, which have generally been selected based on assumptions, convenience, technical feasibility and/or novelty. In particular, there has been little to no informed consideration and/or evaluation of the suitability of the selected representation forms to the users and tasks they are intended to support. Furthermore, there has been minimal comparison of the potential of multiple, alternative techniques (e.g. other than maps) for representing, presenting and interacting with the same geospatial information.

Addressing these (and other) shortcomings, a set of cartographic UI design models has been developed for communicating useful geospatial information to the users of a DHR travel mLBS – a common application area involving non-expert users. Described in Chapter 11, the eight design models together comprise a comprehensive cartographic UI structure catering to the varying needs, characteristics and use contexts of a specific target user population. A single high-level model presents the content of, and structural relationships between, seven major Modules designed to support users' primary DHR travel goals. Of these Modules, three form the basis of the remaining seven detailed models – 'View my current location', 'Get info about a location' and 'Find things to do'. These in turn provide alternative inputs, outputs and interaction flows for several common (geospatial) user tasks, incorporating a range of cartographic representation,

presentation and interaction techniques considered useful by the intended users. The design models are among the first of their kind to provide extensive treatment of the cartographic aspects of a mLBS application UI, with a focus on maximising usefulness in the delivery of geospatial information to non-expert users. Furthermore, while illustrating how useful cartographic design may be achieved for mLBS applications in general, the models provide a valuable foundation for anyone seeking to develop useful DHR travel mLBS applications. Indeed, their application to a given UI (where found to be appropriate, based on preliminary investigations and validation) could potentially save researchers/developers considerable conceptual design effort, while enabling development activities to begin almost immediately.

Comprising a major focus of the design models' development, alternative techniques for representing, presenting and interacting with geospatial information were compared and evaluated to determine the relative usefulness of each within the cartographic UI. To this end, a range of potentially relevant cartographic representation, presentation and interaction techniques was initially compiled – drawn from existing, isolated mLBS studies (mainly involving individual representation forms). This process served to inform the selection of cartographic representation techniques trialled for the design models, enabling educated assumptions to be made for matching particular techniques to defined DHR travel tasks. From the published research it appears that this is the first time such detailed consideration has been given to determining the appropriateness of alternative representation forms, prior to undertaking design. Indeed, this is a major departure from most existing studies, which select isolated techniques and then evaluate and improve their individual usefulness for one or more tasks, with little consideration given to their initial suitability. Instead, useful techniques were allowed to emerge out of a diverse range of representation forms, with users given multiple options to compare and evaluate in order to determine those offering the most utility[1].

The user-based evaluations served not only to identify techniques which offered particular utility for each given task, but also those that were of little use (e.g. image maps, automated voice output and animated graphics) – the latter ultimately being excluded from the final design models. Additionally, a number of techniques were revealed to offer utility for more than one task (e.g. egocentric maps, text descriptions and 1D graphics), while the importance of tailoring such representations to the task at hand was identified. Unsurprisingly, the evaluations revealed that no single 'best' representation technique exists for every user and task. As such, in order to

[1] Note that certain identified representation forms were not able to be evaluated within the technological boundaries of the research (e.g. 3D maps/models). It is acknowledged that these may offer greater usefulness than those incorporated within the design models and as such their investigation is recommended as part of future work in this area.

ensure effective and equitable communication of the component geospatial information, multiple – and in some cases multimodal – options were provided within the design models (per task), thus catering to each individual's underlying goals, interests, abilities and preferences. It was also discovered during the evaluations that alternative representations of the same information have the potential to complement one another, providing more information and thus usefulness than a single representation can on its own, further justifying the provision of options. To offer maximum utility to individual users, however, the exploration of techniques for adapting *between* representation alternatives is advised, so that users are always initially presented with the 'correct' option (i.e. appropriate to their personal context).

The main input techniques that were established to hold particular usefulness within a DHR travel mLBS application are: text entry, voice-recognition, map-based selection, list-based selection (in some cases combined with images) and automated searching (e.g. positioning a user via A-GPS). As indicated above, various combinations of these are considered most useful as alternative options for inputting the same geospatial information. Similarly, a number of useful output techniques were revealed by the research, with the main examples comprising the following combinations (i.e. with each offering multiple alternatives): (1) expandable/collapsible text description, on-demand voice, egocentric map and images; (2) egocentric map (in some cases with animated symbols) and diagram; and (3) egocentric map (in some cases linking to panoramas) and text (in some cases with simple graphics). Illustrated by this brief summary, egocentric maps proved to be the most important representation form for accessing geospatial information while travelling. Despite limitations on their size and extent, users expressed a strong desire for maps due to their provision of complete geographic context for the information sought (i.e. distance, direction, pathways, impediments), even when this level of detail was not required to complete the task. This suggests that many users will not find use in, and thus accept a DHR travel mLBS application, where sufficient access to maps is not provided. As a result the design models recommend incorporating maps as an option for all geospatial information outputs and many inputs, in each case (as discussed above) being accompanied by at least one alternative representation form to cater to situations when a map may be of limited utility. Again, the information offered by each map must cater specifically to the task at hand, however consistency between the various maps employed within a single UI proves to be vital, with identical behaviour, functionality and appearance serving to increase their individual usability.

Judging from the importance of egocentric maps within the DHR travel mLBS application, the focus of much of the recent research on mobile map design is justified and encouraged. Indeed, while not its intention, the results of the current research may even contribute towards a sought-after definition of comprehensive cartographic design guidelines for the mLBS medium. In this respect, particular value is seen in an additional set of research outcomes comprising general recommendations for the communication of geospatial information through mLBS applications, which make suggestions relating to both the design of individual representation, presentation and interaction forms and that of the overall cartographic UI (e.g. options, flexibility and control). Further to this, another way in which the research may add to general mobile cartographic theory concerns the recent proposal by Reichenbacher (2004) for matching typical geospatial tasks to common representation forms as a tool to support the design of mLBS applications. While it is the contention of this research that the suitability (and overall usefulness) of various cartographic representation forms needs to be determined for each given application and user population, it is acknowledged that such a tool may one day provide a valuable starting point for the initial selection of techniques to trial – provided that it is sufficiently broad and offers multiple alternatives for different tasks within a variety of application settings. With this in mind, it is expected that the design models may contribute towards the evolution of this, by offering empirical evidence regarding the suitability of different representation forms for particular geospatial tasks within a DHR travel setting. Of course, this must be combined with other, independent research results to validate the models' recommendations for different applications and user groups.

Perhaps the most important aspect of the design models generated by the research is their grounding in real user data. This was achieved through the adoption of a qualitative UCD methodology that informed the models' development while increasing their usefulness at each stage, through four user-focused activities: user profiling, user task analysis and two phases of iterative design and evaluation. Note, the latter involved a prototype 'Holiday Helper' service, which was built to embody the design models (developed for the browser of an i-mate™ SP5 SmartPhone using XHTML-MP). In particular, the user profiling and user task analysis together offered value by gathering detailed knowledge directly from the target users regarding their characteristics, goals, tasks and geospatial information requirements with respect to DHR travel. The subsequent application of this knowledge to the evolution of a cartographic UI structure ensured that the design models addressed real user needs from the beginning, rather than relying on potentially incorrect assumptions and second-hand evidence. Following on from this, the more detailed design process was also firmly focused on the users – being guided by representative personas and scenarios developed as part of the user task analysis. Finally, user-based evaluation of the design models served to validate the structure of the cartographic UI while providing direct user feedback relating to the usefulness of alternative representation, presentation and interaction techniques for different tasks. Again this was preferable to relying on researcher assumptions regarding the models' utility and usability (no matter how expert or informed), with the users themselves considered to possess the most accurate knowledge of their own needs, goals and abilities. Therefore, when updating the models based on the evaluation findings – e.g. rejecting representations demonstrating little to no utility and improving the usefulness of those techniques considered suitable – this was conducted with the knowledge that each change was in response to real user needs.

The overall UCD research methodology provided a valuable framework for developing cartographic UI design models that offer utility and usability to their target users. Based on a widely accepted UCD approach and making use of common methods and techniques for improving usefulness in computer systems, the methodology as documented in this thesis is expected to transfer readily to the design and development of any given mLBS application type. It is acknowledged, however, that the methodology itself was somewhat limited compared to what could be achieved given more time, personnel and monetary resources. For this reason an alternative set of methods and techniques is proposed, aimed at expanding the depth and breadth of the data collection and analysis at each stage of the UCD process to thereby further increase the usefulness of the final outcomes – be they cartographic design models or a fully functional mLBS application. This is again equally applicable to other mLBS application design and development. It should be reiterated, though, that UCD is not a strict process and thus the recommendations made here can be adapted in many ways to suit the available project resources, so long as the base principles of UCD are upheld (refer to Section 4.2).

Earlier in this chapter, the value of the cartographic UI design models as a foundation for building useful travel mLBS applications was identified. This is not the extent of the benefits offered by the research results, however, with a number of additional outcomes produced by the UCD methodology which other researchers and developers may find useful. The first of these is the comprehensive User Profile (Table 5.6), which describes the range of relevant physical characteristics, geospatial knowledge and experience, travel behaviours and information (access) preferences present within the target user population. Augmenting this, the user personas (Section 6.5.3) and scenarios of application use (Section 6.5.6) produced by the user task analysis, provide easily interpretable summaries identifying the users' various travel goals, tasks and information requirements. Although not generalisable to other user groups, these resources together provide valuable information about the needs and abilities of a non-expert user group which, at the very least, suggest appropriate themes for investigation when designing travel applications. Further to this, the set of goal-task graphs also produced by the user task analysis (Figure 6.4 to Figure 6.9, inclusive) provide a succinct visual portrayal of the user population's travel-related goals, tasks and information requirements, including the interrelationships between these. Able to be interpreted as a basis for design in numerous different ways, these offer an alternative starting point to the design models for similar research (e.g. to derive alternative design models) and/or the development of travel-related mLBS applications.

12.2 Future Directions

This thesis has contributed to the emerging area of Cartography concerned with communicating geospatial information in a useful manner to non-expert users through mLBS applications. Looking back at the history of cartographic communication mediums, mLBS is an extremely young field, and as such there remain many avenues for future investigation that can contribute to the overall usefulness and acceptance of its products.

Much of the mobile cartographic research to date has revolved around the design of *map-based* representations to support users' geospatial tasks, along with methods for adapting these to suit the user's current context. As demonstrated here, however, there are numerous other techniques available for representing, presenting and interacting with geospatial information, many of which offer particular utility to mobile users for different situations. Specific importance is therefore seen for future work in this area to continue to expand the focus of ensuring usefulness within mLBS applications beyond map representations. As part of this, the inclusion of alternative techniques, which ideally complement one another, needs to be considered for individual tasks in order to provide options catering to different users and/or contexts of use. Furthermore, techniques need to be explored for adapting the UI so that the user is presented with the appropriate representation option given their personal usage context. Finally, if such research is conducted on a sufficiently broad scale – i.e. for numerous application types and disparate user populations – it is expected that a valuable collection of mappings between common mobile user tasks and useful cartographic representation forms may indeed eventually evolve, offering a significant starting point for future designers and developers of mLBS applications.

Due to their research-oriented nature, many of the mLBS projects documented in the published literature have investigated user-related issues through the development of a prototype. These are generally tied to a single device (in some cases two), make use of specially prepared data and are evaluated under a limited set of technological and environmental conditions. The current study was no different in these respects. While the resulting representations are useful, it may be argued that this can only be claimed for the devices, data and conditions involved. Therefore, in order to gain greater insight into the widespread usefulness of the cartographic UI, it is recommended that future work in this area should expand the scope of the prototyping and evaluation activities by:

(a) designing and evaluating representation, presentation and/or interaction techniques for a broad cross-section of commonly used handheld devices; (b) trialling the techniques' feasibility/usefulness using a variety of realistic data; (c) assessing individual techniques' utility and usability under a range of technological conditions (e.g. low device battery, positioning unavailable, intermittent network connection, etc.); and/or (d) evaluating the techniques within different environmental settings (e.g. bright vs. low light levels, none vs. high background noise, clear weather vs. rain, none vs. multiple external distractions).

An additional outcome of the research was a list of design recommendations aimed at further improving the usefulness of the cartographic design models. While many of these may be readily applied (with some already incorporated within the final design models), a small number warrant more extensive investigation to determine their feasibility prior to implementation and evaluation. One of these involves investigating the potential of combined, and preferably multimodal, input techniques for specifying geospatial entities about which to obtain information. In the context of the current research, this may involve the use of voice recognition to input the name of a location of interest, while at the same time gesturing on a map (e.g. using a joystick or stylus) to specify the state within which the location is thought to lie, thereby narrowing down the search and speeding up the entire process. Another example might be drawing an area on a map (e.g. using a stylus) while using voice recognition to request activities within that region which are 'child-friendly'. The practicalities of such multimodal interactions must be explored, however, particularly when differences in device input capabilities are considered (e.g. touch screen vs. joystick-based).

Two further design recommendations prompt additional investigation concerning map representations in particular. The first of these relates to providing users with the ability to hide and display map features at will (as incorporated within the design models). While such functionality adds particular utility to the maps themselves, it also creates the potential for these representations to become unusable through the display of 'too many' symbols – i.e. due to reductions in map clarity. For this reason, work is needed towards determining appropriate upper (and possibly lower) limits for the number of point, line and area features that can be displayed on a mobile map. These may then be applied to the map representations within a given application, preventing – at least to some extent – the user from creating overly cluttered (or blank) map displays. However, with possible map sizes and scales varying widely according to individual task requirements and the devices employed, and the need to account for and optimise the visual interplay between alternate feature types, this is no simple matter. Indeed, it will most likely involve the development of multiple algorithms for calculating map feature limits that are appropriate to each individual map/scale, rather than an optimal figure that can be generically applied across all mobile maps.

Further to this, it is recommended that users are offered a range of different styles which can be applied across all map representations within a given application. Examples of this may include maps with a traditional vs. sketched appearance and/or the use of particular cultural conventions[2]. Again, research is required to determine the feasibility of implementing such functionality, much of which will centre on the underlying data, with vector formats necessary for making changes to the map symbolisation. In particular, techniques for 'on-the-fly' generalisation of features (i.e. to adapt the data to each map style) need to be investigated, including their feasibility for the mobile medium and the usefulness of the resulting representations (e.g. download times may be increased). Furthermore, alternative techniques should be considered (e.g. for when 'on-the-fly' generalisation proves to be impractical), including the viability of, and procedures for, creating and maintaining separate databases for each available map style. Finally, additional application-specific investigation is required to determine the range of map styles (and associated symbolisation rules) required to cater to the needs and preferences of a given target user population, as well as whether or not the ability to apply alternate map styles does indeed offer increases in usefulness.

While the research was focused on *representational* issues in improving the usefulness with which geospatial information is communicated, two more commercially-oriented themes emerged from the user-driven data which warrant future attention. The first of these relates to the data underlying the cartographic UI, with many users expressing concerns over the quality and currency of the geospatial information provided and citing this as a factor governing their use and overall acceptance of a given mLBS application. Most relevant on an individual application basis, these factors are often out of the control of the designer/developer, being the primary responsibility of the data provider. Apart from carefully sourcing data that is regularly checked and updated, however, potential is seen for addressing/alleviating users' distrust of the information through the UI design. Here two avenues for investigation are proposed: (1) communicating the quality and accuracy of the underlying geospatial data as part of each cartographic representation; and (2) allowing users to make updates to the presentation where they encounter inaccuracies (e.g. an unmarked one-way street) and/or out-of-date information (e.g. changed opening hours for an attraction), with the potential to share such changes with

[2] Consider here the different map rendering preferences between road users in Melbourne VIC and Sydney NSW (both in Australia), with the former favouring centreline-style road representations, while the latter prefer to see casements. A search for each city at www.Whereis.com will demonstrate these and other cultural differences.

other users – note, however, issues relating to the possible abuse of such functionality require careful consideration (i.e. changes may need to be verified before being added globally to the system).

A second commercial concern, which was expressed by many users, relates to the costs involved with using a mLBS application. Indeed, pricing proves to be one of the biggest issues affecting the acceptance of these products, with consumers generally being unwilling to pay unless sufficient value is added to their lives – e.g. convenience, safety, time-saving and/or money-saving – particularly when similar or equivalent information is available for free, or at a lower cost, elsewhere. This was certainly the case for the DHR travel mLBS application, with any costs involved in using the service expected to be justified by both a useful cartographic UI and underlying data of high quality and accuracy. Even with a useful and value-added product, however, it is unlikely that consumers will ever accept high prices for access to everyday geospatial information through mLBS applications, with most not acknowledging the additional value offered and/or expecting such information to be free. For this reason it is recommended that additional work should focus on determining realistic upper limits in terms of how much users are willing to pay to access mLBS applications, using this to make recommendations regarding appropriate pricing models (e.g. a service-provider pays system). It is important for issues of usefulness to remain part of these investigations, however, with common techniques for reducing costs (e.g. on-page advertising) having the potential to adversely impact the utility and usability of the cartographic UI.

In closing, it must be reiterated that this research was focused on the range of cartographic representation, presentation and interaction forms currently feasible for mLBS, that also fell within the scope of the study (the latter largely dictated by the prototype platform employed). With technology continually advancing and opening doors to new possibilities, there will undoubtedly be a great number of other techniques available in the not-too-distant future that could prove even more useful for DHR travel (and other) mLBS applications, beyond those compared and evaluated here. As such, ongoing work is required to identify and evaluate new and emerging representation techniques for mLBS in order to determine those which offer the greatest potential for improving the utility and usability with which geospatial information is communicated. One example may be 3D mapping/modelling, which is becoming increasingly feasible in mobile settings.

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Applications based on mLBS technology are becoming more widespread and will continue to do so for the foreseeable future. In the process increasing numbers of non-expert users will be exposed to widely varying cartographic representations. In order to cater to the needs of individual, untrained users and ultimately ensure the success of mLBS products, it is important that the representations and UIs providing access to these are designed in such a way that the communication of the underlying geospatial information is useful. This research has highlighted this issue and provided a framework and recommendations by which useful cartographic design for mLBS applications may be achieved. It is only the beginning, however, with the relative youth of this cartographic communication medium promising many new and exciting avenues of research in the future.

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Appendix A - User Profiling Materials

A.1 Call for Participation Email

Welcome and thanks for volunteering to test Sensis products. You have registered on our database for the Sensis Usability Lab and we've selected you as being a potential candidate for upcoming product research.

Sensis, RMIT University and Webraska Mobile Technologies (joint venture) invite you to take part in some exciting new research for a mobile Location-Based Service. In the future, this service will make it easier to travel around Australia by providing all the information that is needed, at your fingertips. We simply ask that you complete an online survey which is ***step one*** in the research process.

If you have any queries or concerns about the process outlined in this email, please contact Karen Wealands.

Privacy
Your privacy is of utmost importance to us and therefore you may be assured that we will not store or use any of the details that you provide for purposes other than those stated here. If you have any questions concerning privacy, please refer to our privacy policy - <URL provided>.

What's in it for me?
This is an opportunity to contribute to leading edge research in geospatial science and will make a real contribution to useful and usable products for everyday people. In recognition of your time and ideas, some financial compensation will be provided at certain stages of the research.

About the survey
This online survey is linked to a PhD research project into the usability of geospatial information (e.g. maps) delivered on small screen devices (e.g. mobile phones and handheld computers). It aims to collect information from you regarding how you currently access geospatial information, particularly when travelling, and how you would prefer to access such information in the future. We will also ask you about your proficiency with mobile phones, computers and geospatial information in general.

Plain Language Statement
Please read the attached Plain Language Statement, which provides further details, including privacy considerations, and a brief background of the project.

This document has been included to comply with RMIT University Human Research Ethics Committee requirements. It is provided in Adobe Acrobat format (you can download Acrobat Reader from <URL provided>). If you are not able to read the attachment, please let us know and we will provide it in a different format.

What's involved?
The survey should take no longer than 30 minutes to complete. All you need to do is access the prepared **online questionnaire** within the next two weeks.

It can be found at <URL provided>.

Next steps
The final section of the questionnaire, **Section G - Contact Details**, is optional. It has been included to gather contact information for those who wish to register their continuing interest to participate in the project.

Note that this is highly encouraged, with compensation offered for further assistance. If you would like to participate further, please provide sufficient details for us to contact you again (e.g. your first name and an email address or phone number).

Sensis Usability Lab database
If you no longer wish to participate in Sensis product evaluation, you can ask to be removed from our database at any time, simply by emailing your request to <email address provided>.

Thank you for your time. We look forward to receiving your feedback.

Karen Wealands BGeom (Hons), BSc
PhD Candidate
Geospatial Science, RMIT University
<contact details provided>

Lesley Forsyth
Human Factors Specialist
User-Centred Design, Search Business Unit,
Sensis Pty Ltd

A.2 Plain Language Statement

16 August 2004

RMIT UNIVERSITY

GEOSPATIAL SCIENCES

School of Mathematical and Geospatial Sciences

Excellence in:
- GIS & Remote Sensing
- Measurement Science
- Multimedia & Visualisation
- Risk & Community Safety
- Sustainable Development

GPO Box 2476V
Melbourne Australia 3001

Telephone + 61 3 9925 2213
Facsimile + 61 3 9663 2517
Email: geospatial@rmit.edu.au

PROJECT INFORMATION

Representation models for the delivery of useful, interactive geospatial information services via the mobile Internet

Dear Participant,

My name is Karen Wealands and I am writing to you to invite you to participate in a research project that I am conducting in conjunction with Sensis™, as part of my PhD program in the School of Mathematical and Geospatial Sciences at RMIT University. My investigations are under the supervision of Associate Professor William Cartwright and Dr Suzette Miller, both lecturers at RMIT, Mr Kirk Mitchell, General Manager of Webraska Mobile Technologies, Asia-Pacific and Mr Peter Benda, Manager – Human-Computer Interaction of Sensis.

BACKGROUND

Location-based services (LBS), available on mobile phones and handheld computers, are becoming increasingly popular. Today, a growing number of people are accessing information on the go, in order to answer location-related questions such as "where is my nearest ATM?" and "how do I get home from here?" Despite the appeal of many of the services on offer, the speed with which they are becoming available reflects a general industry trend of design driven by the technology rather than the needs of the end user – such as yourself – with the usability of the services often suffering. In light of this, RMIT University, Webraska Mobile Technologies and Sensis are working together, with the support of the Australian Research Council (ARC), to trial different methods for representing spatial information within LBS, based on the needs of actual users.

The primary aim of this research is to apply User-Centred Design techniques to develop useful spatial representations for LBS. We hope that it will pave the way for future LBS that are highly useful and user-friendly, catering to the needs of everyday people.

CALL FOR PARTICIPATION

To help us with our research, we are seeking people between the ages of 25 and 40 who regularly travel overland (eg. by car, motorbike, bicycle), to generally unfamiliar inter/intra-state destinations for tourism purposes, and who are willing to provide us with some general information relating to these activities. You have been contacted based on your potential to satisfy these criteria, as well as your previous registration of interest in assisting with Sensis product testing. At this stage participation simply involves the completion of an online questionnaire relating to your current travel habits, your use of spatial information when travelling, and your technological and spatial experience. This will take approximately 30 minutes to complete and can be done at your own convenience. Note that your consent to participate in this stage of the study will be automatically implied if you choose to complete and submit the questionnaire, which can be found at: <URL provided>.

There is also the opportunity (and encouragement) for participants to continue their involvement in the study beyond the questionnaire, if they choose, with compensation for your time and effort offered. If you are interested in finding out more about this, please complete the relevant section of the questionnaire, including the provision of minimal contact information so that we may follow up with you – note that providing your contact details <u>does not oblige you</u> to participate further. Additionally, you are invited to examine the existing study materials to help in making the decision about whether or not to continue – please contact my supervisors or myself should you wish to obtain this information.

PRIVACY

No findings that could identify you will be published as part of this research. Only the combined data of all participants will be presented (at international conferences) or published (in refereed journals), with one exception being useful quotes, which will be presented anonymously. Additionally, both Webraska and Sensis will be supplied with a report detailing the findings of the study, in aggregate form only. Note there will be no identifying information stored with your online questionnaire responses. If you indicate that you are interested in further involvement with the study, you will need to provide sufficient contact details for follow up purposes only. Importantly, all questionnaire responses **will remain confidential**, subject to legal constraints.

Only my supervisors and I will have access to the research data, which will be securely stored in a locked cabinet at RMIT University for a period of five years prior to being destroyed, as prescribed by the *Joint NHMRC/AVCC Statement and Guidelines on Research Practice*. Note that the RMIT University Human Research Ethics Committee has given its approval to this project.

CONTACT INFORMATION

In conclusion, please be aware that participation in this research is entirely voluntary. If you agree to participate you may withdraw at any time simply by not completing the questionnaire or by notifying one of the researchers, by phone, email or in writing. All of the relevant contact details are provided at the bottom of this letter. Similarly, if you have any queries or would like to be informed of the aggregate research findings, please don't hesitate to contact us.

Thankyou for your time.

Karen Wealands BGeom (Hons), BSc
PhD Candidate
<contact details provided>

Dr Suzette Miller PhD, BAppSc (Cartography)
Supervisor
<contact details provided>

Assoc Prof William Cartwright
Supervisor
<contact details provided>

Mr Kirk Mitchell
Supervisor
<contact details provided>

Mr Peter Benda
Consultant
<contact details provided>

Mail:
Attn: Karen Wealands
C/o Geospatial Science,
RMIT University
GPO Box 2476V,
Melbourne Victoria 3001

Any complaints about your participation in this project may be directed to the Secretary, RMIT Human Research Ethics Committee, University Secretariat, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 1745.
Details of the complaints procedure are available from the above address.

A.3 Online Questionnaire

Introduction (Home Page)

Travel and Technology Questionnaire

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Prepared by the Department of Geospatial Science, RMIT University in conjunction with Sensis™ and Webraska Mobile Technologies

Please refer to the list of **important terms** at the top of each section for definitions of some of the concepts used throughout the questionnaire. If you encounter anything that is unclear, please note this, along with the question number, in **Section F - Comments**

This questionnaire relates to a PhD research project entitled 'Representation models for the delivery of useful, interactive geospatial information services via the mobile Internet'. It will be used to build up a profile of users for subsequent research activities and product development. In filling out this questionnaire you will be asked to answer questions relating to your current holiday-related travel habits, use of location information when travelling, and technological experience.

It is important that you answer each question with your own honest and considered views and opinions.

Note that the questionnaire has seven sections and should not take more than half an hour to complete.

Start Questionnaire

Any complaints about your participation in this project may be directed to the Secretary, RMIT Human Research Ethics Committee, University Secretariat, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 1745. Details of the complaints procedure are available from the above address.

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Section A – General Information

Travel and Technology Questionnaire

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SECTION A - General Information

This section aims to find out some general information about you and your experiences with location-based information.

Important terms:
Geospatial information - maps, written and spoken directions, addresses, etc., where the information is presented relative to its geographic location on the Earth.

Geographical Information System (GIS) - an information system that is designed to capture, store, update, manipulate, analyse and display all types of geographically referenced (i.e. geospatial) information.

Cartography - the making and study of maps.

Navigation - determining or following a course of travel (i.e. 'wayfinding').

Route - a course of travel from one place to another (eg. how you get from home to work).

Landmark - a recognisable feature such as a building (eg. post office), a monument (eg. the Shrine) or an attraction (eg. local park); generally does not include street names.

Home | A | B | C | D | E | F | G

Q1. How experienced are you in dealing with geospatial information?
Tick ☑ each statement that applies.

- ☐ Not particularly, only for everyday activities (eg. using maps, looking up addresses).
- ☐ I took one or more Geography subjects at high school (year 10 onwards).
- ☐ I have looked up maps on the Internet (eg. Whereis® Online, RACV Touring Maps, etc.).
- ☐ I have used digital mapping software (eg. GIS such as MapInfo® or ArcView; CAD packages such as AutoCAD®, etc.).
- ☐ I have taken one or more University subjects relating to geospatial information (eg. Surveying, GIS, Cartography, Geography).

  Please list subject name(s): ____________

- ☐ I have completed a qualification related to geospatial information.

  Please list course name(s): ____________

- ☐ I am an academic in the field of geospatial information.
- ☐ I am a professional in the field of geospatial information.

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Q2. What are your experiences with map reading and navigation generally like?
Select the most correct option for each statement.

	Always	Often	Sometimes	Never
I can read Melway™ and/or UBD™ maps with ease	○	○	○	○
I have difficulty reading navigational maps *other than Melway™ or UBD™* (eg. state road maps, hiking trail maps)	○	○	○	○
I tend to turn maps around so that they 'face' the direction I am travelling	○	○	○	○
I usually know, or can easily work out, where North is	○	○	○	○
I find it easy to **follow** a route using written or spoken directions and distances (eg. "turn left at Murray St, then it's about 300m on your right")	○	○	○	○
I find it easy to **follow** a route using landmarks (eg. "turn right at the old post office, then it's up a bit further on your left")	○	○	○	○
I find it difficult to retrace my steps after visiting a new destination	○	○	○	○
I commonly get lost, especially in unfamiliar locations	○	○	○	○
I find it easy to **provide** someone with a route using written or spoken directions and distances	○	○	○	○
I find it easy to **provide** someone with a route using landmarks	○	○	○	○

Q3. Your age:

○ under 18 ○ 18-24 ○ 25-30 ○ 31-40 ○ 41-50 ○ 51+

Top

Q4. Your gender:

○ Male ○ Female

Q5. Where do you live?
Note, this questionnaire is for Australian residents only.

○ VIC ○ TAS ○ SA ○ NSW ○ NT ○ WA ○ QLD ○ ACT

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Any complaints about your participation in this project may be directed to the Secretary, RMIT Human Research Ethics Committee, University Secretariat, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 1745. Details of the complaints procedure are available from the above address.

Section B – Travel Habits

Travel and Technology Questionnaire

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SECTION B - Travel Habits

This section relates to the way you currently travel within Australia. It is focused on your recent holiday-related journeys.

Important terms:
Holiday - travel, away from home, for tourism and/or leisure purposes; includes weekends away; does not include business trips (unless time is specifically set aside for tourism / leisure activities).

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Q6. In the past two years...
(a) ...how many holidays did you take *within Australia*?
Select one option.

○ None ○ 1 - 3 ○ 4 - 6 ○ 6 - 12 ○ 12 or more

(b)...what was the most common 'distance' you travelled to reach your holiday destination(s)?
Select one option.

○ Interstate
○ Intrastate (i.e. within your state)
○ Both, equally as common

(c) ...what was the most common mode of transport you used to initially get to your holiday destination(s)?
Tick ☑ multiple options if you can't choose just one.

☐ Car, truck, etc. ☐ Motorcycle ☐ Bicycle ☐ Train ☐ Bus ☐ Boat ☐ Aeroplane
☐ Other, please specify:

(d) ...what was the most common mode of transport you used while at your holiday destination(s)?
Tick ☑ multiple options if you can't choose just one.

☐ Car, truck, etc. ☐ Motorcycle ☐ Bicycle ☐ Public Transport (eg. bus, train) ☐ Taxi ☐ Foot ☐ Coach
☐ Other, please specify:

Q7. During this travel, what were the main activities that you participated in?
Tick ☑ each activity that applies

- ☐ Sightseeing - national parks, state forests
- ☐ Sightseeing - coastal regions
- ☐ Sightseeing - cities / towns
- ☐ Sporting events (eg. organised tournaments, triathlons)
- ☐ Arts/music festivals or events
- ☐ Water sports - casual (eg. swimming, surfing, sailing, scuba diving)
- ☐ Bike riding - casual
- ☐ Scenic driving
- ☐ Extreme sports (eg. hang gliding, white-water rafting)
- ☐ Skiing / snowboarding
- ☐ Hiking (longer than 1 day)
- ☐ Bushwalking (walks of 1 day or less)
- ☐ Bird watching
- ☐ Visiting friends / relatives
- ☐ Adventure parks (eg. Seaworld, Dreamworld)
- ☐ Shopping
- ☐ Other, please specify:

Q8. Was any of this travel to holiday destinations that you'd never been to before?
Select one option

- ○ Yes. Approximately how much? ____ (eg. 25% were new to me)
- ○ No

Q9. What was the average duration (i.e. length of time) of the holidays you took?
Select one option

- ○ Too variable to say
- ○ 1 - 4 days
- ○ 1 - 2 weeks
- ○ 2 weeks - 1 month
- ○ 1 - 2 months
- ○ Over 2 months, please specify: ____

Q10. If you stayed overnight using accommodation other than friends or family, how did you *generally* go about choosing and booking it?
Select one option

- ○ Chose and booked prior to leaving on holidays
- ○ Chose and booked upon arriving at my destination(s)
- ○ Chose prior to leaving on holidays and booked upon arriving at my destination(s)
- ○ Each of the above, equally as common as one another
- ○ None of the above

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Any complaints about your participation in this project may be directed to the Secretary, RMIT Human Research Ethics Committee, University Secretariat, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 1745. Details of the complaints procedure are available from the above address.

Section C – Travel Information

Travel and Technology Questionnaire

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SECTION C - Travel Information

This section relates to your use of geospatial information during the travels you defined in Section B.

Important terms:
Geospatial information - maps, written and spoken directions, addresses, etc., where the information is presented relative to its geographic location on the Earth.

Navigation - determining or following a course of travel (i.e. 'wayfinding').

Holiday - travel, away from home, for tourism and/or leisure purposes; includes weekends away; does not include business trips (unless time is specifically set aside for tourism / leisure activities).

Q11. What types of 'location-related' information do you commonly use before and/or during your holiday travels?

Tick ☑ each option that applies

- ☐ Directions (navigation information - may be written, spoken, map-based)
- ☐ Traffic conditions
- ☐ Weather reports
- ☐ Public transport system
- ☐ Accommodation location
- ☐ Location of services - restaurants, petrol stations, supermarkets, etc.
- ☐ Location of recreational facilities - parks, swimming pools, etc.
- ☐ Location of tourist attractions / recommendations (eg. museums, art galleries)
- ☐ Other, please specify:

Q12. What aids commonly help you navigate to and/or at your holiday destination(s)?

Tick ☑ each option that applies

- ☐ Street directory (eg. Melway™, UBD™, etc.)
- ☐ State road map(s)
- ☐ Tourist Maps
- ☐ Internet maps / directions (eg. Whereis®)
- ☐ City Guides (eg. CitySearch.com.au™, Lonely Planet™ City Guides)
- ☐ Tourist Guides (eg. Lonely Planet™, RACV Discover Australia)
- ☐ Handheld GPS (eg. Garmin®, Trimble™)
- ☐ Street / traffic / tourist signs
- ☐ Memory
- ☐ Passenger / companion assistance
- ☐ Landmarks (locations of known features)
- ☐ Directions from locals
- ☐ Intuition
- ☐ Vehicle navigation unit (i.e. on-board computer)
- ☐ Hand-written directions
- ☐ Other, please specify:

Q13. What other information do you commonly use to make decisions - eg. about where to stay and eat, and things to see and do - when planning and undertaking your holidays?

Tick ☑ each option that applies.

- ☐ Printed directories (eg. Yellow Pages®, White Pages®
- ☐ Local tourist radio (eg. recommendations on things to see and do)
- ☐ Local newspapers (eg. upcoming events, interesting attractions)
- ☐ Tourist Information Centres
- ☐ Tourist brochures / guide books
- ☐ Friends' recommendations
- ☐ Local knowledge (i.e. ask the locals)
- ☐ Websites / online directories (eg. CitySearch.com.au™)
- ☐ Other, please specify:

Q14. What problems have you experienced when finding your way or making decisions during your holidays?

Please elaborate.

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Section D – Location-Based Travel Needs

Travel and Technology Questionnaire

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SECTION D - Location-Based Travel Needs

This section relates to your needs (i.e. a 'wish-list') for geospatial information **during the travels you defined in Section B**. You are asked to identify the specific types of information that you would use if it were available and how you would prefer to access it.

Important terms:
Geospatial information - maps, written and spoken directions, addresses, etc., where the information is presented relative to its geographic location on the Earth.

Route - a course of travel from one place to another (eg. how you get from home to work).

Holiday - travel, away from home, for tourism and/or leisure purposes; includes weekends away; does not include business trips (unless time is specifically set aside for tourism / leisure activities).

Handheld computer - more than just a personal organiser, refers to a computer that fits into your pocket or the palm of your hand (as opposed to a desktop or laptop/notebook computer); sometimes referred to as a PDA (Personal Digital Assistant), examples are HP iPaq™ and Palm™ Pilot.

Q15. What information would you potentially like to have available to help you find your way when travelling on holiday?

Tick ☑ each option that applies.

- ☐ Directions involving the shortest route (to/from destination) - i.e. in terms of distance travelled
- ☐ Directions involving the fastest route (to/from destination) - i.e. in terms of time taken
- ☐ Directions involving the most scenic route (to/from destination)
- ☐ Directions involving the safest route (to/from destination)
- ☐ Directions involving the most cost effective route (to/from destination) - i.e. accounting for toll roads, etc.
- ☐ Directions including 'stopping points' of your choice along your chosen route (to/from destination) - eg. I want to go from Melbourne to Sydney via Wagga Wagga.
- ☐ Locations of prominent landmarks, features, attractions along your chosen route
- ☐ Traffic conditions along your chosen route
- ☐ Other, please specify:

Q16. How would you prefer to access the above (and other) forms of information to help you plan your trip and then find your way during your travels?
Select one option for each method.

Time of use:	Before	During	Both	I would not like this
Paper maps (eg. Melway™, ™, state road maps)	○	○	○	○
DVD/CD-ROM based digital maps ('a snapshot in time'), on a computer screen - in your home or in your car	○	○	○	○
Internet based digital maps (always up-to-date), on a computer screen - in your home, in your car or in your hand	○	○	○	○
Graphical representations other than maps (eg. animated arrows signalling turn directions and distances)	○	○	○	○
Audible cues (eg. sounds signalling upcoming turns, alerts, etc.)	○	○	○	○
Directions / information written by hand on paper (eg. with diagrams)	○	○	○	○
Directions / information written on, or printed from, a computer screen (eg. with graphics) - in your home, in your car or in your hand	○	○	○	○
Directions / information spoken by a passenger or companion	○	○	○	○
Directions / information spoken by an operator or a computer (i.e. a speaker phone set-up)	○	○	○	○

Other, please specify:

Q17. What other types of information would you like to have available to you during your holiday -related travels?
Tick ☑ each option that applies.

- ☐ Location of nearby petrol stations
- ☐ Location of nearby hotels or other accommodation
- ☐ Location of nearby ATMs / banks
- ☐ Location of nearby places to eat - restaurants, cafes, etc.
- ☐ Location of other nearby services/amenities (eg. taxi ranks, train stations, supermarkets - *refer to Q18 for more ideas*).

Please specify all:

- ☐ Location of major tourist attractions
- ☐ Maps and/or images (eg. photos, diagrams) of your location for finding your way around
- ☐ Advertisements for discounts on accommodation (or other products/services) at nearby locations
- ☐ How close you are to nearby friends and family, including directions to their location(s)
- ☐ Up-to-date weather information for your current location, destination, etc.
- ☐ Information about current events at your location, destination, etc.
- ☐ Virtual tours / detailed information for nearby attractions
- ☐ Other, please specify:

Q18. Below is a list of common Places of Interest. Thinking about each in turn, how useful would it be for you to have access to its location and related information (eg. via a map), during your holiday-related travels?
Please select the level of usefulness that you would attach to each.

Places of Interest	Level of Usefulness: Very useful	Quite useful	Limited in usefulness	Not useful at all	Indifferent
Take Away Food Outlets	○	○	○	○	○
Banks / ATM's	○	○	○	○	○
Service Stations & Garages	○	○	○	○	○
Hotels	○	○	○	○	○
Motels	○	○	○	○	○
Chemists / Pharmacies	○	○	○	○	○
Restaurants	○	○	○	○	○
Cafes	○	○	○	○	○
Cinemas	○	○	○	○	○
Caravan / Tourist Parks	○	○	○	○	○
Bars / Pubs / Wine Bars	○	○	○	○	○
Liquor Stores	○	○	○	○	○
Medical Practitioners	○	○	○	○	○
Auto Electrical Services	○	○	○	○	○
Real Estate Agents	○	○	○	○	○
Florists	○	○	○	○	○
Backpackers Accommodation	○	○	○	○	○
Tow Trucks / Towing Services	○	○	○	○	○
Mechanics / Motor Engineers & Repairers	○	○	○	○	○
Car, Truck, Bus &/or Minibus Rental	○	○	○	○	○

Q19. Imagine you have access to a service called 'Holiday Assistant', which runs on your mobile phone or handheld computer (i.e. you carry it with you) and uses a digital display with sound and graphics to provide you with instant, up-to-date, location-based information, similar to the types listed in the questions above, all while you are travelling...

(a) How likely would it be for you to use such a service?
Select one option

- ○ Not at all
- ○ Unlikely
- ○ Unsure, require more information
- ○ Probably
- ○ Definitely

(b) At what stage do you think you'd be most likely to use such a service?
Tick ☑ each option that applies.

- ☐ Before departing on your travels (i.e. for planning your holiday)
- ☐ While travelling to your destination
- ☐ For planning, when at your destination, (eg. to find out about services, attractions, events, etc.)
- ☐ 'Out and about', when at your destination (eg. to navigate to services, attractions, events, etc.)
- ☐ N/A

(c) Why would/wouldn't you use a 'Holiday Assistant' service?
Please elaborate on your choices for parts (a) and (b).

(d) How would you prefer to pay for such a service?
Select one statement.

- ○ A medium, one-off subscription cost with additional charges based on usage amounts above a capped level
- ○ A high, one-off subscription cost (unlimited usage with no additional charges)
- ○ A low, monthly subscription cost with additional charges based on usage amounts above a capped level
- ○ A higher, monthly subscription cost (unlimited usage with no additional charges)
- ○ I wouldn't be prepared to pay for it
- ○ Other, please specify:

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Any complaints about your participation in this project may be directed to the Secretary, RMIT Human Research Ethics Committee, University Secretariat, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 1745. Details of the complaints procedure are available from the above address.

Section E – Mobile Phone and Computer Skills

Travel and Technology Questionnaire

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SECTION E - Mobile Phone and Computer Skills

This section relates to your current use of mobile phones and computers.

Important terms:
Handheld computer - more than just a personal organiser, refers to a computer that fits into your pocket or the palm of your hand (as opposed to a desktop or laptop/notebook computer); sometimes referred to as a PDA (Personal Digital Assistant), examples are HP iPaq™ and Palm™ Pilot.

SmartPhone - a handheld computer that is also a mobile phone; an example is the O2 xda.

Route - a course of travel from one place to another (eg. how you get from home to work).

Holiday - travel, away from home, for tourism and/or leisure purposes; includes weekends away; does not include business trips (unless time is specifically set aside for tourism / leisure activities).

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Q20. Do you currently use/own a mobile phone or SmartPhone?
Select one option.

- ○ Yes, go to Q21
- ○ No. Have you ever used a mobile phone?
  - ○ Yes, go to Q22
  - ○ No, go to Q24

Q21. How often do you use this mobile phone or SmartPhone?
Select one option.

- ○ Daily - frequent use
- ○ Casual user (eg. once a day)
- ○ Emergencies only
- ○ Rarely (not incl. emergencies)
- ○ Never

Q22. Have you ever used a mobile phone or SmartPhone for anything other than voice calls (eg. SMS, email)?
Select one option.

- ○ Yes, go to Q23
- ○ No, go to Q24

Q23. What did you use the mobile phone or SmartPhone to do, other than voice calls?

Tick ☑ each option that applies.

- ☐ SMS - Short Message Service
- ☐ MMS - Multimedia Messaging Service (or PXT)
- ☐ Email
- ☐ Phonebook
- ☐ Browse the Internet (via WAP)
- ☐ Listen to music / the radio
- ☐ Play games
- ☐ Take photos / video
- ☐ Alarm / event notification
- ☐ Other, please specify: ________

Q24. How often do you use a computer (desktop/laptop, handheld or SmartPhone)?

Write the type or brand of each computer that you use in the appropriate space (Note, you don't have to fill in every space).

	Desktop / Laptop	Handheld computer	SmartPhone
	PC or Macintosh?	Brand?	Brand?
All day, every day (eg. for work duties)			
Once a day (eg. to check email)			
2 - 3 times a week			
Once a week			
Once every two weeks			
Once a month			
Less than once a month			

If you never use a computer, go to Q28.

Q25. Below are some statements regarding the use of computers. For each of the two computer types listed, which of the statements apply to you?

Tick ☑ the appropriate boxes.

	Desktop / Laptop	Handheld / SmartPhone
I use a computer for word-processing tasks.	☐	☐
I use a computer for spreadsheet tasks.	☐	☐
I use a computer for email.	☐	☐
I use a computer for Internet access.	☐	☐
I use a computer to play games.	☐	☐
I use a computer for more complex tasks (eg. tailored business or academic software).	☐	☐
I use a computer for calendar and address book (ie. personal organiser) functions.	☐	☐
I can write programs for computers.	☐	☐

Other, please specify (including the computer type):

____

Q26. Below are some statements regarding people's opinions of computers. Which of these apply to you?
Tick ☑ each option that applies.

- ☐ I enjoy working with computers.
- ☐ I find computers relatively easy to use for my current needs.
- ☐ I have no strong like or dislike for working with computers.
- ☐ I would be reluctant to use a computer for tasks that are more complex than my current needs.
- ☐ I find computers hard to use. I don't understand them.
- ☐ I don't like working with computers.
- ☐ Other, please specify:

Q27. If you have used a handheld computer before, have you ever connected it to a mobile phone (eg. for use as a modem)?
Select one option. Skip this question if it doesn't apply.

- ○ No
- ○ Yes. **What connection method(s) did you use for this purpose?**
  Tick ☑ all options that apply.
  - ☐ Infrared (IR)
  - ☐ Bluetooth®
  - ☐ A cable (eg. USB, serial)
  - ☐ Other, please specify:

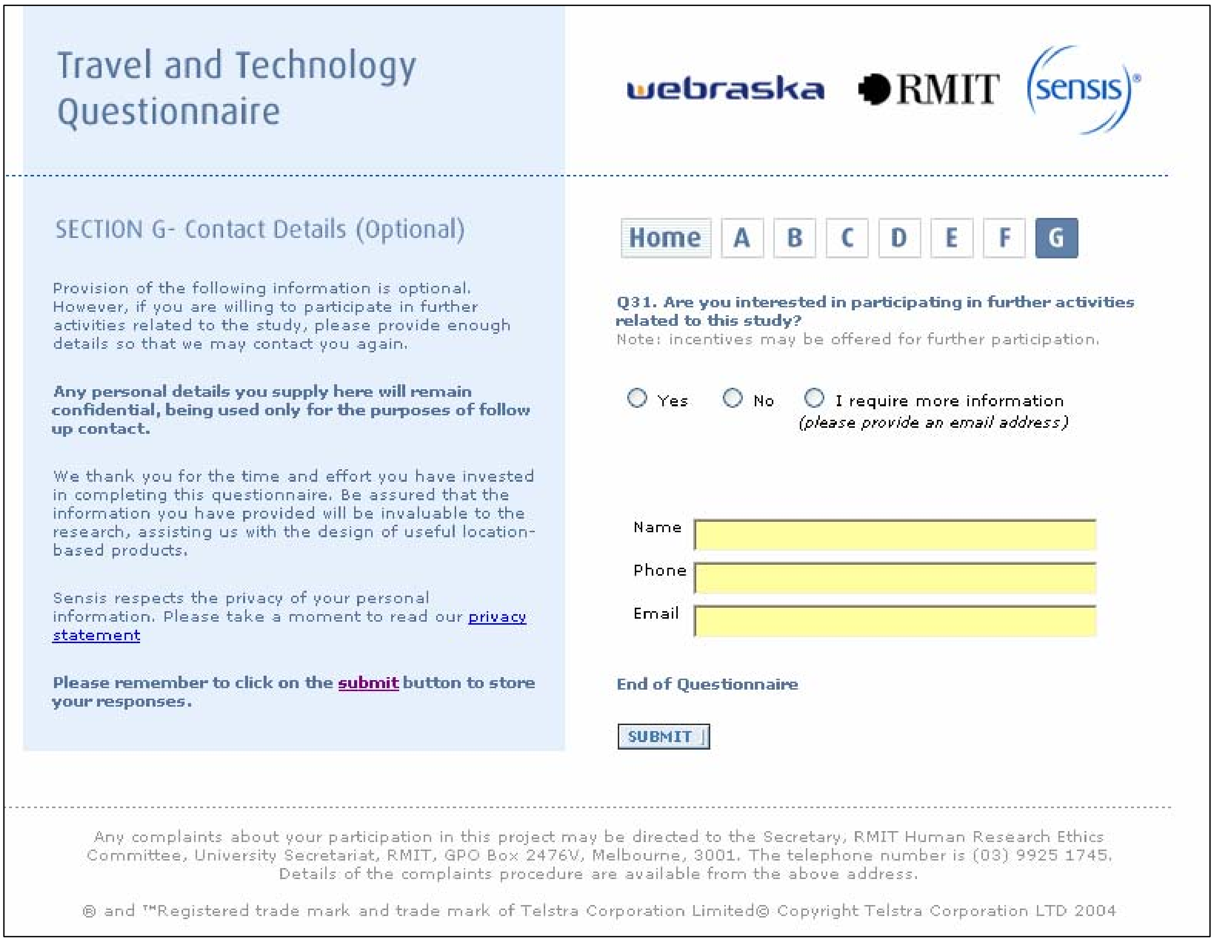
Q28. Have you ever used a Vehicle Navigation Unit (i.e. in-car computer) to follow your route while on holiday?
Select one option.

- ○ No
- ○ Yes. **How useful did you find it?**
  Select one option.
  - ○ Not useful at all
  - ○ Limited in usefulness
  - ○ Quite useful
  - ○ Very useful
  - ○ Indifferent

Q29. Do you have any problems with your vision that may affect your viewing of a computer screen (large or small)?
Please describe.

Any complaints about your participation in this project may be directed to the Secretary, RMIT Human Research Ethics Committee, University Secretariat, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 1745. Details of the complaints procedure are available from the above address.

Section F – Comments



Travel and Technology Questionnaire

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SECTION G- Contact Details (Optional)

Provision of the following information is optional. However, if you are willing to participate in further activities related to the study, please provide enough details so that we may contact you again.

Any personal details you supply here will remain confidential, being used only for the purposes of follow up contact.

We thank you for the time and effort you have invested in completing this questionnaire. Be assured that the information you have provided will be invaluable to the research, assisting us with the design of useful location-based products.

Sensis respects the privacy of your personal information. Please take a moment to read our privacy statement

Please remember to click on the submit button to store your responses.

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Q31. Are you interested in participating in further activities related to this study?
Note: incentives may be offered for further participation.

Yes No I require more information *(please provide an email address)*

Name
Phone
Email

End of Questionnaire

SUBMIT

Any complaints about your participation in this project may be directed to the Secretary, RMIT Human Research Ethics Committee, University Secretariat, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 1745. Details of the complaints procedure are available from the above address.

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Section G – Contact Details (Optional)

Travel and Technology Questionnaire

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SECTION F - Comments

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Q30. Are there any other comments you would like to make relating to anything in this questionnaire?
Eg. You may have encountered some concepts or questions that were unclear - if so, please note them here, along with the relevant question number. Alternatively, you may want to add extra information that you think is relevant, but that you didn't get the chance to record under one of the other questions.

Any complaints about your participation in this project may be directed to the Secretary, RMIT Human Research Ethics Committee, University Secretariat, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 1745. Details of the complaints procedure are available from the above address.

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Appendix B - User Task Analysis Materials

B.1 Recruitment Script

- Hi, my name is Karen Wealands and I'm calling on behalf of RMIT University in conjunction with Sensis and Webraska mobile technologies.
- You recently participated in an online 'Travel and Technology' questionnaire for a project we're conducting into the usability of geospatial information on mobile devices.
- At the end of the questionnaire you indicated that you were interested in participating in further activities related to our study and gave us you contact details.
- I'm now following up to see if you're still interested in continuing your participation into the next phase which involves one-on-one interviews about recent travel you've undertaken.
- *If no…*
  - Would you be interested in taking part in any of the future activities (including a focus group or product testing)?
  - Thankyou for your time.
- If yes…
  - Would you be available to participate in the interviews, being conducted between 25th November and 1st December (i.e. the coming two weeks)? There are afternoon and evening sessions available.
  - The interview may take up to 1.5 hours, and you will be compensated for your time and assistance with a $100 gratuity.
  - We have several times and dates available, but before we try to book you in, do you mind answering a couple of quick questions just to ensure that we have a range of participants?
    - Have you recently been on a holiday (within Australia) to a destination that was new to you, or at least relatively unfamiliar?
    - What was your mode of transport to get to your destination, for that particular trip?
- We'd love to have you participate if we can find a time/date that suits you. Those still available are …
- The interview will be held at Sensis - the address is 222 Lonsdale Street, Melbourne. It's part of the QV complex (which is on the corner of Swanston and Lonsdale Streets) and you enter Sensis off Lonsdale St – walk up until you see the sign and revolving door. The nearest train station is Melbourne Central.
- Being a large office complex, there are a few security procedures you'll have to follow when you arrive:
  - First, you must report to the concierge desk on the ground floor where you will need to provide your name, organisation (if applicable) and my name, Karen Wealands, as the person you are visiting. You will be given a temporary access pass which you must wear around your neck at all times within the building.
  - Next, you'll need to take a lift to Sensis reception on the 6th floor (you will need to use your security pass to access this level in the lift – swipe it in front of the scanner and press the button).
  - At Sensis reception, ask the receptionist to contact me in relation to the RMIT interviews using my mobile phone number which they should already have, but just in case it is <number provided>. As soon as they contact me I will meet you to take you to the interview room.
- I suggest that you allow 10-15 mins before the interview time to allow for public transport or parking (which is located under the QV complex).
- Because the interviews are scheduled back-to-back it is important that participants arrive on time. Would you like a reminder call, approximately 2 hours before the interview time (preferably a mobile phone number)?

- I will be emailing you all of the details you'll need within the next couple of days, including the building access we've talked about and a Plain Language Statement describing the research.
- You can email or call me prior to the interview to ask any questions you may have – my contact details will be at the bottom of the email.
- One last thing I'd like to ask is for you to do some minor preparation before the interview. This consists of spending some time thinking about the last holiday you took within Australia that was to an unfamiliar location. The reason I'm asking you to do this is that during the interview I will be asking you about your travels and I believe it may help you to think about it beforehand so that you are more comfortable during the interview. It may also help to speak to others that accompanied you during the trip. Some examples of the things you will be asked about include the planning you did beforehand, your experiences whilst journeying to your destination and how you got around at your destination. You don't need to spend a lot of time on this, just what you feel comfortable with.
- Finally, if you need to pull out of the interview, for whatever reason, that is completely fine. I'd appreciate though, it if you could let me know ASAP so that I can find someone else to fill the timeslot.
- Thanks for you time and willingness to participate. I look forward to meeting you at the interview.

B.2 Confirmation Email

Hi <name>,

Thanks for agreeing to take part in the next phase of our research into the usability of geospatial information on mobile devices. This is a joint project involving RMIT University, Sensis and Webraska Mobile Technologies. Please reply to this email in order to confirm that you received it and that the interview time stated below is in fact the time we previously agreed upon.

As we discussed over the phone, your interview is scheduled for <time> on <date>. It will take no more than 1.5 hours and is located at Sensis. The address is 222 Lonsdale Street, Melbourne – it is part of the QV complex, with entry off Lonsdale St (refer to the attached map). I would appreciate it if you could arrive just before the interview in order to allow for the required entry procedures, which are:

- First, report to the concierge desk on the ground floor where you will need to provide your name, organisation (if applicable) and my name, Karen Wealands, as the person you are visiting. You will be given a temporary access pass which you must wear around your neck at all times within the building.
- Next, you'll take a lift to Sensis reception, located on the 6th floor (you will need to use your security pass to access this level in the lift – swipe it in front of the scanner and press level 6).
- At Sensis reception, tell the receptionist you are here for the RMIT interviews and they will contact me on my mobile phone number – which they should have, but just in case it is <phone number provided>. As soon as they contact me I will meet you to take you to the interview room.

I suggest that you allow 10-15 minutes before the interview time to allow for public transport or parking (there is a car park located underneath the QV complex – see map for entrances). [At your request, I will give you a reminder call on the day of the interview, approximately 2 hours before the scheduled time.]

I have attached to this email two other documents: (1) the Plain Language Statement for this stage of the research, which will explain the purpose of the interviews along with information regarding your privacy, and (2) a consent form which you will be required to sign – note the attachment is for your information only at this stage, I will provide a hard copy for your signature at the interview. If you require any further information, please don't hesitate to contact me.

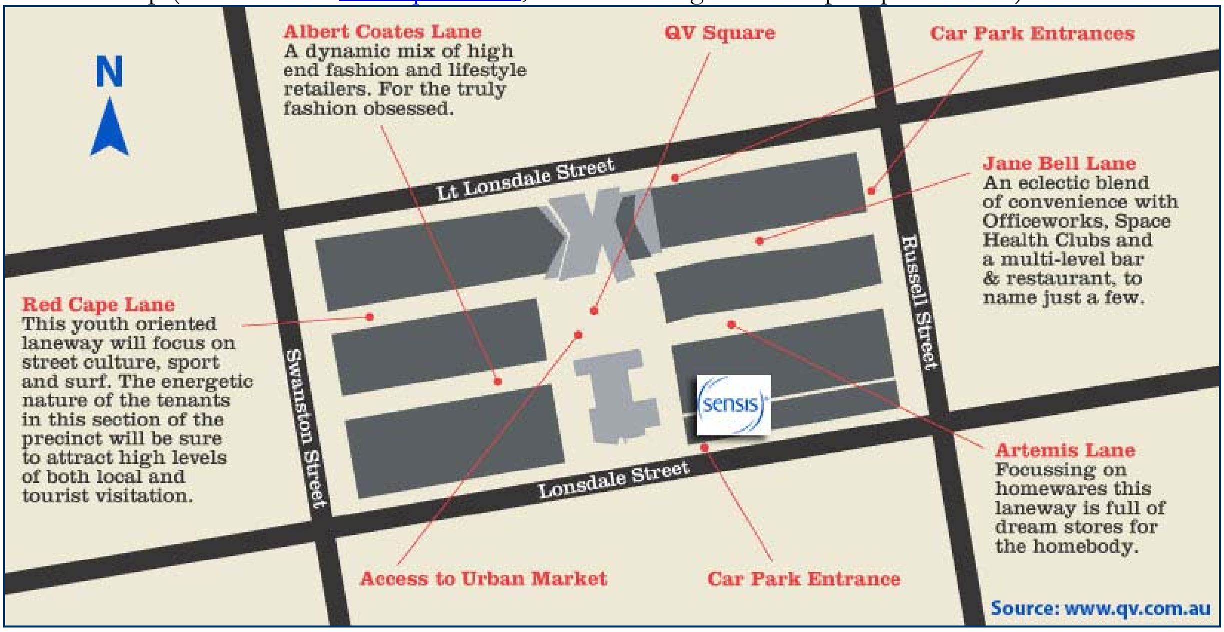
Finally, as I mentioned on the phone I would like you to do some minor preparation before the interview. All that I ask is that you spend some time thinking about the last holiday you took within **Australia** (i.e. leisure- rather than work-related travel). If possible, I'd like you to focus on a trip that was to a destination you had never been before or at least were relatively unfamiliar with beforehand. The reasoning behind this preparation is that I will be asking you about your travels and believe it may help you to think about it beforehand so that you are more comfortable during the interview. It may also help to speak to others that accompanied you during the trip. Some examples of the things you will be asked about include the planning you did beforehand, your experiences whilst journeying to your destination and how you got around at your destination. You do not need to spend a lot of time on this, just what you feel comfortable with.

I'd like to thank you again for agreeing to take part in the research and look forward to meeting you on <date> at <time>.

Regards,

Karen Wealands BGeom (Hons), BSc
PhD Candidate
Geospatial Science, RMIT University
<contact details provided>

Attached map (sourced from www.qv.com.au, with Sensis logo and compass point added):



B.3 Plain Language Statement

16 November 2004

RMIT UNIVERSITY

School of Mathematical and Geospatial Sciences

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Melbourne Australia 3001

Telephone + 61 3 9925 2213
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Email: geospatial@rmit.edu.au

PROJECT INFORMATION

Representation models for the delivery of useful, interactive geospatial information services via the mobile Internet

Dear Participant,

My name is Karen Wealands and I am writing to follow up on my invitation for you to participate in the next stage of a research project I am conducting in conjunction with Sensis™, as part of my PhD program at RMIT University. I previously contacted you in relation to an online questionnaire, which you completed as part of the first stage of the project. It is based on your responses to this questionnaire, as well as your previous registration of interest in assisting with Sensis product testing, that I have contacted you again with respect to continuing your participation.

My investigations are under the supervision of Associate Professor William Cartwright and Dr Suzette Miller, both lecturers at RMIT, Mr Kirk Mitchell, General Manager of Webraska Mobile Technologies (Asia-Pacific) and Ms Lesley Forsyth, Human Factors Specialist (User-Centred Design) of Sensis. Below is a brief summary of the research for your information.

BACKGROUND

Location-based services (LBS), available on mobile phones and handheld computers, are becoming increasingly popular. Today, a growing number of people are accessing information on the go, in order to answer location-related questions such as "where is my nearest ATM?" and "how do I get home from here?" Despite the appeal of many of the services on offer, the speed with which they are becoming available reflects a general industry trend of design driven by the technology rather than the needs of the end user – such as yourself – with the usability of the services often suffering. In light of this, RMIT University, Webraska Mobile Technologies and Sensis are working together, with the support of the Australian Research Council (ARC), to trial different methods for representing spatial information within LBS, based on the needs of actual users.

The primary aim of this research is to apply User-Centred Design techniques to develop useful spatial representations for LBS. We hope that it will pave the way for future LBS that are highly useful and user-friendly, catering to the needs of everyday people.

CALL FOR PARTICIPATION

To help us with the next stage of the research project, we have sought previous participants willing to take part in discussions of their experiences during recent holiday travel. Your agreed participation involves attendance at a one-on-one interview where you will be asked questions relating to your use of spatial information when travelling. The interview will take no longer than one and a half (1½) hours. An observer will be present during each of the sessions, which will also be videotaped for later analysis, provided that you consent to this. All efforts have been made to meet at a time that is convenient to you; note that you will be compensated for your time and any expenses associated with your participation. This will be in the form of a gratuity of $100.

PRIVACY

No findings that could identify you will be published as part of this research. Only the combined data of all participants will be presented (at international conferences) or published (in refereed journals), with one exception being useful quotes, which will of course be presented anonymously. Additionally, both Webraska and Sensis will be supplied with a report detailing the findings of the study, in aggregate form only. Importantly, all interview/focus group responses **will remain confidential**, subject to legal constraints.

Only my supervisors and I will have access to the research data, which will be securely stored in a locked cabinet at RMIT University for a period of five years prior to being destroyed, as prescribed by the *Joint NHMRC/AVCC Statement and Guidelines on Research Practice*. Note that the RMIT University Human Research Ethics Committee has given its approval to this project.

CONTACT INFORMATION

In conclusion, please be aware that participation in this research is entirely voluntary. You may withdraw at any time simply by notifying one of the researchers, by phone, email or in writing. All of the relevant contact details are provided at the bottom of this letter. Similarly, if you have any queries or would like to be informed of the aggregate research findings, please don't hesitate to contact us.

Thankyou for your time.

Karen Wealands BGeom (Hons), BSc
PhD Candidate
<contact details provided>

Dr Suzette Miller PhD, BAppSc (Cartography)
Supervisor
<contact details provided>

Assoc Prof William Cartwright
Supervisor
<contact details provided>

Mr Kirk Mitchell
Supervisor
<contact details provided>

Ms Lesley Forsyth
Consultant
<contact details provided>

Mail:
Attn: Karen Wealands
C/o Geospatial Science,
RMIT University
GPO Box 2476V,
Melbourne Victoria 3001

Any complaints about your participation in this project may be directed to the Secretary, RMIT Human Research Ethics Committee, University Secretariat, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 1745.
Details of the complaints procedure are available from the above address.

B.4 Consent Form

HREC Form No 2b

RMIT HUMAN RESEARCH ETHICS COMMITTEE

Prescribed Consent Form For Persons Participating In Research Projects Involving Interviews, Questionnaires or Disclosure of Personal Information

SCHOOL OF	**Mathematical and Geospatial Sciences**		
DEPARTMENT OF	**Geospatial Science**		
Name of participant:			
Project Title:	**Representation models for the delivery of useful, interactive geospatial information services via the mobile Internet**		
Name(s) of investigators:	**Karen Wealands** (Student Researcher)	Phone:	<provided>
	William Cartwright (Senior Supervisor)	Phone:	<provided>
	Suzette Miller (Supervisor)	Phone:	<provided>
	Kirk Mitchell (Supervisor)	Phone:	<provided>

1. I have received a statement explaining the interview involved in this project.
2. I consent to participate in the above project, the particulars of which - including details of the interview - have been explained to me.
3. I authorise the investigator or his or her assistant to interview me.
4. I acknowledge that:

   (a) Having read Plain Language Statement, I agree to the general purpose, methods and demands of the study.
   (b) I have been informed that I am free to withdraw from the project at any time and to withdraw any unprocessed data previously supplied.
   (c) The project is for the purpose of research and/or teaching. It may not be of direct benefit to me.
   (d) The privacy of the information I provide will be safeguarded. However should information of a private nature need to be disclosed for moral, clinical or legal reasons, I will be given an opportunity to negotiate the terms of this disclosure.
   (e) The security of the research data is assured during and after completion of the study. The data collected during the study may be published, and a report of the project outcomes will be provided to Webraska Mobile Technologies. Any information which will identify me will not be used.

Participant's Consent

Name: ______________________________ Date: ______________

(Participant)

Participants should be given a photocopy of this consent form after it has been signed.

Any complaints about your participation in this project may be directed to the Secretary, RMIT Human Research Ethics Committee, University Secretariat, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 1745.
Details of the complaints procedure are available from the above address.

B.5 Task Analysis Interview

Interview Script

Travel and Technology Interview

Legend
[ ] - To be asked only if relevant to the participant (based on a previous response)
• - Probes to elicit extra information, where required

Introduction (script)

I'm going to ask you questions about your holidays within Australia. I'm interested in hearing about your actual experiences – whether good or bad – with various aspects of your holidays including planning for the trip, getting there, what you did while you were there, as well as a little bit about what happened when you arrived home.

A – Introduction

1. Have you got any travel coming up or planned for the near future?
    - How far into the future is it?
    - Have you been there before?
    - How often do you generally travel on holidays within Australia (e.g. per year)?

2. I'd like you to [keep this upcoming travel in mind, but now] visualise the last holiday you took within Australia that was to somewhere you'd never been before or was fairly unfamiliar to you. Can you describe your trip for me, in as much detail as you like (e.g. in terms of what you did, the order you did it all in, the actual activities you participated in, etc.):
    - who did you go away with (no names, just relationships & gender)?
    - how did you get there (i.e. transportation)?
    - how long did you stay?
    - what sort(s) of accommodation did you stay in?
    - how did you get around at your destination (i.e. transportation)?

B – Pre-trip

I'm now going to show you a short presentation that will hopefully get you thinking about the sorts of location-related information you generally use to plan your Australian holidays (it doesn't have to be just about this holiday). It will run on its own and I'd like you to just watch it through, letting any memories of trip-planning come to the surface.

Show PowerPoint presentation 1 (pre-trip resource examples)

3. Thinking about your last holiday [and your upcoming one], what were your overall criteria when you chose your holiday destination?
    - What activities did/do you want to do there?
    - Were/are you visiting friends/family?
    - What information influenced your final decision?
    - Did the (time) length of your trip dictate your holiday criteria or did your criteria dictate the (time) length of your trip (i.e. what came first)?
    - How / why did you choose the particular mode(s) of transport you took?

4. These next questions relate to any location-related research you might have done [/are doing] about your destination before you left [/leave]:
    a. What types of maps, if any, did you look at?
        - Where did you get these?
    b. Where did you look for information on what activities were there?
    c. Did you try to find out if there were any local events on at the time of your visit?
        - How did you go about doing this?

d. What other information did you try to find out before the trip (e.g. weather forecasts, etc.)?
e. Is this the usual amount and type of research you do into new destinations before a holiday?
  - What other types of research have you done for other trips?
f. How easy was it for you to find out what you wanted to know – for example, some people find it frustrating trying to find the information they need, while others have no problems at all?

5. Now I want to ask a few questions about any location-related planning you might have done [/be doing] prior to your holiday:
   a. [How well did you plan the route you would take to get there?
      - What information or criteria did you use to help you in this planning?
      - Did you plan any stop offs along the way?]
   b. Did you plan the activities you would take part in when you got there?
      - Did you plan a schedule for these in advance?
   c. How did you plan/choose your accommodation?
      - Did you make any other sorts of advance-bookings (e.g. for tours, etc.)?
   d. Is this the usual way you go about planning when going somewhere new?
      - What other sorts/amounts of planning have you done on other trips?
      - Why do you choose to plan to this level (any constraints)?
   e. How easy was it for you to find out what you wanted to know to help you plan – again, some people have bad experiences with finding this sort of information, while others don't?

C – On-trip

We've gone through the stages of travel planning, now I'm going to show you a short presentation that I hope will bring out some of your memories about the sorts of location-related information you generally use while you're travelling. Again, it will run on its own and I'd like you to watch it through.

Show PowerPoint presentation 2 (on-trip resource examples)

6. Returning again to you last holiday, I'm interested in hearing about how you actually got to your destination:
   a. [How closely did you follow the route you'd planned?]
   b. What sorts of information or 'tools' did you take with you to help you get to your destination and/or to get around when you got there?
   c. What other forms of location-related information did you use along the way – for example, things in the surrounding environment?
   d. What sort of problems, if any, slowed down or interrupted your progress along the way (e.g. did you get lost, encounter heavy traffic, etc.)?
      - What did you do in that situation?
      - What other sources of information do you think might have helped?
   e. Who did most of the navigating?
   f. Did you make any unplanned stop-offs along the way?
      - How did you find it/them?
      - What did you do there?
      - What information did you need/use there?

7. What were your general goals/aims when you were at your holiday destination (i.e. what did you want to get out of your trip)?
      - Did you want to get to know the location?
      - Did you want to maximise your time there and do as much as possible?
      - Did you just want to relax?

8. When you arrived at your destination, what was it like generally finding your way around?
   a. Did you use any 'tools' to help you with this (e.g. maps)?
      - Where did you get them from (e.g. things you were carrying, things in your surrounding environment, your own thoughts and knowledge)?

b. How did you go about working out where you were (i.e. orienting yourself) in terms of the destination itself?
    - Did you have any problems? If so, what did you do in such situations?

c. Who did most of the navigating?
d. How much faith did you have in the tools you used (i.e. how useful were they)?
e. What other sources of information do you think might have helped?

9. How did you generally figure out how far away and in what direction specific things were that you wanted to do / places you wanted to visit?
    a. Did you have any problems? If so, what did you do in such situations?
    b. Did you use any 'tools'?
        - Where did you get them from?
    c. How much faith did you have in the tools you used (i.e. how useful were they)?
    d. What other sources of information do you think might have helped?

10. At any stage throughout your holiday, did you ever feel that you were lost (even for a few minutes)?
    - What did you do in that situation?
    - What information did you use?
    - What other sources of information do you think might have helped?

11. Based on the situations we've been discussing, I'm interested in finding out what information sources you prefer to use when you're on holidays. That is to say, what is it that makes you use one source or form of information over another (e.g. guidebooks vs. maps vs. asking locals vs. tourist info centres)?

12. At some stage you probably had to make a choice between two things you wanted to do, but could only do one. Try to remember one such decision or trade-off from your last holiday. What helped you make the decision (e.g. information, values)?

13. When you were on holidays, what other people did you interact with (other than your travel companions)?
    - Did you meet up with friends or family?
    - Did you join any tour groups?
    - Did you get to know other tourists?
    - Do you usually do any of this?

14. By the end of your holiday, how familiar/comfortable did you feel you had become with your destination?
    - How confident were you that you could find your way around easily?

D – Post-trip

That's the end of my questions about the holiday itself. Now I'd like to ask a couple of questions about the end of your travels.

15. When you got home, who did you share your travel experiences with?
    - Is this your usual behaviour after a holiday?

16. How do you think that your experiences will contribute to planning or undertaking your next [/upcoming] travels (e.g. in terms of methods of information access, routes, decision-making, etc.)?

E – Familiar destinations

17. We've talked about preparations you've made before a trip, the things you've done whilst you're travelling and a little bit about what happens when you get home, and this has all been about a holiday to somewhere you've never been before. Now I'd like you to think back to your last trip to somewhere you had been before. Can you comment on how any of these aspects – pre-trip planning, on-trip activities and post-trip reflection – differed for this more familiar trip?
    - Did you do that same level of research or planning beforehand?
    - Did you have any problems while you were travelling?
    - Did you use any of the same resources?
    - Did you share your experiences when you got home?

F – Future information sources

Describe the 'Holiday Assistant' service

18. What sort of characteristics would the information provided by the 'Holiday Assistant' have to have in order for you to use it (e.g. currency, accuracy, etc.)?
    a. How useful would you find knowing your exact location (via GPS or other)?

19. What sort of 'tips' or other specific information would you find useful whilst travelling (e.g. events, discounts on accommodation, etc.)?

20. What is your opinion of 'push'-type services (i.e. where you provide a profile of your interests and if something of relevance comes into date/time/location range you are 'pushed' information about it)?

21. How responsive should such a service be in terms of the time taken to search for the information you want and then have it presented to you (i.e. how patient would you be)?
    - Before the trip
    - During the trip

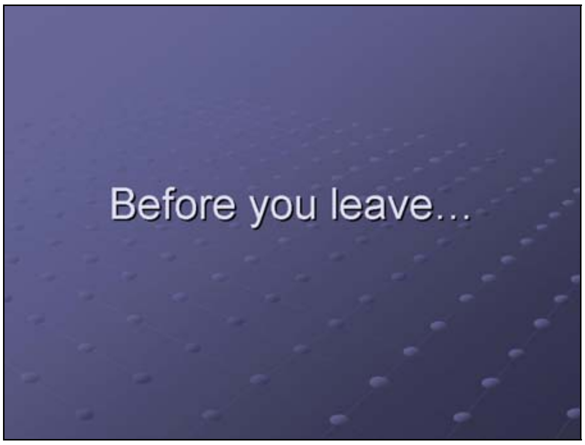
22. What sort of mobile devices / technology would you be comfortable using in order to access the 'Holiday Assistant' (e.g. mobile phones, handheld computers, GPS units)?
    - Would you prefer a stationary device for pre-planning/research activities?

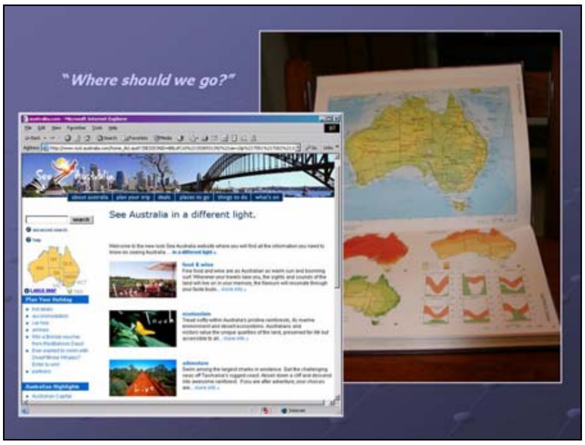
F – Other

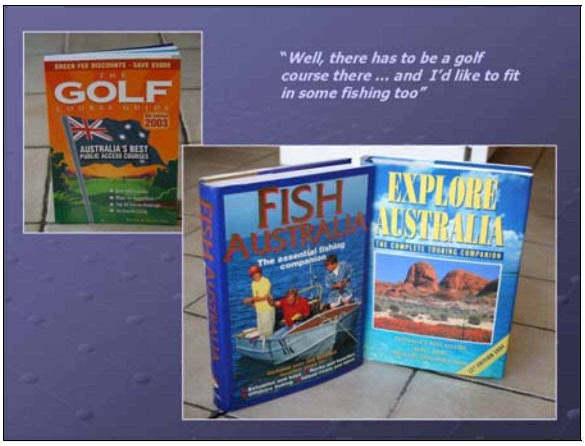
23. That covers everything I wanted to ask you today. Do you have any else you'd like to add?

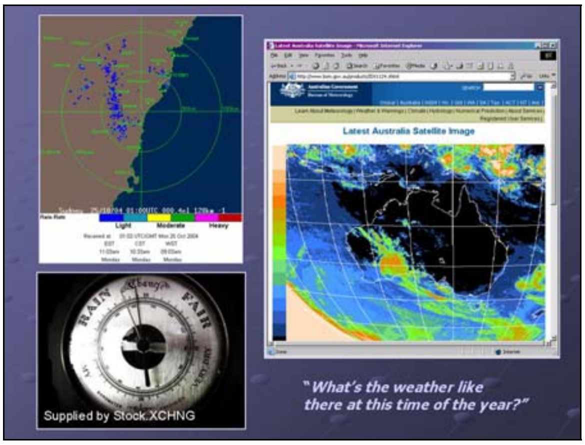
Debrief

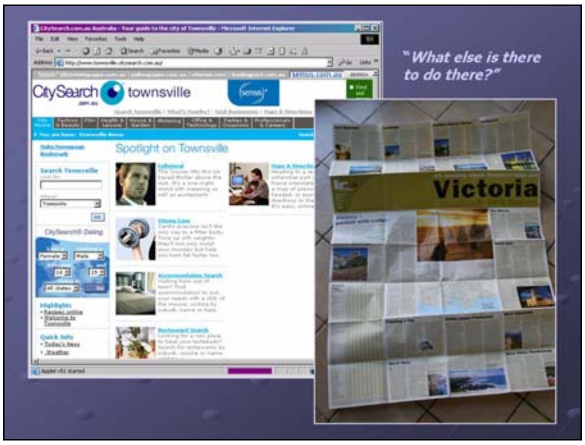
Presentation One: Pre-trip Resources

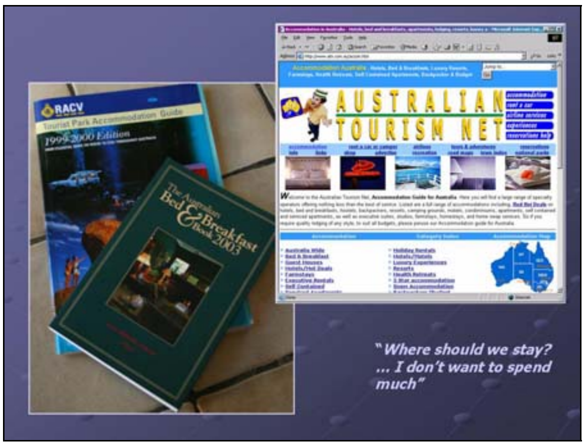


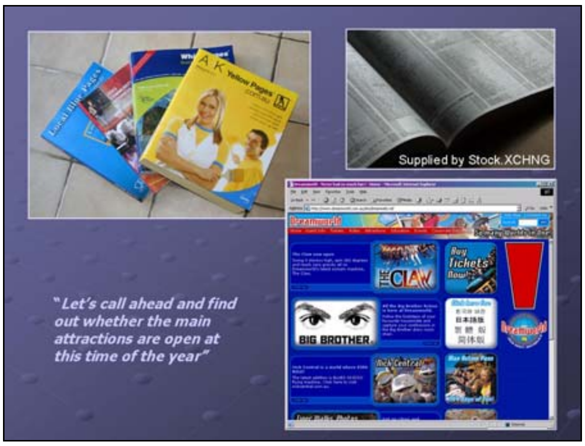


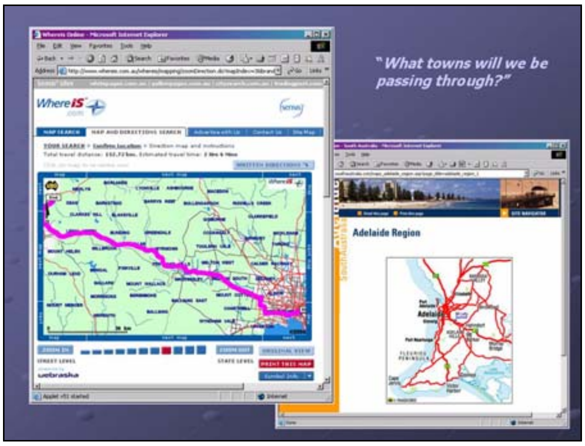




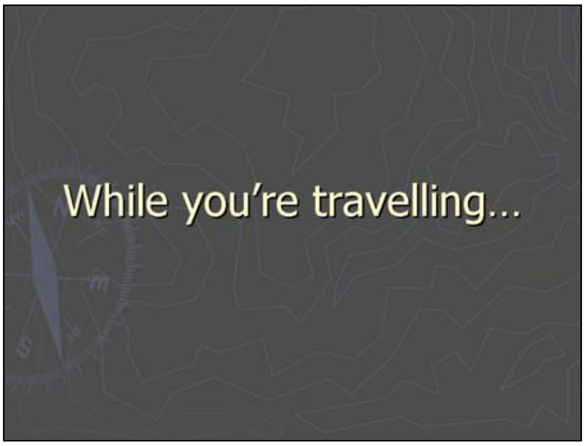


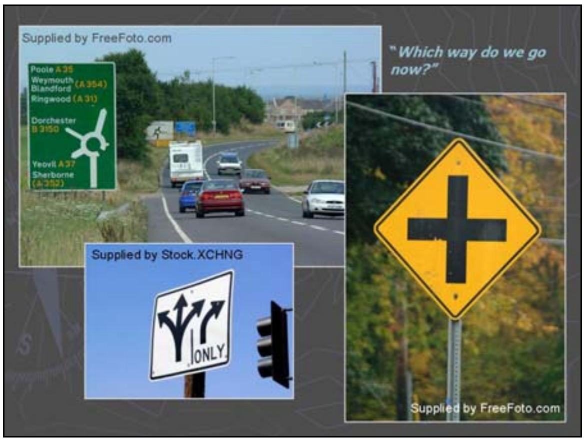


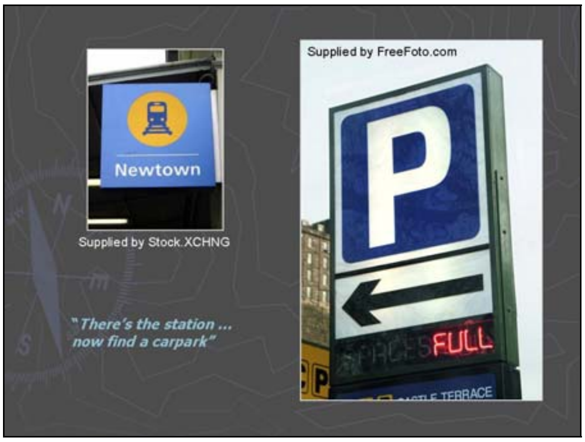




Presentation Two: On-trip Resources






Newtown
Supplied by Stock.XCHNG
"There's the station ... now find a carpark"
Supplied by FreeFoto.com
P
FULL


Supplied by Stock.XCHNG
WARNING
CLIMBING ON ROCKS, SWIMMING & WADING UNSAFE
NEXT 25km
Supplied by Stock.XCHNG
Supplied by www.bigfoto.com
FIRE DANGER TODAY
"We'd better watch out along here"


"Look out for it ... it shouldn't be much further"
All images supplied by Stock.XCHNG


Images supplied by Stock.XCHNG
"Call your brother and let him know we'll be there in 15 mins"

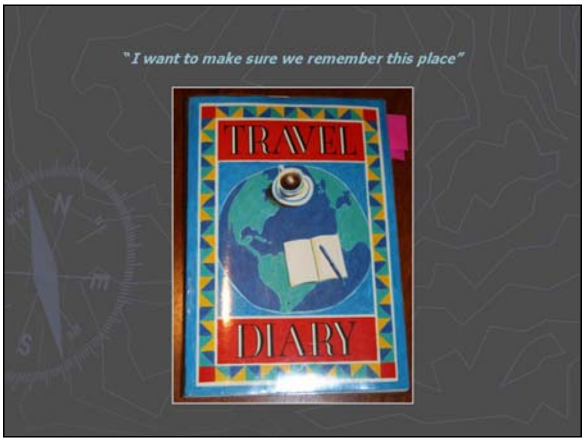

"Let's ask those people over there which way it is"
Images supplied by Stock.XCHNG


"I think we'd better look at the map"
Images supplied by Stock.XCHNG


"Is there anything special happening in town while we're here?"
Supplied by Stock.XCHNG
Supplied by Stock.XCHNG


"Oh no, the weather doesn't look good up ahead"
Images supplied by Stock.XCHNG


"Where should we go for dinner tonight?"
GOOD FOOD GUIDE 2003
Yellow Pages
Local Blue Pages


"I want to make sure we remember this place"
TRAVEL
DIARY

B.6 Interview Narrative Summaries

Participant 1

Averaging two holidays per year for leisure and over 15 for business, *Participant 1* is considered a frequent domestic traveller. In fact, she has a trip planned within the next month to visit family in Sydney, a destination she is quite familiar with. *Participant 1's* general pattern of travel is to book accommodation in advance, mostly based around pre-defined dates, which then dictates her plans and the route to her final destination. Apart from accommodation (which she mainly pre-books for larger towns/cities or when the destination is expected to be busy), her holiday planning is quite vague – *Participant 1* and her partner prefer an unstructured "organic, evolving" travel experience, rather than one that is rigidly planned. She has neither the time nor interest in doing a lot of pre-planning.

On a recent trip, *Participant 1* travelled to Brisbane by private car with her partner. This trip lasted two weeks during which time they also visited Lakes Entrance and Sydney. Another recent driving holiday took them to Adelaide and the Barossa Valley. Her accommodation for each trip ranged from Bed & Breakfasts (B&Bs) to motels and hotels/resorts, with her choice of accommodation type tending to vary based on their criteria at the time. *Participant 1* prefers not to camp or stay in caravan parks, but is comfortable with all other forms of accommodation. She generally selects and books her accommodation online or else follows the recommendations of friends and family. Apart from honouring family commitments, *Participant 1's* holiday criteria for her Lakes Entrance–Brisbane trip included driving an unfamiliar route for interest, the opportunity to visit local art (and craft) galleries and wineries, spending quiet time alone with her partner and escaping work / the everyday pressures of life. The time span of her trip was essentially dictated by family obligations, with other activities fitted in, where possible. In terms of pre-trip research, *Participant 1* generally tends not to do much as it reminds her of work, although for this holiday she looked online to obtain an estimate of the drive time from Melbourne to Lakes Entrance, and at Web-based maps providing directions to their booked accommodation.

Participant 1 did not look for any information on holiday activities prior to her trip, but expects that if she had she would have used the Web – she doesn't like to collect/read magazines or brochures before a trip. She also did not seek any information on local events, as these were not of interest to her. Nor did she look for other types of information, citing that she's done sufficient travel to know what to expect whilst on holidays. *Participant 1* conceded that she normally doesn't have the time to do much research prior to travelling, although now that she has Broadband Internet at home, she may start to do more. The only concerns *Participant 1* had about her pre-trip research related to her belief that not all accommodation operators were online and that the existing listings were quite poor and "patchy". In this respect, she wondered whether she had missed out on her 'ideal accommodation' because it was not listed on the Web.

Participant 1 and her partner did not plan their route before departing, beyond following the sequence (locations and dates) of their booked accommodation. Nor did they plan any specific stop offs along the way, except to change drivers and/or buy petrol as the need arose. In general, they may stop to see things of interest along a route, although this doesn't tend to happen much. Additionally, they made no attempt to pre-plan any non-family activities at any of their trip destinations. In terms of accommodation bookings for the Lakes Entrance–Brisbane trip, *Participant 1* pre-booked for their key destinations online (stating that she often books somewhere where they've stayed before, which was the case in Sydney). The rest of their trip was generally unstructured in terms of accommodation and other planning.

Having done a lot of east coast travel, *Participant 1* was quite familiar with most of the roads / route she followed on her Lakes Entrance–Brisbane trip. Despite very little route planning, she and her partner knew that they wanted to take the coast road, which they had never travelled before, and found it relatively easy to follow. *Participant 1* made use of her Melway on both trips, up until they had travelled beyond the scope of the street directory. She also tends to collect additional route (and other) information along the way, where necessary, as was the case on the way to Adelaide during which she purchased and used an Australian Road Atlas (however this proved useful only for following the main arterials, as it was not very detailed). The one routing problem that *Participant 1* encountered during her holidays was an unplanned 'detour' via Mt Gambier on the way to Adelaide (several hours out of the way). She put this down to a lack of pre-planning, stubbornness and inability to find a comprehensive map of the entire journey block between Melbourne and Adelaide (required by her partner to visualise the most direct route). Apart from this detour, *Participant 1* did most of the navigating during their holidays. She said that this is her general pattern as she has a good sense of direction, while her partner does not.

Whilst travelling between accommodation destinations, *Participant 1* made several unplanned stop offs to visit art galleries and wineries. Some of these were advertised, some she became aware of while driving past (eg. saw a sign), and others she found out about at tourist information centres/booths. Her other stop offs included visits to regional university campuses – something her partner is very interested in – and scenic drives to see what nearby/interesting locations looked like (e.g. the Atherton Tablelands during a previous trip). One of *Participant 1's* more specific unplanned stop offs involved visiting her grandfather in Moss Vale during her Lakes Entrance–Brisbane trip. Although she didn't know exactly how to get there, she successfully found her way using her sense of location (i.e. no maps).

When at each of her holiday destinations, *Participant 1's* general aims/goals were similar to her initial holiday criteria. She participated in family-related activities at her key destinations, but otherwise sought relaxation with her partner in locations where there were few people around. Her basic pattern on arriving at a destination was to find accommodation and then seek out a local information centre/booth in order to obtain local information (and maps, where needed) to decide what she could do within local area (about 150km radius). In this way she did up to two days of forward activity planning, but left her options open beyond this. In destinations where she hadn't pre-booked accommodation, she tended to drive down the main street of the town until she found suitable lodgings. In the Barossa Valley, however, a local festival meant she had difficulty finding accommodation in this manner. The solution was found with a B&B consolidation agency, accessible through tourist information centres in medium-sized towns, which provided a list of available B&Bs and their attributes (e.g. pricing).

Participant 1 finds it fairly easy to orient herself in unfamiliar destinations. She puts this down to travelling a lot and having been trained from an early age to read maps. She tends to use the layout of a town to orient herself and is usually aware of North. If something unexpected happens, *Participant 1* can re-orient herself without a map and get herself and her partner back on track. It is likely, however, that her partner would struggle in the same situation. One of the tools *Participant 1* used whilst on holidays was road signage, which she found to be "fabulous" in Victoria, much less so in Queensland ("you're on your own") and somewhere in between in New South Wales and South Australia (SA), although it was generally easier to get around in SA. Of the maps she used, she conceded that some free maps available from Tourist Information Centres were not reliable, often having inaccurate scales (among other things), but her awareness of their shortcomings helped her alleviate any problems. In general, where she senses any impending difficulties with getting to her accommodation, *Participant 1* relies on local advice, calling the operators in advance for directions and landmarks that she can follow – she places much faith in such information. She found particularly useful the B&B service in SA. In terms of other sources of information that may have been helpful, *Participant 1* cites the fact that she is a vegetarian, and sometimes has difficulty finding appropriate restaurants close to her accommodation and when eating 'on the road'. She noted that Tourist Information Centres don't have much information on this.

Participant 1 had no problems working out in which directions things she wanted to do and places she wanted to visit were. She admits, however, that she is "chronic underestimator of time". This is mostly a result of her not knowing the condition of the roads on which she will be travelling, speed reductions caused by sun glare and/or traffic conditions, weather conditions ahead (although this has not caused any problems thus far) and so on. *Participant 1* did not feel "lost" at all during her travels, although she feels she has a general sense of knowing when she is travelling in the wrong direction. In such cases she will turn the car around and backtrack or sometimes stop to check with a map (paper-based or 'in the head'). Her partner has difficulty reading maps and so finds it difficult to assist with the navigation in this way. *Participant 1's* preferences for information sources gravitate towards maps, particularly local maps collected from tourist information in the area she is visiting. She likes to get a sense of the local area and feels that online maps are relatively incomplete in comparison. *Participant 1* prefers not to carry any technological devices whilst on holidays, only taking her mobile phone "under sufferance". She would actively choose **not** to have a positioning device or electronic tool whilst travelling, although her mother's recent positive experience with a navigation device prompted her to hypothesise that she may in fact like this if she had it herself.

When presented with a choice between two destinations/activities whilst on holidays, *Participant 1* tends to make a decision based on what fits in best with the journey (especially in terms of time). She tries not to backtrack, preferring a continuous route where possible. Therefore she would not choose an option that required deviation from her route. By the end of her recent travels, *Participant 1* felt that she had become comfortable with her major destinations, such that she could return there and find things or else give directions to other people wanting to visit there. For the smaller destinations, she felt like she knew what was in town and where it was relative to other towns. Apart from the family she visited, her work colleagues (when attending a conference) and friends, e.g. where they lived at one of her destinations, *Participant 1* tended not to interact with other people during her recreational holidays. After each trip, *Participant 1* shared her holiday experiences with friends, family, work colleagues and associates, but generally only when asked about the trip. Having reflected on her experiences, she feels that there are a number of ways that her travels will contribute to future holidays. For example, she will not allow her partner to do any navigating, after their detour through Mount Gambier. Also, she may in future plan a little bit more to avoid such situations. She has had positive experiences pre-booking accommodation at her key destinations and will continue to do so in order to provide some structure to the holiday. The Lakes Entrance–Brisbane trip helped her to learn which sections of the route to avoid when visiting again, e.g. where road conditions, traffic and the time of the year proved problematic, and places not worth visiting again.

When comparing her travel to familiar and unfamiliar destinations, *Participant 1* noted that she is more careful in booking accommodation for unfamiliar travel so that nothing is left to chance. Also, when she is visiting somewhere she goes regularly, she tends to have preferences about where to stay and places to visit again. *Participant 1* likes to be more experimental, in terms of looking for things to do, when she visits somewhere unfamiliar. Most of her trips involve both classes of destination.

When presented with the concept of the 'Holiday Assistant' *Participant 1* stated that it would not be of immediate interest to her. She commented that in order for her to use it, it must provide information that is relevant to her – she would especially not like a lot of advertising, pop-up windows, pop-up events/activities, etc. unless they were tailored to her interests (eg. via a profile). *Participant 1* liked more the idea of being able to search for specific information, such as opening hours for galleries and small wineries. Moreover, she would expect the information provided by the 'Holiday Assistant' to be "perfect" in terms of currency (i.e. up-to-date) and accuracy. According to *Participant 1*, the positioning aspect of the service would be most useful if it provided an estimated time of arrival at her destination – although this would mainly be important when she had to be somewhere at a specific time. She commented that ideally the device would be location- and context-aware, knowing what her interests were and alerting her when she was nearby an attraction matching her profile. She would want to have this type of information within sufficient time to make the decision whether or not to visit the attraction (e.g. five minutes before the turn-off).

The types of 'tips' or other specific information that *Participant 1* would find useful while travelling include large attractions and seasonal events (so that she may avoid them), alerts – e.g. weather warnings particularly for remote tropical regions), road blocks/closures, town closures – and the location of petrol stations of a particular type. *Participant 1* had mixed feelings about 'push'-type services, rejecting broad tourist information, but accepting the idea of context-relevant information such as local art galleries, or safety warnings for the region. She did not accept the idea of push advertising, except in larger towns and cities where there is a lot happening. *Participant 1* was not concerned with a relatively large lag time when searching for information using the 'Holiday Assistant', as long as she was made aware of it before conducting the search, or was at least told how long at the time of the search. She would mainly use the service in the morning when she had sufficient time to plan her day, however for her more immediate information needs, she would expect it to be comparable in speed to the fixed Internet. Finally, *Participant 1* felt that she would be comfortable using a mobile phone of relatively high standard to access the 'Holiday Assistant', however she was concerned that this would not meet her expectations for data input. Instead she suggested that she would be prepared to hire a PDA-type device to access the service, however she would not purchase one. In remote areas especially, *Participant 1* wanted a device that could be positioned. In terms of pre-planning and research, *Participant 1* preferred the use of a desktop machine with a fixed Internet connection for reasons of increased speed, larger screen size and greater responsiveness.

Participant 2

Averaging between four and six holidays per year, *Participant 2* is considered a frequent domestic traveller. While most of his holidays consist of weekend driving trips within Victoria, he tries to take a longer holiday every couple of years. He also tries to organise trips where he can take his dog – this is often part of his holiday criteria – and now considers child-friendly locations too. On a recent trip, *Participant 2* and his wife travelled to Cape Bridgewater on the Victorian coast (near the border of South Australia). They had been there previously, but at the time stopped only briefly (at which time they got engaged). Apart from this, *Participant 2* also recently travelled to Cairns (by airplane) and regularly travels to Wilson's Prom (by car) with friends.

Participant 2's holiday to Cape Bridgewater covered one weekend with this choice of destination prompted by his and his wife's sentimental link to the location as well as the fact that they had never actually stayed there before (i.e. it was somewhere 'new'). Their other criteria were Cape Bridgewater's beachside location, the fact that it was not too far to drive from Melbourne for the weekend and their prior knowledge that the local sightseeing was good. They also anticipated that they may be able to take their dog along. A final, important, criterion was the fact that *Participant 2's* wife was seven months pregnant at the time and so they wanted, above all, a relaxing holiday. This was also the reason that they had little interest in planning any active recreation during the trip. *Participant 2* and his wife drove by private car to Cape Bridgewater, citing this as the most practical means of transport for them to get there.

As far as pre-trip research was concerned, *Participant 2's* wife did the majority of this – a logical choice as she works in the tourist industry as is thus fairly resourceful when it comes to finding out such information. To this end she looked at a number of tourism Websites (e.g. VisitVictoria.com and GreatOceanroad.com) to find out information on accommodation and activities in the area, as well as to look at maps of the region. They tend to most of their pre-trip research online. Other maps that *Participant 2* looked at in advance were the Melway and the Vic Roads Country directories. *Participant 2* and his wife did not try to find out if there were any local events on at the time of their visit, however they did search for information pertaining to restaurants near to their accommodation. Had they not been so focused on relaxation, it is likely they would also have checked weather forecasts, which would affect their common activities of walking and swimming.

Participant 2 did not plan their route to Cape Bridgewater, simply because as far as he was concerned there was only one, fairly straightforward, way to get there. He noted that they would normally have taken the coastal scenic route, however this time they wanted to get there as quickly as possible (for his wife's comfort) and so took the inland route. The only activities that *Participant 2* and his wife 'planned' in advance were to visit the spot where they had become engaged, to do some local sightseeing and to drive along the coast beyond Cape Bridgewater. These activities were not scheduled however. Their accommodation was chosen and booked online, being a holiday house rental which they chose for its view of the beach (they were not able to find any accommodation that allowed dogs). They made no other advance bookings at this time (there was no need), however they would normally do so if they felt it was necessary. This level of research and planning was somewhat less than usual for *Participant 2* and his wife, primarily because of their preference to relax on this holiday. Normally they would also do further research by visiting tourist information centres along the way to collect information (e.g. about local events) and speak to operators. In spite of their planning, they also like to have a bit of flexibility and *Participant 2* noted that a lot of their preferred activities don't need to be planned (e.g. walks). Overall, *Participant 2* felt that their pre-trip research and planning experience was quite simple, aided by the ease of online searching and email communication with the accommodation operators. This he compared to the research they did before their Cairns trip whereby they had difficulty finding online information regarding tours of the Daintree rainforest.

The route that *Participant 2* had 'planned' was followed precisely under the navigation of his wife (who is "very good with directions"), whereby they drove directly from Bundoora to Cape Bridgewater, stopping off only for toilet breaks, to stretch their legs, to buy snacks/the newspaper, etc. Along the way they utilised their Vic Roads Country Directory and their Melway, having confidence in the accuracy of each. They also took with them a 'sketch map' to find the home of the accommodation owners (and the accommodation itself), where they needed to pick up keys. This map was emailed to them in advance by the owners and included landmark information that helped them to locate the house (the owners lived near the airport and so they followed road signs to the airport). The only problem that *Participant 2* and his wife encountered was almost running out of petrol when exploring the coast beyond Cape Bridgewater. They had not realised how far the drive to Nelson was and could not find a petrol station in between the two towns. *Participant 2* felt that they could have used extra information at this time (e.g. signs or other) about the locations of any nearby petrol stations that were not on the main road.

When at their destination, their goals were again to relax, but also included investigating real estate in the area (with the view to buying a holiday house in the future) and *Participant 2* wanting to pursue his hobby of digital photography. Upon their arrival at Cape Bridgewater, *Participant 2* and his wife had no real problems orienting themselves and finding their way around, apart from an initial wrong turn (in the dark) at the entrance to their accommodation. At this point they made use of the sketch map they were given and his wife's memory to rectify the situation – she continued to do most of the navigation around their destination. They knew where the coast was and tended to use this during their local navigation. When asked what other information they could have made use of at their destination, *Participant 2* responded that a local map would have been helpful (although they never looked for one), or even a Palm Pilot to which they could have downloaded relevant digital maps.

In order to figure out the direction of, and distance to, places/things of interest, *Participant 2* made use of road signs, their Vic Roads Country Directory and the information in brochures / a visitor folder found at their accommodation (including directions and time estimates). The folder in particular was a trusted source since it was created by people who lived in the area – *Participant 2* and his wife had faith in this local knowledge. When asked what other information might have help in getting around, *Participant 2* could not think of anything, although he suggested that asking locals can be a very helpful information source – e.g. a visit to the local fishing tackle shop can provide recommendations for good places to fish. *Participant 2* and his wife did not get lost whilst holidaying at Cape Bridgewater, however he was able to recount a situation during their trip to Cairns. After borrowing a friend's car and driving around the Kuranda area, they couldn't find their way back to the main road. Having no street directory in the car, they chose to drive around until they found their way back to the main road, traffic – this took over ten minutes.

In general, *Participant 2* prefers to use online mapping tools (e.g. Whereis) and information for holiday research/planning because he feels (and hopes that it would be) up-to-date. He notes that the Melway can be out-of-date if you don't have the latest version – indeed he purchased a new Melway following his trip to Cape Bridgewater. That said, *Participant 2* prefers to read from paper rather than a computer screen and so prints any useful information he finds online. When at his destination, *Participant 2* relies on local knowledge, where possible, including verbal directions and recommendations. He also likes to visit local information centres at the start of a trip in order to work out some of the things they'll do there. When faced with a choice between two possible activities (scuba diving vs. white water rafting in Cairns), *Participant 2* sought additional information relating to each in order to make his decision. As such, the respective costs of the activities, their timing, availability and other factors (eg. the conditions were not ideal for rafting), helped *Participant 2* and his wife to decide to go scuba diving. At the end of their Cape Bridgewater trip, *Participant 2* felt that he was not entirely familiar with the destination itself (i.e. finding his way around) since they didn't drive around much, however he acknowledged that it was only a small town and not very complex to navigate. He was, however, much more familiar with Cairns at the end of that trip since they'd driven around a great deal and been comparatively active during the five days they were there. Therefore he was confident he could return to Cairns and be comfortable finding his way around.
When travelling, *Participant 2* tends not to actively seek out people other than his travelling companions to interact with, except when he asks for local assistance. He does, however, enjoy interacting with others in certain situations such as at markets ("the people seem friendly") and other campers on his holidays to Wilson's Prom. When he arrives home, *Participant 2* generally shares his travel experiences with his family, friends and work colleagues. In addition to sharing holiday stories, he provides recommendations to people planning to travel in the same area. In terms of how his travel experiences tend to contribute to his future travels, *Participant 2* concluded that because he and his wife do a lot of local sightseeing, they often find places they'd like to return to, which they sometimes do (e.g. Cape Bridgewater).

When asked about the differences in his planning, research and experiences between holidays to familiar and unfamiliar destinations, *Participant 2* recalled his annual Australia Day camping trip to Wilson's Prom, with up to 12 friends. He noted that they plan for this familiar trip, however in different ways (e.g. who does the shopping, who's driving, etc.). They don't have any queries when it comes to the route and the length of time it will take to get there, but they will still use their road directory to visit places they haven't been to before (i.e. side trips). *Participant 2* feels that by continuing to visit the same destination, they are able to improve their experience each time, compensating for the shortcomings of previous years. He also notes that he can still get lost at this 'familiar' location if driving by himself, because he tends to venture off the track more and takes more risks. The types of information that *Participant 2* seeks on these holidays differs to others since he is part of a group and so is interested in group discounts (e.g. for wineries), group accommodation, etc.

When presented with the concept of the 'Holiday Assistant' *Participant 2* stated that, in order for him to use it, it would have to be possible to download maps (e.g. of local amenities, surrounding areas, restaurants, information centres, etc.). He also asserted that the information provided needs to be 100% current, however conceded that this is dependent on the nature of the information and who provides it – Government maps should be up-to-date, but he wouldn't expect those provided by private operators to be as current. *Participant 2* was receptive to the idea of the service being able to determine his location; however this would only be useful insofar as it was in reference to something (i.e. a map). The sorts of specific information or 'tips' that *Participant 2* suggested would be useful to him included: local sightseeing information, particularly about less frequented/signposted places; restaurants and reputable reviews (not just other travellers' opinions); seasonal vs. year-round activities; one-off events; scenic routes; and 'local knowledge' maps, e.g. where a good place is to spot dolphins.

Participant 2 had mixed feelings about 'push'-type services, seeing the benefits of using them, but also finding them intrusive at times. He would accept these only if he had control over the information that was pushed and how often this occurred. *Participant 2* felt that the information would need to be highly specific to him, being tailored for different trips and circumstances whilst travelling (e.g. dog- and/or child-friendly accommodation). He also stated that the user must be able to turn on and off the 'alerts'. In terms of the responsiveness of the service, *Participant 2* would expect the information searches to be fairly quick, considering that information may be needed in a hurry whilst on the move. He has previously used many types of mobile device (SmartPhones, handheld computers, laptops) and so felt generally comfortable with the idea of using any such technology to access the 'Holiday Assistant', even GPS which he has never used before. As far as his pre-trip planning and research, *Participant 2* was not averse to the idea of using a mobile device to undertake this, however he was concerned at the cost, predicting that he would personally use a desktop PC to do this as he considers it less expensive and more readily available.

Participant 3

Participant 3 is considered a frequent domestic traveller, taking between four and five trips per year (inclusive of family holidays). His usual pattern when travelling somewhere new is to book the first two nights' accommodation, followed by enough research to learn how to get to there and where he can find suitable food. He also likes to arrive during daylight, in order to get his bearings. Beyond this he prefers to be more spontaneous. *Participant 3* did exactly this on a recent ten-day trip to Cairns with his girlfriend, who was visiting from the UK. Originally they had planned to drive down the Great Ocean Road in Victoria, but had a lot of trouble finding accommodation due to the trip falling on a long weekend. Having no luck finding somewhere to stay online, they decided to change their plans.

The criteria that *Participant 3* and his girlfriend placed on choosing their new destination centred on *Participant 3* having never been there before (his girlfriend had been briefly and recommended it). It was also an attractive option since it was reasonably accessible and inexpensive (in terms of flights and accommodation). *Participant 3* also liked the fact that Cairns was somewhere they could relax, yet offered plenty of things to see and do. The specific activities they wanted to take part in (and did) included snorkelling on the Great Barrier Reef at Green Is, a trip on the Skyrail above the Daintree, short walks (e.g. to waterfalls), enjoying the local food, visiting National Parks and scenic driving. They chose to fly to Cairns mainly to save time as they wanted to maximise their limited time there.

Prior to their trip, *Participant 3* and his girlfriend looked at several maps, including atlases (which helped them decide on their destination) and the locations of their accommodation, the latter available both in their Lonely Planet (LP) guidebook for North Queensland and online at specific hostel websites. They also made use of LP guides to find out about local activities, having borrowed these books from the library and photocopied relevant pages. They did not attempt to find out about local events at the time of their visit, mainly due to their limited time there. Their trip took place at Easter and thus they were more interested in determining what local attractions were available / operational. Other information that they tried to find out before departing included: the location of vegetarian restaurants (both *Participant 3* and his girlfriend are vegan); accommodation and ferry availability/timing/cost for Fitzroy Is. (via the Fitzroy Is. Website); distances to / proximity of activities around their accommodation via hostel Websites); and the weather at the time of their visit (via the newspaper) – although they could not make any changes based on this.

Participant 3 and his girlfriend mostly used the Web in order to do holiday research and communicate with each other. *Participant 3* cited that this is the usual amount and type of research that he does for new holiday destinations, however he noted that if timing wasn't such an issue he would probably do less. He found it relatively simple to undertake this research, mainly starting with guidebooks or Web search engines (e.g. to find accommodation) which enabled more specific information to be located, although some Websites proved difficult to navigate. Less simple was finding information about food. *Participant 3* found that online restaurant information for vegans is often not up-to-date and is generally limited to vegetarian food. This is a common problem for him.

In terms of planning, *Participant 3* wanted to go to both Fitzroy and Green Islands and contacted each (online and via email) to see whether the ferries were running – there was no need to pre-book. They also planned a rough schedule to visit Green Is. first, Fitzroy Is. last, and to travel north to Cape Tribulation and Mossman National Park in between. *Participant 3* likes to create a rough framework for a trip and then fill in the details at the destination. He prioritises key activities/destinations and then is more spontaneous about the other things he does.

Participant 3 and his girlfriend chose and booked their first two nights accommodation online in advance, preferring to stay at backpackers' hostels throughout their trip due to the perceived low cost. They chose and booked their additional accommodation based on availability, using their LP guide photocopies to select and call hostels inquiring about availability. They made no other pre-bookings, although felt that they should have booked Skyrail in advance as it was booked solid on the day they wished to go, so they had to book in for later in the trip once there. *Participant 3* agreed that this is the usual way he goes about planning for a new destination – very much on-the-fly, with a general idea of what he wants to do and extra things slotted in along the way. He reasoned that he doesn't like to arrive at a destination not knowing where he's going to sleep that night, based on his International travel experiences, but finds that less structure provides the flexibility to do more spontaneous things that he didn't necessarily know about beforehand. *Participant 3's* planning was relatively easy, although he found it difficult in some cases to find direct contact details for accommodation operators. He also felt that he should have done some research into non-hostel accommodation, as the hostels they stayed at were no cheaper than some B&Bs and hotel, and were certainly less private.

Participant 3 and his girlfriend followed closely the rough schedule they'd planned in advance, which was simple considering its flexibility. They took with them their LP photocopies (maps and accommodation options) as well as the addresses of suitable restaurants. They also had a hand-drawn map they'd created from a Web map of hostel locations – they did not want to rely on the LP maps as they considered these inferior. Other location-related information that they made use of included tourist maps/brochures picked up at the destination, road signage and the advice of hostel operators, which assisted them with directions, time estimates and ideas for things to do. *Participant 3* and his girlfriend hired a car to travel further north, through Port Douglas to Cape Tribulation. The trip through the Daintree proved to take much longer than anticipated, primarily because of the low speed limits and poor road conditions– which were not marked on any of the maps they'd looked at. This meant that they arrived at their destination much later than expected and could not fit in the walking activities they'd planned after they arrived.

During the driving segment of their trip, *Participant 3* did most of the driving and they navigated jointly – his girlfriend is not as spatially aware as he is and had some difficulties in this respect. Along the way, they made many unplanned stop offs and spur-of-the moment side trips, generally prompted by recognising something (e.g. on a sign) that they had seen in brochures, or just happening upon something of interest to them. Occasionally they missed a turn-off to an attraction and, rather than back-tracking, just changed their plans and went somewhere else. *Participant 3* appreciated the flexibility that hiring a car provided, compared with organised tours. The hire car also helped them to fulfil their goals of spending time together, doing enjoyable activities, visiting new places and just relaxing.

Participant 3 again made use of local tourist maps to help in orienting himself and finding his way around – he did most of the navigating around town. Also useful in this respect were his recognition of street intersections, and in general he had no real problems, citing that the towns they visited were mostly small and well laid out. It was a little more difficult in Cape Tribulation as many of the roads were not signposted. When on foot, *Participant 3* preferred to use maps to navigate as he dislikes asking for directions. He had faith in these tools, but where they couldn't find something (e.g. specific buildings) he would ask a local. In terms of other information he thought might have helped, *Participant 3* spoke of the knowing the availability of accommodation/activities – if he'd known how popular some things were he would have booked in advance (eg. Skyrail); listings for hotels and B&Bs with up-to-date pricing information – as an alternative to hostels; a comprehensive food/restaurant guide; and local weather forecasts/recommendations – they spent a rough day snorkelling on the reef, encountering seasickness and poor visibility.

To determine the proximity of and distance to specific things/places, *Participant 3* used maps and asked tourist desks about tours, ferries, etc. He also asked accommodation operators' advice about places to go, weather, travel times, etc. Again, the only problems they encountered were with underestimating travel times. *Participant 3* was content with these sources of information – he tends to prefer simple (tourist) maps for navigating, so long as they contain enough information to orient yourself (e.g. roads, obvious landmarks). He often annotated the maps himself with pertinent information (e.g. directions). Other sources of information that *Participant 3* would have found useful in advance were road conditions and speed limits, as well as general indications of travel time and recommendations linked to the maps. There was only one point at which *Participant 3* and his girlfriend felt they were lost. This was when they were trying to find their accommodation at Cape Tribulation and weren't sure if they were on the correct road. At this time they double-checked their information, looked at what signage was there and kept on going, hoping to find what they were looking for, but willing to ask for assistance.

When asked about his information source preferences, *Participant 3* highlighted guidebooks as highly important to him when going anywhere for more than a few days. He also pointed out that vegetarian food/restaurant guides were becoming increasingly important as well. His felt that his mobile phone had been an invaluable tool for making bookings and following up information when 'on the road', and emphasised the importance of having a map when he travels somewhere unfamiliar – he doesn't like being lost. In situations where he has to make a choice between two things he wants to do on holidays, *Participant 3* named time as the main determining factor. At such times he will prioritise his activities, destinations, etc and then work out what he can do in the time available. *Participant 3* felt that he had become reasonably comfortable with Cairns and its surrounds by the end of their trip, being confident that he no longer needed a map to get around.

Whilst travelling, *Participant 3* and his girlfriend interacted with a number of other people, including accommodation operators, locals (for suggestions, directions), restaurant staff and fellow travellers. This is their normal level of interaction. On arrival back home they shared their experiences with each other (e.g. when going through their photos and building scrapbooks), their family and friends. Looking back on their trip, *Participant 3* feels that their experiences will contribute his future travels in several ways. Firstly, they will no longer stay at hostels within Australia. Secondly, they would hire a car again (as opposed to day tours), since this proved an enjoyable experience. Thirdly, they will continue to book accommodation online and finally, they will seek out the most recent guidebooks available so that their information is as current as possible. When asked about the differences in planning and undertaking holidays to somewhere unfamiliar compared with somewhere very familiar, *Participant 3* cited a recent Victorian trip. He felt that he did a similar level of planning, research and prioritisation for this trip, however being in his home state the process was easier (e.g. he used his Melway for navigation). Again he made use of the Web to find and book accommodation, but rather than asking locals advice along the way, he used his past experiences and knowledge to determine where to go, what to do and how long things would take. He tended to use maps less in general.

When presented with the concept of the 'Holiday Assistant', *Participant 3* listed maps at the top of his list of what the service should incorporate. He also wanted reasonable location information (e.g. "you are here"), local information about activities and destinations (comparable to tourist brochures), accommodation listings (including availability, price and facilities), restaurant listings and weather and road conditions. He expected that the information provided would be up-to-date to within a year. *Participant 3* believed that knowing his exact location would be most useful when walking (to within 20-30m) and that when driving his location should be known to within 1km, but he only required this in certain situations, such as when trying to find his accommodation. In terms of 'tip's and specific information that he would like the service to provide, *Participant 3* suggested the availability of accommodation and activities, and local weather forecasts. When asked his opinion of 'push'-type services, *Participant 3* did not see them as being particularly useful during a trip, as he finds out such information during his pre-planning. He stated that it would really depend on how well tailored the service was to him as to whether he found it beneficial – e.g. if it pushed information on accommodation and restaurants that matched his own personal criteria, then he would find it useful.

When asked about the expected responsiveness of the service, *Participant 3* believed it is dependent on cost. If paying a lot of money for the 'Holiday Assistant', he would expect it to be very fast, however for a lower cost he would be prepared to wait up to a minute for results to be returned. Reusability is also important to *Participant 3*, who would be more interested in renting the service rather than purchasing it – e.g. $50-$100 to hire assuming it provided the same level of value as a guidebook. As far as technology is concerned, *Participant 3* was comfortable with the idea of using any type of mobile device, however insisted that the service and device must be intuitive. He would be more inclined to use a larger client (e.g. a desktop PC) to do his pre-planning due to its greater functionality and larger screen.

Additional comments

"Thinking about it some more, the rental price for the Holiday Assistant would need to be comparable to the price of a good guide book ($30 - $40), as guide books are generally single use only (due to information going stale). At this price up to around $50 it would be an easy decision to rent the Holiday Assistant. (Thinking $5 a day for a standard 10 day holiday). As I said in the interview, my expectation is that you get what you pay for."

"Great functionality I would expect to pay for, but would have to realistically consider the cost above $50 for rental. I couldn't imagine paying for a 10 day holiday more that $100 for hire. When put in perspective with a nights accommodation ($70)."

Participant 4

Participant 4 is considered a moderately frequent domestic traveller, taking one to two holidays per year. In fact, she already has upcoming trips planned to Adelaide and Mollymook (?), which are both places she's visited before. On a recent holiday, *Participant 4* travelled to Brisbane and Surfer's Paradise (Gold Coast) for a week with her husband and five year old daughter. She had been to Brisbane previously, but that was for business and therefore she was relatively unfamiliar with the destination from a leisure point of view. *Participant 4* and her husband had a number of criteria in mind when selecting this holiday destination, not least the low airfares they were able to purchase ($29 each). Also important was their desire to travel somewhere warm, of relatively low cost and with suitable activities for their daughter (this trip was primarily for her enjoyment). They were limited in terms of the time they had available for their trip, however this was not seen as a problem since they were flexible and could alter their plans to fit within the available timeframe.

Prior to departing on the trip, *Participant 4* looked at a number of Web-based maps, including Whereis.com.au and also RACV.com.au – the latter used to determine the distance between Brisbane and Surfer's Paradise. Since theme parks were a focal point of their holiday, *Participant 4* also used the Web to browse the various theme park websites in order to obtain activity-related information (e.g. 'what is the minimum height allowed for children to swim with the dolphins at Seaworld?'). She did not attempt to find out about local events at the time of their visit as this information was not relevant to them. In terms of additional information, *Participant 4* remembered consulting a 'CitySearch'-type site in advance of her travels to find out about extra activities at their destination. *Participant 4* concedes that this is the usual amount and type of research she does before a holiday – that is, she prefers to use the Internet for domestic travelling. She likes to get a lot of detail on her destination and finds the Internet to be a simple way of doing this. *Participant 4* feels that local Websites are especially trustworthy, as opposed to those that have broader information. The only problem she had during her research for this trip was finding out local weather information for the time they would travelling – although she assumed it would be hot, she felt she had to take cool weather clothes just in case.

Participant 4 also did a sizeable amount of planning before the trip, beginning with the route to their final destination. In this respect, she used Whereis to figure out how to get to Avalon to catch their Jetstar flight, and she also accessed a local Queensland tourism website to find information about the train from Brisbane to Surfer's Paradise, which they planned to take as soon as they arrived. She also looked up Internet-based train/bus timetables and local maps for their accommodation, getting to/from theme parks, etc. Additional planning included pre-booking a '3 Park Super Pass', to visit Warner Bros Movie World, Sea World and Wet 'n' Wild Water World. When choosing and booking their accommodation, *Participant 4* again used the Internet, visiting the site 'Wotif', which offers last-minute discount accommodation. Her criteria when selecting a place to stay included its proximity to Surfer's Paradise, the facilities on offer (and associated value for money) and whether there were transfer services to the theme parks. The accommodation she chose in the end was a self-catered (resort) townhouse. Again, this was *Participant 4's* usual level of planning – she likes to pre-plan sufficiently to save stress when she arrives at her destination. Overall, she found it simple to undertake most of her planning, with the flight found and booked easily online and the theme park tickets readily available through the RACV website/shops.

When travelling to their destination, *Participant 4* and her family made use of the various research and planning she'd undertaken, following closely the route to Avalon, getting straight on the train to Surfer's Paradise at Brisbane and taking advantage of the free transfers that were included with their accommodation. When travelling to the theme parks, she used bus timetables to work out when to catch the appropriate bus and did some research to ensure that this was the cheapest and quickest option. *Participant 4* did most of the navigating to get to, and when at, their destination – her husband tends to leave all the organising and navigating to her. The information they took with them from home to help with these tasks included printed Whereis maps (although they didn't need them all). When at their destination *Participant 4* picked up bus timetables that included maps to help them find the stops. The only problem that slowed down their progress at any point of their trip was misinformation provided by one of the bus timetables/signs, which indicated a bus stop that had since closed down. After waiting approximately 45 mins for the bus, *Participant 4* spoke to a bus driver on a different line who told them what had happened and dropped them off at the correct bus stop.

At their destination, *Participant 4* and her husband's goals were simple – they wanted to enjoy a family holiday together, watching and enjoying their daughter experience new things. Their key activities were to visit the theme parks and spend time at the beach. Finding her way around Surfer's Paradise was quite easy for *Participant 4*, who cited that information brochures (including maps) were readily available and the tourist-focus of the destination meant that everything was well marked (e.g. via signs). The fact that they knew exactly what they wanted to do also helped, as did asking their various bus drivers for assistance, when necessary. They tended not to need maps in Surfer's Paradise itself as the main road was a particularly useful landmark from which everything could be located. Prior to their trip, *Participant 4* had looked at maps on a couple of Queensland tourism websites to determine the proximity of their accommodation to the main town, shopping centre and theme parks (essentially creating her own 'mental map'), and used this prior knowledge to help orient herself during her time there. She thus had no problems with finding her way around and working out how far away and in what direction things and places of interest were. *Participant 4* did not feel that she had been lost at any stage during her holiday, however she recalled that the Youth Hostel they'd booked for their last night had changed its name and so they couldn't immediately find it. In this instance they asked at the local Police station and were given the information they needed. On arrival at the hostel, they found that they should have brought their own linen and so had to purchase a blanket – something they would have liked to have known in advance.

In general, *Participant 4* prefers to use Internet-based information to prepare for her holidays. She feels that in this way she can find out almost everything she needs to know at any time, using sites she is comfortable with. When at her destination she will sometimes ask advice from locals, although in her experience she has generally found them to be the least helpful. When faced with a choice between two options whilst on holidays, *Participant 4* generally makes the decision with distance being a major factor (i.e. she would often choose the closest option). In terms of her Brisbane holiday, she chose not to hire a car to cover the distance to Surfer's Paradise as she just wanted to relax.

By the end of her trip, *Participant 4* was extremely familiar with the destination, having been comfortable with getting around from the first day, due to the amount of research she'd done beforehand. During their trip, *Participant 4* and her family interacted with a few different people, however this was not generally proactive on their part. They found out local information on things to do / recommendations from their bus drivers and also interacted somewhat with international tourists who approached them to ask for assistance. When they arrived home, *Participant 4* shared her holiday experiences with their colleagues, friends and family as well as some of her customers – a great rapport-builder. When asked how her experiences will contribute to her future travels, *Participant 4* felt that she would use the Web again since it proved so successful for her. She also suggested that she would do more research before a trip to somewhere less familiar, as well as making more use of local knowledge when there. Conversely, when asked about the differences in her planning and research for a more familiar destination, she stated that she generally doesn't do much, using a recent trip to Canberra as an example. For that trip her pre-planning was limited to working out what time she had to be there and thus what time to leave in the morning. Having lived there previously, she didn't need to do any other research.

When presented with the concept of the 'Holiday Assistant', *Participant 4* asserted that the service would have to have Internet access so that she could get answers to all of her research-related questions. She would want it to be map-based, showing where she currently is and how to get to where she wants to go. She also recommended that it should include different modes of transport for routing to different locations. *Participant 4* suggested that the service could incorporate advertisements for local attractions, tailored to the user's interests. Information that she would like to see included were the location of shopping centres/strips, public toilets and service stations (for drivers). She expected the service to be accurate to within a week of something changing. *Participant 4* felt that knowing her exact location and navigating with the device (assumed using text or verbal directions –KW) would be easier than navigating with a paper map – she refers to herself as "map illiterate". Thus this would be a useful feature.

When asked about specific information or 'tips' that the service could provide, *Participant 4* specified pop-up ads for local attractions as useful, but only if they are relevant to the user. She cited a desire for knowing what's available in the surrounding region, including practical things such as amenities and the location of the swimming flags on beaches. She also expressed interest in proximity information, specifically distance and time calculations between two points. *Participant 4* felt that 'push'-type services, would be acceptable as long as the user had control over what was presented – she would only want information pushed that matched her profile – and could block the messages if desired. She was comfortable with push-advertising in the form of special offers. In terms of responsiveness of the service, *Participant 4* stated that she was very impatient (being used to Broadband at home), so she would expect the service to take no longer than 30 seconds to retrieve the information she requested. She was most comfortable with the idea of a Palm Pilot to access the service whilst on holiday, since it had a "decent-sized screen", however she would prefer to use a desktop PC to do her pre-trip research and planning as it would be faster, the screen larger (for viewing maps) and she likes to be able to print things out.

In closing, *Participant 4* stated that the service would have to profile the user accurately in order for her to use it. She would accept such profiling so long as it was there to help her (i.e. rather than for marketing purposes). She felt that it would be ideal if the service learnt from the user's choices, however she would also appreciate new recommendations and would prefer the 'Holiday Assistant' to handle both situations.

Participant 5

Participant 5 is considered a relatively frequent domestic traveller, taking two to three holidays a year. He has upcoming travel planned to Wye River on Victoria's Great Ocean Road, a destination he has never visited before. And recently, *Participant 5* travelled to Brisbane for six days on a work trip. He had not been there since 1988 and so was generally unfamiliar with Brisbane itself.

Whilst driven to travel by his job, *Participant 5* also had some personal criteria for his trip to Brisbane. Specifically, he wanted to visit the beach and to go Scuba diving. The length of time he had available for his trip (and thus any activities he wanted to do) was dictated by work, however he chose to fly there, rather than using his preferred mode of transport – driving – in order to minimise travel time and thus maximise his time for work and leisure. For his Wye River trip, *Participant 5* again has some specific criteria, which in turn dictated his choice of destination. He knew that he wanted to organise a camping holiday with his family and family friends. With this in mind, he wanted somewhere that was within a three-hour drive from Melbourne – they only have limited time for their trip and have to transport camping equipment. He also wanted to go somewhere they had never been before. The activities *Participant 5* wants to include on this holiday – snorkelling, body boarding, etc. – mean that he needed a seaside destination. The availability and cost of caravan parks along the Great Ocean Road helped him to decide on Wye River as the final destination.

Before his trip to Brisbane, *Participant 5* looked at Whereis.com.au to find maps of the city and also performed a number of Google searches as a starting point to investigate activity-related information. For his Wye River trip, he has used RACV guides to find information on accommodation and has also looked at his Melway for maps to the destination. He hasn't yet looked for information on activities, although he feels familiar with what is available along the Great Ocean Road as he's been to the region before and knows that many local features are marked in the Melway. Prior to departing for Brisbane, *Participant 5* actively sought information relating to local events at the time of his visit, using a Brisbane-based website (unfortunately there were none). Other information he researched included the weather in Brisbane for the time of his trip (he generally keeps track of the weather via the Bureau of Meteorology's website and sometimes the Weather Channel, Yahoo.com Weather, etc.). Overall, *Participant 5* was interested in researching what to do, where to go and how to get around at his destination. He noted that he likes to know the weather to ensure that he has appropriate clothing, and that he likes to know where he is in relation to landmarks (e.g. the beach) and cardinal directions (e.g. north) when he gets there. He found the entire process of seeking information to be simple – he didn't feel like he'd missed anything. This is the usual amount and type of research that *Participant 5* does when travelling somewhere unfamiliar: i.e. (1) find location map; (2) find weather; (3) check distances to/from places of interest.

In terms of pre-trip planning, *Participant 5* did not have to do any route planning for his Brisbane trip. For previous driving trips, however, he has made use of the Melway to choose the most appropriate route. An example of this was on a camping a trip to Portland which had two obvious routes – he ended up making his choice based on the comparative ease of towing their trailer of equipment. *Participant 5* expects that his choice of route will follow the same criteria for the trip to Wye River. When it came to activity planning for Brisbane, *Participant 5* had a list of things he wanted to do, which he did not prioritise or schedule. Similarly, he has not planned the activities he and his family will take part in at Wye River, and he does not expect to incorporate any enroute to their destination, since they will be towing a trailer. For his accommodation in Brisbane, *Participant 5* did not have a choice (his company booked him into a low cost hotel). For Wye River, he made use of the RACV accommodation guide to select and book appropriate accommodation, calling around first to determine the availability and pricing of the various campsite options. *Participant 5* cites this as the usual amount of planning he does before a holiday. When asked how easy it was for him to find out the information to plan, he noted that it was relatively easy, however he was frustrated that he could not find all of the information he needed in one location and also believed that some websites were not up-to-date. *Participant 5* had to sift through a lot of data to find out what he wanted to know and conceded that it was easier to find information about Brisbane than Wye River (presumably due to the larger size and tourism market of Brisbane). He feels that he is more able to find and confirm everything he needs to know once he's at a destination.

When on a driving holiday, *Participant 5* finds that he generally sticks to his planned route, although he will divert from this if he and his family see, for example, a signpost pointing to something of interest. When towing a trailer, they tend not to divert, wanting to get to their destination as quickly as possible and then to explore from there. For his trip to Brisbane, *Participant 5* took a number of tools with him to help get around. These included a map of Brisbane, a list of places/attractions he was interested in visiting (gained during his prior research), information about distances to local attractions and his mobile phone. Apart from these, he also used location-related information in the surrounding environment such as sign posts and route markers to get around. Remembering his past driving holidays, *Participant 5* noted that he would often make use of his Melway (until he reached the Victorian border) and if he rented a car, he would use the road maps that came with it. In terms of problems he's encountered enroute to a destination, *Participant 5* again used his trip to Portland as an example, citing a large storm that impeded their progress. He suggested that in order to combat such an occurrence, listening to local radio reports was very important – particularly for gaining information on road closures, weather reports, accidents, etc. In this particular case, since they had already made their campsite booking and they felt that they could not avoid the storm without losing money on their reservation and so drove through it. During driving holidays, *Participant 5* himself generally does most of the navigating, however his wife keeps track of their progress and assists him with the use of a map. Again, they tend not to stop off to undertake activities when towing a trailer, but will make food stops and take rest breaks.

Upon arrival in Brisbane *Participant 5's* major goal was to fill in his days (he worked nights). Particular activities he was interested in were riding the various ferries around Brisbane and visiting local markets – he got around by loop bus, ferry and on foot. To find his way around, *Participant 5* relied heavily on the tourist information (brochures and kiosks) he found at the airport. Here he also made use of maps and information relating to the various transport options available to him. In terms of a city map, he used one he'd previously downloaded to his Palm Pilot as well as a paper map from a tourist magazine. To orient himself he spent some time initially walking around the city and familiarising himself with its layout. He did have some problems, however, with discrepancies between the maps and the real world: "paper maps are flat, but cities are not". *Participant 5* has encountered some frustration with his Palm maps in the past, which do not zoom in to a sufficient level without losing information within the map. In contrast, he tends to find tourist maps quite acceptable. However if he ever becomes lost and the maps cannot assist him, he will ask someone with local knowledge. *Participant 5* did not have much faith in the pre-trip information he'd gathered. When he arrived in Brisbane, however, he was able to validate what he'd researched and thus felt more confident using of it. Other sources of information that *Participant 5* suggested could have been useful to him during his trip to Brisbane included tourist information offices, tourist guides from the hotel and Internet cafes.

Participant 5 always relies on maps to help him figure out how far away and in what direction specific things/places are when holidaying in an unfamiliar location. He likes to have with him an overview map (usually paper-based) that shows indicative distances, however he has experienced problems with judging how map scales relates to real distances – particularly before he has had a chance to develop a familiarity with he region. In terms of the maps themselves, *Participant 5* usually uses those he picks up at his destination. The maps he's taken with him in the past were really only aids to figure out what was 'there'. *Participant 5* has a high level of confidence in the published maps he makes use of when travelling, particularly those from car rental agencies and the Melway / Sydway, etc. He has comparatively less confidence in tourist guide maps. In terms of other sources of information he thought might be useful for locating and getting to different activities when on holidays, he suggested that Whereis could provide the sort of proximity and distance information he required. He also cited similar websites that contain the same sort of information (and better) for overseas travel (e.g. MapQuest, MapBlast).

When asked if he'd ever felt lost while on his trip to Brisbane, *Participant 5* stated that he felt disoriented within the city itself. This occurred, for example, when he got off a ferry after travelling along the river. In such situations, he tended to backtrack (where possible) or else wander around until he found a place that matched the map(s) he was carrying. Although he did not do it much, he also felt that asking local people for help/opinions would have been most useful at these times. Obviously preferring maps when finding his way around a destination, *Participant 5* bases most of his decisions regarding the information sources he uses on cost and access. He prefers to use the Internet to do his pre-trip research and planning, placing a lot of trust in this resource. Once at a location he tends to use tourist information centres, asking questions of the people behind the tourism desk and at hotels. If all of these sources have been exhausted and he still requires information (a rare occurrence), *Participant 5* will visit an Internet cafe, however he prefers not to do this because of the cost. Similarly, cost is also a factor when *Participant 5* has to make a decision between two things he wants to do/places he wants to visit when on holidays. His other criterion in such situations is his assessment of what is more interesting to him. By the end of his Brisbane trip, *Participant 5* felt very comfortable and confident with the city centre, in terms of getting around. He felt that he had covered it sufficiently to know where he was going at any point.

Whilst in Brisbane, *Participant 5* interacted with a small number of people, most notably a work colleague who had travelled up from the Gold Coast, as well as his hotel management. On camping trips, he has generally only interacted with the caravan park management as well as his friends/camping companions. He tends not to interact with others beyond his travel group, such as other campers or locals. After returning from his holidays, *Participant 5* usually shares his travel experiences with his immediate family, as he did after travelling to Brisbane. On that particular trip, he made use of the camera built into his Palm Pilot, which he used to recount his experiences. In retrospect, *Participant 5* felt that his travel to Brisbane will contribute to his future travels to unfamiliar locations in that he will keep in mind those guides and magazines that he found particularly useful, as well as websites he bookmarked during his pre-trip research. When asked to express about how his use of information differed for trips to more familiar locations, *Participant 5* cited that he does less pre-trip research when returning to a destination, however he still seeks local information when there.

When presented with the concept of the 'Holiday Assistant', *Participant 5* responded that such a service would have to be very low cost to the user. He also expected that it would be up-to-date and accurate – he would stop using it if he found information that was out of date, since the same information could be obtained for free using paper products. Additionally, he would like the 'Holiday Assistant' to know his current location and to give context-sensitive directions – i.e. the information/directions provided must be relevant to where he is at the time. For any maps included in the service, *Participant 5* felt that they should contain sufficient information so that they could be easily zoomed in and panned, however in the absence of maps there should at least be text-based directions. In terms of exact positioning, he would find this most useful in the way if a 'you are here'-type map that showed him how to get to a particular location. Although *Participant 5* would normally already be carrying such information, he would like the service to also provide options of what to see and do.

Participant 5 suggested a number of useful 'tips' and specific information that the 'Holiday Assistant' could incorporate, including weather alerts and forecasts (e.g. average temperatures). He also saw benefit in the provision of information relating to upcoming events or items of interest (e.g. cultural activities), and the synchronisation of airline itineraries to a calendar that provided time-based alerts. When asked his opinion of 'push'-type services, *Participant 5* felt that he would accept these, depending on the cost of the service. If they were tailored to his profile, he stated that they would be okay, however they shouldn't occur too often. He also felt that the user should be able to easily unsubscribe from these at any time. *Participant 5* expressed interest in pushed 'summary guides', which are relevant to where the user is at the time and can be accepted or denied (i.e. not instantly downloaded). Such guides should include things to do, places to see, places to shop and should be persistent if required – i.e. able to be saved for 'next time'. *Participant 5* felt that the 'Holiday Assistant' service would need to be highly responsive in terms of the time it takes to search for and retrieve information. He would expect it to be as fast as a desktop web query (i.e. a few seconds) and have the option to search multiple websites. In terms of the technology he would feel comfortable using to access the service, *Participant 5* identified handheld computers and Wi-Fi connections as appropriate. He likes the idea of using just one device for everything – mobile phone, synchronisable with a desktop computer, handheld, Internet connection. He would prefer to use a desktop computer with a fast Internet connection for any pre-trip research and planning.

Participant 6

Participant 6 is considered a frequent domestic traveller. Having recently joined a bushwalking club, he has travelled six to seven times during the past year, however some of these trips covered only one day. He has travelled to Tasmania for a seven day bushwalk, with other destinations having included the Snowy Mountains, Bunyip, the Paw Paw Plain and Wilson's Promontory. *Participant 6's* Tasmania trip lasted seven days and was a new experience for him. He had not been to the Central Plateau region of Tasmania previously and only found out he was going a few weeks in addvance. He travelled there as a member of his bushwalking club, along with 14 other men and women, most of whom he already knew.

When choosing to go on the trip to Tasmania, *Participant 6* had a number of criteria. First, he wanted to travel somewhere he hadn't been before and second, he wanted to go on a club trip with knowledgeable and experienced walkers. The setting also appealed to him: bushwalking in a wilderness area. *Participant 6* had no control over the length of the trip as it had been previously set by the club. To research the trip, he purchased a Tasmanian bushwalking map (however this did not cover the entire walk) and looked at his 'Explore Australia' travel book, viewing information and maps. *Participant 6* also consulted the Bureau of Meteorology's (BOM) weather website, looking at climate graphs for the walking region and to follow the advanced forecast. His activities were largely set in stone (i.e. bushwalking), however he spoke to the trip leader to obtain the outline of the trip and to look at the path they would be taking. *Participant 6* did not try to find out any information about local events at the time of his visit, since it was not particularly relevant, however he noted that perhaps someone should have – there was a rodeo on in Deloraine at the time they were there. This is the usual amount of research that *Participant 6* does for trips to unfamiliar locations. He prefers to buy maps beforehand to get an overview of his destination, mostly for his own interest and curiosity. *Participant 6* found it relatively simple to find the information he needed – his leader told him which map to get and he is quite familiar with the BOM website.

The bushwalk itself was well planned in advance by the club leaders. In terms of planning his own route to the walk site, *Participant 6* was meticulous. He had to be in Devonport on a particular day and chose to take the ferry to get there (despite trying, he wasn't able to coordinate with others to travel there together). He doesn't like flying and the idea of taking the ferry for the first time appealed to him. *Participant 6* chose to travel during the day because he couldn't get a single cabin and didn't want to sleep in a chair for the night trip. He booked the ferry in advance after consulting the timetable. After researching the available transportation options to the ferry terminal, *Participant 6* planned the route he would follow, which included consulting train, tram and bus timetables. He also planned to meet up with fellow walkers from the group to travel to the site together the next day. In terms of booking his accommodation, *Participant 6* consulted his Lonely Planet (LP) guide. After reading descriptions for various backpacker's hostels (his preferred type of lodging), he made his decision based on the cost, location and atmosphere. Unfortunately, however, some of the latter information proved misleading, with his chosen hostel described as "quiet", when in fact it was quite noisy – this somewhat degraded his confidence in the guide. *Participant 6* booked his accommodation in advance. When asked whether this was the usual amount of planning he does before a trip, *Participant 6* felt that it was probably more than he'd usually do, citing the fact that because Tasmania is an island, it is less straightforward and more time consuming to get there (as opposed to driving within Victoria). Overall, he felt that the planning process was simple – he is an organised person and made sure that he allowed plenty of time to plan.

Participant 6 followed his planned route to Devonport exactly. Once he'd met up with his fellow travellers, it was out of his control getting to the bushwalking site since he was driven there in a private car (some of the other walkers brought their cars with them). He took with him to Tasmania his bushwalking map and his LP guide, although there was no need to take the guide on the walk itself. In terms of other location-related information *Participant 6* used to get to his destination, he found the train timetable signage useful for catching the correct train. The only things that slowed down *Participant 6's* progress to the bushwalking site were a one-hour delay for the ferry departure and some confusion in meeting up with the other travellers in Devonport. Although he could do nothing about the ferry, he was able to use his mobile phone to contact and coordinate meeting up with the other walkers. Upon his arrival in Devonport, *Participant 6* met up with one companion, with whom he did some last-minute shopping for the trip. He didn't have time for sightseeing – he was focussed on the walking trip. Upon leaving Devonport, *Participant 6* felt relatively comfortable with finding his way around the parts he had visited.

During his time in Tasmania, *Participant 6* held a number of goals, including taking a break from work, escaping civilisation in a wilderness area, getting back to nature, improving his personal fitness and enjoying the company of his fellow walkers. Within Devonport, *Participant 6* had limited time to find his way around, however when he needed to orient himself, he used the maps in his LP guide to do so (*Participant 6* noted that these maps were not ideal, but where sufficient for his purposes). On the bushwalk, he was generally aware of his orientation, using his compass to figure out where North was. He is not an experienced bushwalker himself, but had faith in the leader who was very experienced and did the majority of the navigation. *Participant 6* did some navigation himself for his own interest (e.g. on side walks) using the map that he'd brought with him. Apart from their maps, *Participant 6* and the group used various location-related information to help them navigate, including compasses and natural features/landmarks (e.g. lakes, creeks, tree stands, mountains, etc.). At the end of the walk, *Participant 6* felt he had a good idea of the countryside around where they'd walked and was confident he could go back and do more walking there.

Enjoying activities such as bushwalking and fishing throughout his trip, *Participant 6* cited only one small instance where he and the group were obstructed. This occurred after a lunch stop at a hut whereby they couldn't immediately find the trail to continue on their walk. In this instance they relied on their leader to guide them, following his advice to spread out and search in different directions. This worked, with someone eventually finding the trail. When asked about his preferences for information sources whilst on holiday, *Participant 6* responded that he likes to look at maps and is confused by verbal directions (he has difficulty remembering them). He prefers to have a detailed (e.g. 1:25,000, 1:50,000) map for navigation when walking and a good, detailed road map when driving. Overall, he likes to see all of the information around him and/or information that is specific to his purpose (e.g. bushwalking). *Participant 6* also tends to use guide books a lot of the time, having found them reasonably reliable for finding accommodation and places to eat.

During his travels, *Participant 6* interacted with a number of people. These included other people on the ferry, the hostel owner and, of course, his fellow walking companions. When he arrived home, he shared his travel experiences with his family, friends and work colleagues. He also saw slides that other walkers had taken during the trip and a DVD movie!. When asked how his experiences would contribute to future travels, *Participant 6* stated that he always picks up ideas when bushwalking – for example, he will take more fuel next time and will prepare for snow if visiting Tasmania again. He will also be more mindful with respect to the location of his accommodation (e.g. "is it next to a main road?"; "will it be quiet?"). In comparing his Tasmanian trip to those he's taken to more familiar destinations, *Participant 6* used a recent daytrip to Lorne as an example. In that case, the level and type of planning and research he undertook was much different considering he knew where he was going, how far away it was and how long it would take to get there. He took with him only a photocopied map and indicated that overall, it was "a lot less fuss".

When presented with the concept of the 'Holiday Assistant', *Participant 6* felt that the inclusion of GPS positioning would be very beneficial for bushwalking. He would like to use such a feature for recording the walking trail and tracing the path of the ferry, train, etc. He also saw its use in tracking other walkers in the group in order to know were they are. *Participant 6* believed the GPS coordinate system should be configurable to match the map being carried and that the positioning accuracy should be high (within 25m). He has recently attended a GPS training sessions and so can understand the benefits. In terms of 'tips' or other specific information, *Participant 6* thought that accommodation, places to go out and the proximity of restaurants to his current location would be useful, particularly if he had not done any pre-planning and didn't have a guide book. He objected strongly to the idea of 'push'-type services, generally finding them intrusive. He prefers to investigate things himself, even if the service offered highly up-to-date information. *Participant 6* did, however, see the benefit of emergency information, such as weather warnings, being pushed by the service.

Participant 6 felt that the 'Holiday Assistant' should search and retrieve information as fast as if searching via the desktop Internet or looking through a guide book. Moreover, he would prefer the service to present information in a more static manner (akin to a digital guide book). *Participant 6* was unsure about the technology he would be comfortable using to access the service, preferring not to use a laptop, but never having used a Palm Pilot or GPS receiver before. He felt that the ultimate device might be bulky or unwieldy and suggested that he doesn't mind carrying around his mobile phone. He's also happy to carry his LP guide, so would be happy with something of comparable weight. *Participant 6* is, however, more keen on a larger screen display (e.g. something that folds out).

Participant 7

Participant 7 is considered a moderately frequent domestic traveller, taking two holidays per year, on average. He is currently planning a trip to Sydney in February, a destination he has never been to before. One of his recent holidays was a weekend in Cairns for a work conference (another unfamiliar destination), with his wife accompanying him. *Participant 7* and his wife had no choice in their destination when travelling to Cairns (one of his company's regular training seminars), although he always tries to incorporate a holiday, or at least leisure time, into his business trips. The amount of time that they had available for the trip was strictly limited by *Participant 7's* other business commitments, as is the time they can spend during their trip to Sydney – although they will try to take a few extra days. Their criteria for their extra time is to enjoy the conference location – Luna Park – and to fit in some dining and entertainment. They will fly to Sydney, as they did with Cairns, because it is convenient (in terms of the time required) and cheap. For both trips, they selected and booked their flights online after comparing the prices of the available carriers.

Prior to their trip to Cairns, *Participant 7* and his wife looked at a number of maps. After trying to use RACV online and finding that their maps did not cover QLD, he visited streetdirectory.com. He also found maps for their accommodation on octopustrvel.com. *Participant 7* stated that he really likes maps, particular where everything he needs is available on a single map. As an opposing example, he cited Whereis maps which he feels, are too simplified, and lack clarity of relevant information. *Participant 7* generally prefers large-scale information and likes the legend to be visible at all times. Due to their limited time there, *Participant 7* did not attempt to find information about activities in Cairns for the time they were there. He suggests, however, that he may have time to do more investigation for their trip to Sydney, considering they might be there for longer. One specific activity that he and his wife are interested in taking part in is seeing a stage show (which will require online advance ticket booking). Additionally, he knows from prior experience (i.e. his Cairns trip) that octopustravel.com has links to events and attractions as well as accommodation, so he will likely look at this prior to departing.

Other information that *Participant 7* sought before travelling to Cairns included more detailed information about getting around the city, including the availability of taxis (he felt that the maps he'd found were insufficient for pre-planning). To find this out, he emailed their accommodation with a query. He also used friends' local knowledge to find out about the weather for the time of their trip. *Participant 7* admits that he usually doesn't do much research before travelling – he tends to be more spontaneous, not liking to plan his itinerary unless he is very time-constrained. Overall, he found his research a little frustrating as it took him two to three websites to find a suitable map and then he had to do his own comparison and interpolation to work out what he wanted to know.

Again, *Participant 7* does not like to plan too much in advance of travel, recalling only one previous holiday in Western Australia where he'd booked all of his accommodation in advance and therefore maintained a strict schedule – this was not his preference, however, but rather that of his travelling companion. The only thing that *Participant 7* knows he will plan in advance for his Sydney trip is their accommodation and tickets for a stage show – but this is only out of necessity. Anything he does plan, however, must fit around his work commitments. For Cairns, *Participant 7* booked their accommodation in advance. He had intended to follow a recommendation he'd been given, but found out it wasn't a good deal so searched for hotel accommodation himself, via octopustravel.com (which he found using Google). His accommodation criteria were: proximity to the conference centre, facilities, availability and cost. *Participant 7* felt that this is his usual method and amount of planning when travelling on business and stated that he likes to book things in advance only when time is short. For a longer trip, he prefers not to book all of his accommodation so that he can be more spontaneous. *Participant 7* found the planning process for his Cairns trip fairly easy – he was happy with his experiences using Google to find out information, and also the online process for booking accommodation.

Participant 7 and his wife took a number of tools with them that they used when they arrived in Cairns. Among these were their flight itinerary, online accommodation receipt, maps that his company had supplied for the conference and a SmartPhone (which unfortunately does not support the current Java-based downloadable maps). Other location-related information that they made use of in Cairn included tourist brochures and maps that they picked up at the hotel, as well as local knowledge in the form of recommendations and directions from taxi drivers, hotel staff and *Participant 7's* associates. The only problem that *Participant 7* and his wife encountered in getting to Cairns was that they'd booked their flights for the wrong weekend and ended up paying for additional flights.

Apart from his conference attendance during the days, *Participant 7* and his wife had some goals for their leisure time in Cairns. In particular, they wanted to spend some non-work time together, see some of the local area, relax, do some walking (exercise) and socialise (e.g. eat out) with his business associates. They found it fairly easy in general to find their way around Cairns, since they were staying close to the conference centre and knew what side of the town the beach was on. *Participant 7* created his own 'mental map' of the area from looking at the maps beforehand and they were able to follow signs to reach places of interest. *Participant 7* has a reasonably good sense of direction and he finds that he can build a mental map quite easily, which helps him to get around and generally leads to him doing most of the navigating (as he did in Cairns). He felt that having looked at the maps prior to their trip helped to give him a good overview of Cairns, but suggested that he would also have liked to have Internet-based maps on his SmartPhone and perhaps a digital compass.

For determining how far away and in what direction specific things / places were, *Participant 7* again cited his previous viewing and comparison of several Internet maps. For example, one map didn't have a scale but showed street names, whilst another had a scale, but no real features. Looking at these together helped him to learn the proximity of various locations, but also reinforced his desire for a single map that contained everything he needed. *Participant 7* felt comfortable with the tools he used for getting around, having a high degree of faith in the mental map he'd created. Despite this, however, *Participant 7* and his wife did encounter a situation where they were momentarily lost. This occurred when they walked out of a different exit from the conference centre. At his point they became disoriented – they could not find any street signs on the nearby corner. After walking further along, however, they found a sign and used their tourist map to locate themselves. *Participant 7* suggested that a digital compass and more street signs would have been useful in this situation.

When asked about his preferences for information sources whilst travelling, *Participant 7* highlighted his SmartPhone as his most preferred tool. He would ideally like to use it to bring up maps since he has it with him all the time, and he expects that he could obtain more up-to-date information using it than what is contained in tourist brochures. He also likes to have access to local information when at a new destination, provided it has sufficient detail (he tends to find tourist maps lacking in this respect). He used the Melway as an example of a good level of detail. By the end of their trip, *Participant 7* felt fairly comfortable with their local area within Cairns, however he had the impression that the town was larger than they had experienced. He would therefore like to go back to see what else is there.

Whilst in Cairns, *Participant 7* interacted with a number of people. These included his business associates, many of whom he had never met, as well as local inhabitants (e.g. hotel reception, taxi drivers, etc.). On their arrival home, *Participant 7* and his wife shared their experiences with their family and friends as well as his work colleagues. In terms of how his experiences will contribute to future travel, *Participant 7* felt that he'd had great success with booking his accommodation and flights online and so he would do this again. In comparing the amount of research and planning he undertook for his trip to Cairns with that for more familiar locations, *Participant 7* asserted that he would generally do more planning (including accommodation pre-booking) for an unfamiliar destination since he wouldn't know his way around, the distance between things, where the accommodation is located, etc.

When presented with the concept of the 'Holiday Assistant', *Participant 7* was receptive to the idea but emphasised that it would need to be detailed ("the more detail the better"). Thus he would expect everything to be on one map (i.e. streets, scale, orientation, etc.), with some user profiling for the map content. However he would like the ability to turn different levels of information on and off. *Participant 7* felt that user control of the information that is presented is of utmost importance and suggested that the profile should be stored on the device so that all aspects of the service can make use of it. In terms of the service being able to provide exact positioning, *Participant 7* was happy with this. He believed that it would be convenient – e.g. when an area is unknown or to determine where he is with respect to a map. In terms of other 'tips' or specific information that he'd like to have provided, *Participant 7* stated that it would depend on the destination, his familiarity with it and the length of stay. With this in mind he highlighted climate/weather information, operating times of services and facilities and other local knowledge.

Participant 7's opinion of 'push'-type services was that he agrees with the concept however he finds they can be frustrating when inundated with information he doesn't want (or at inappropriate times). He prefers the idea of an information service based on his own profile, rather than subscribed advertising, which may or may not be relevant to him. *Participant 7* understands that more time may be required in order to receive more detail from a service such as the 'Holiday Assistant'. Therefore he would have some patience, but would still expect the service to be fairly responsive (30-40 seconds is too long for loading a webpage). He would also like to be able to vary the information he received based on his immediate needs, rather than being restricted to only information that matches his subscribed profile.

In terms of the devices he would be comfortable using to access the service, *Participant 7* had no restrictions. He felt that something 'handheld' (i.e. portable), but of a practical size (i.e. large enough to read) would be most convenient, and suggested that it should be more rugged than a mobile phone (i.e. it can be accidentally dropped and still operate). His opinion was that it should be more of a 'tool' than an electronic device and he suggested that it should be an integrated system. For example, he would accept a larger device if it incorporated a SmartPhone, compass and GPS. *Participant 7's* final comments concerned the usability of the 'Holiday Assistant' service. He saw this as an important factor, in addition to a requirement for the user to define their own information needs, rather than others making assumptions for them. Overall, he would want to have control over the information that is presented via the service, and how it is presented.

Participant 8

Participant 8 is considered a low to medium frequency domestic traveller, taking one holiday per year on average. She has an upcoming holiday planned to Echuca, a destination she is unfamiliar with. Recently she travelled with her husband on their honeymoon to Olinda (Mount Dandenong) for a weekend – this was again somewhere with which she was not very familiar. *Participant 8's* criteria when choosing Olinda as a holiday destination were somewhere not too far away from home (they wanted to drive there) and of relatively low cost. They also wanted a small retreat where they could relax and get away from the 'everyday'. The length of their trip was restricted by work commitments – they wanted to save her husband's annual leave for when their baby arrived. *Participant 8* and her husband chose to drive by private car because they felt that it was easier (*Participant 8* was pregnant at the time) and more cost effective. For similar reasons they will also drive to Echuca, a destination that was chosen for them – they were given a few days accommodation for free as part of a promotional gift. Their criterion for their trip to Echuca is thus to 'see what is there'.

For their Olinda holiday, *Participant 8* and her husband did no pre-trip research or planning, other than booking their accommodation. Hence they did not look at any maps or any information on activities or events at their destination – they were focused on enjoying their weekend getaway. *Participant 8* felt that the amount and type of research and planning she does before a holiday generally depends on its length and purpose. For example, she would do more prior research/planning for a longer trip. Also, this trip was more about relaxation than planning and undertaking activities. In effect, they planned 'non-activity' for their time away. In terms of their accommodation, *Participant 8* found and pre-booked this via the Internet (possibly through the RACV website). Their choice of accommodation – a Bed & Breakfast (B&B) – was in keeping with their desire to relax, and *Participant 8* narrowed down their options based on appearance, description and cost. She found this a moderately easy process, conducting her search and comparison over two to three weeks.

The first time *Participant 8* and her husband looked at a map was when they got into their car to depart for Olinda and consulted their Melway. Doing so, they gave themselves an overview of the route and then started to drive. Along the way, they made use of road signs with place names and directions and when they became unsure of their progress they followed the maps more closely. Reaching Olinda was non-problematic, however it was more difficult finding their actual accommodation. This was because they were travelling late at night (i.e. it was dark) and they had to follow dirt tracks to reach the B&B. Fortunately, they had been given verbal directions by the accommodation owners which helped them to reach their destination. Throughout this process, *Participant 8* drove whilst her husband navigated.

Whilst in Olinda, *Participant 8's* general goal was to enjoy quiet relaxation in and around their accommodation. In fact, there was not much to do there other than sit and relax. They did, however, take walks around the area which comprised dirt tracks surrounded by bush. Aware that there were no signposts and they were not carrying any maps, *Participant 8* and her husband made sure to backtrack so that they wouldn't get lost. In terms of travelling into the Olinda township (e.g. to visit local shops), there were sufficient road signs for them to follow for this purpose. *Participant 8* had no problems in general working out where she was in and around Olinda. She mostly relied on her sense of direction, but admitted that she had no idea where North was. She did, however, have a relative amount of faith in her own spatial awareness – e.g. she could backtrack without much trouble. Her preference when going somewhere new is to look at a map rather than use written directions. But once she has been there she feels it's easy to find her way back. *Participant 8* suggested that it may have been helpful for then to have had a map of the local area showing points of relevance. By the end of the trip she was fairly confident that she could find the accommodation again and comfortable with Olinda as a destination.

On their way home from Olinda, *Participant 8* and her husband made an unplanned stop off. This was to a National Park – William Rickett's Sanctuary – where they stayed for a couple of hours and had a picnic lunch. They also took photos. Information about the sanctuary was provided within the National Park as was signage for the car park, which was some distance from the picnic area. When choosing to stop somewhere for lunch, *Participant 8* and her husband had had options other than the Sanctuary, however they chose it because: (a) it was directly on their way home; (b) the weather was poor and they felt they could leave the Sanctuary easily if necessary; and (c) people had recommended the Sanctuary to them. When asked about her preferences for information sources whilst travelling *Participant 8* stated that she always relies on the Melway, which she finds sufficiently comprehensive for her needs and always has on hand. Similarly, when driving outside Victoria she likes to use road maps specific to the local region. She has also used city maps in the past. *Participant 8* tends to forget verbal directions, preferring the visual nature of maps.

During their holiday, *Participant 8* and her husband interacted with very few people, preferring time on their own. When they returned home, they shared their experiences with family and close friends. When asked how her experiences will contribute to future travels, *Participant 8* responded that it is a progressive process. She learns from all aspects of travel, e.g. what to pack, travel times, music and entertainment to take, etc. *Participant 8* feels that the further away the destination is, the more likely she is to plan. Particularly if travelling interstate, she would make sure she was well planned, understood the distances involved, had planned stop offs, and so on. Conversely, in comparing unfamiliar travel with that to a more familiar location, *Participant 8* used a recent trip to Dromana as an example citing greater comfort with the route and destination. During that trip she did not feel the need to pre-plan, however they did get lost due to unknown changes to the roads they took – their familiarity had, in effect, contributed to this situation since they didn't check the route beforehand.

When presented with the concept of the 'Holiday Assistant', *Participant 8* stated that it must be very visual. She would want to have maps with differing scales and levels of detail; e.g. route overview, alternative routes, things to see along the way. After selecting a route, she would then want the maps to become more detailed and be able to be used as a directional tool. In terms of exact positioning, *Participant 8* felt that this would be extremely useful when travelling long distances, and would be invaluable in remote locations. Additional tips and specific information that *Participant 8* suggested for the service included temperatures, weather forecasts, time zone differences, accommodation locations, rest stops and proximity searches (e.g. for nearest conveniences, distances between destinations, etc.).

Participant 8 had mixed feelings about 'push'-type services, feeling that they could be very useful, but also very annoying. She felt that her acceptance of them would depend on the information involved. Specifically, she would find retail and promotional information annoying, but if the information was highly specific to her it would be considered useful. For example, *Participant 8* was receptive to the idea of being alerted when within range of a petrol station. In general, she was also receptive to the idea of filling in a profile so that information could be tailored to her interests, however she was mindful of how else the information may be used, beyond the purpose of the 'Holiday Assistant'. When asked about the expected responsiveness of the service, *Participant 8* anticipated that the search and retrieval of information would be within 30 seconds. She felt that if it was any longer than this the service would not be worth having. In terms of the technology used to access the service, she was comfortable with the idea of employing a Palm Pilot (despite having never used one before) or else something attached to a mobile phone. *Participant 8* liked the idea of renting the service, or at least having access to it only for the time it is needed.

Appendix C - Development Platform Constraints

C.1 Supported XHTML Elements

Table C.1 The availability of XHTML elements – including controls – to the XHTML Mobile Profile (Microsoft Developer Network 2007).

Element	Available	Description
A	Yes	Designates the start or destination of a hypertext link
ABBR	Yes	Sets or retrieves abbreviated text for the object
ACRONYM	Yes	Indicates an acronym abbreviation
ADDRESS	Yes	Used to specify information such as the address, signature and authorship for the document
APPLET	Yes	Ignored until a Java Virtual Machine (JVM) is installed
AREA	Yes	Defines the shape, coordinates, and associated URL of one hyperlink region within a client-side image map
B	Yes	Specifies that the text be rendered in bold
BASE	Yes	Specifies an explicit URL used to resolve links and references to external sources such as links and images
BASEFONT	Yes	Sets attributes of the default font to be used when rendering text
BGSOUND	Yes	Enables a background sound to be played when the page is visited
BIG	Yes	Specifies that the enclosed text should be in a larger font than the current font
BLOCKQUOTE	Yes	Sets apart a quotation in text
BODY	Yes	Denotes the beginning and end of the document body
BR	Yes	Inserts a line break
CAPTION	Yes	Specifies a brief description or caption for a table.
CENTER	Yes	Centres subsequent text and images
CITE	Yes	Specifies a citation, and the enclosed text is rendered in italics.
CODE	Yes	Specifies a code sample, and if a monospace (courier) font is installed on the device, the enclosed text is rendered in a monospace font
DD	Yes	Indicates a definition in a definition list (DL), and the definition is indented from the definition list
DEL	Yes	Indicates text that has been deleted from the document
DFN	Yes	Indicates the defining instance of a term, and the enclosed text is rendered in italics
DIR	Yes	Denotes a directory list
DIV	Yes	Specifies a container or division in the document
DL	Yes	Denotes a definition list
DT	Yes	Denotes a definition term within a definition list (DL)
EM	Yes	Emphasizes text by rendering it in italics
FONT	Yes	Specifies a new font, size, and colour to be used for rendering the enclosed text
FORM	Yes	Specifies that the contained controls are part of a form
FRAME	No	Specifies an individual frame within a FRAMESET
FRAMESET	No	Specifies a frameset consisting of 1 or more frames
H1 ... H6	Yes	Renders text in a range of heading styles and sizes
HEAD	Yes	Provides a random collection of information about the document
HR	Yes	Draws a horizontal rule

Table C.1 (cont.) The availability of XHTML elements – including controls – to the XHTML Mobile Profile (Microsoft Developer Network 2007).

Element	Available	Description
HTML	Yes	Identifies the document as containing HTML elements
I	Yes	Specifies that the enclosed text should be rendered in italics
IMG	Yes	Embeds an image in the document
INPUT TYPE=button	Yes	Creates a button control
INPUT TYPE=checkbox	Yes	Creates a check box control
INPUT TYPE=hidden	Yes	Transmits information about the client/server interaction
INPUT TYPE=image	Yes	Creates an image control that, when clicked, causes the form to be submitted immediately
INPUT TYPE=passwor d	Yes	Creates a single-line text entry control, similar to the text control except that text is not displayed as the user enters it
INPUT TYPE=radio	Yes	Creates a radio button control
INPUT TYPE=reset	Yes	Creates a button that, when clicked, resets the form's controls to their initial values
INPUT TYPE=submit	Yes	Creates a button control that, when clicked, submits the form
INPUT TYPE=text	Yes	Creates a single-line text entry control
INS	Yes	Specifies text that has been inserted into the document.
KBD	Yes	Renders enclosed text in a fixed-width font
LABEL	Yes	Specifies a label for another element on the page
LEGEND	Yes	Inserts a caption into the box drawn by the fieldset object
LI	Yes	Denotes one item in a list
LINK	Yes	Enables the current document to establish links to external documents
LISTING	Yes	Renders text in a fixed-width font
MAP	Yes	Defines a client-side image map that contains one or more AREA elements specifying hot zones on the associated image and binding those zones to URLs
MENU	Yes	Creates an unordered list of items consisting of LI elements
META	Yes	Conveys hidden information to the server and the client
NOFRAMES	Yes	Contains the HTML for browsers that do not support frames
NOSCRIPT	Yes	Contains the HTML for browsers that do not support scripts
OBJECT	Yes	Inserts an ActiveX® control onto the page
OL	Yes	Creates an ordered list consisting of LI elements
OPTGROUP	Yes	Allows authors to group choices logically
OPTION	Yes	Denotes one choice in a SELECT element
P	Yes	Denotes a paragraph
PARAM	Yes	Sets the property value for a given OBJECT element
PRE	Yes	Denotes preformatted text and renders it in a fixed pitch font
Q	Yes	Sets apart a quotation in text
S	Yes	Renders text in strikethrough type
SAMP	Yes	Denotes a code sample
SCRIPT	Yes	Specifies a block containing script to be interpreted by the script engine
SELECT	Yes	Denotes a list box or drop-down list

Table C.1 (cont.) The availability of XHTML elements – including controls – to the XHTML Mobile Profile (Microsoft Developer Network 2007).

Element	Available	Description
SMALL	Yes	Specifies that the enclosed text is rendered in a smaller font
SPAN	Yes	Specifies an inline text container
STRIKE	Yes	Renders enclosed text in strikethrough type
STRONG	Yes	Renders enclosed text using a bold style
STYLE	Yes	Specifies a style sheet for the page
SUB	Yes	Specifies that enclosed text is displayed in subscript
SUP	Yes	Specifies that enclosed text is displayed in superscript
TABLE	Yes	Specifies that contained content is organized into a table consisting of rows and columns
TBODY	Yes	Designates rows as the body of the table
TD	Yes	Specifies a table cell
TEXTAREA	Yes	Specifies a multiline text input control
TFOOT	Yes	Designates rows as the table's footer
TH	Yes	Specifies a table header column
THEAD	Yes	Designates rows as the table's header
TITLE	Yes	Contains the title of the document
TR	Yes	Specifies a table row
TT	Yes	Renders text in a fixed pitch font
U	Yes	Renders text that is underlined
UL	Yes	Creates a bulleted, unordered list consisting of list items (LI)
VAR	Yes	Renders enclosed text in italics
XML	Yes	Defines an Extensible Markup Language (XML) data island
XMP	Yes	Renders text used for examples in a fixed-width font

C.2 Supported Events and Event Handlers

Table C.2 The events and event handlers supported by the XHTML Mobile Profile (Open Mobile Alliance 2006).

Event	Event Handler Attribute	Support
Load	onload	Mandatory
Unload	onunload	Optional
Click	onclick	Mandatory
Double Click	ondblclick	Optional
Mouse Down	onmousedown	Optional
Mouse Up	onmouseup	Optional
Mouse Over	onmouseover	Optional
Mouse Move	onmousemove	Optional
Mouse Out	onmouseout	Optional
Focus	onfocus	Optional
Blur	onblur	Optional
Key Press	onkeypress	Optional
Key Down	onkeydown	Optional
Key Up	onkeyup	Optional
Submit	onsubmit	Mandatory
Reset	onreset	Mandatory
Select	onselect	Optional
Change	onchange	Optional

C.3 Scripting Support

From the XHTML Mobile Profile v1.1 Specification (Open Mobile Alliance 2006):

"The scripting language defined for use with the XHTML Mobile Profile is ECMAScript Mobile Profile [ESMP]. Support for scripting is RECOMMENDED … The XHTML Mobile Profile 1.1 user agent MUST support the scripting language ECMAScript Mobile Profile. The MIME media type for ECMAScript Mobile Profile is text/ecmascript. The user agent MUST also support ECMAScript Mobile Profile scripts identified with media type text/javascript. The user agent MAY support other scripting languages."

Note, according to the Microsoft Developer Network (2007): "Internet Explorer Mobile supports only the Jscript language".
Refer to http://msdn2.microsoft.com/en-us/library/yek4tbz0.aspx for the JScript Language Reference.

C.4 External Style Sheets

From the XHTML Mobile Profile v1.1 Specification (Open Mobile Alliance 2006):

"Style sheets can be used to style XHTML Mobile Profile documents. If a WAE user agent supports styling of documents with style sheets, it MUST support the style language WAP CSS [WCSS], a subset of CSS2 with WAP-specific extensions. A user agent MAY support other style languages."

From the Microsoft Developer Network (2007):

"Cascading Style Sheets (CSS) are used to give HTML documents a consistent appearance … Use Cascading Style Sheets to specify the values of various attributes that control the appearance and behaviour of web pages … CSS styles can be placed into <STYLE> blocks or stored in external cascading style sheet (.css) files that can be accessed via a <LINK> tag."

Appendix D - Preliminary Design Evaluation Materials

D.1 Recruitment Script

- Hi, my name is Karen Wealands and I'm calling on behalf of RMIT University in conjunction with Sensis and Webraska Mobile Technologies.
- Some time ago you participated in an online 'Travel and Technology' questionnaire for a project we're conducting into the usability of geospatial information on mobile devices.
- At the end of the questionnaire you indicated that you were interested in participating in further activities related to our study and gave us your contact details.
- I'm now following up to see if you're still interested in continuing your participation in the next phase, which involves one-on-one evaluations of a prototype mobile travel service.
- *If no…*
  - Thankyou for your time.
- If yes…
  - Would you be available to participate in the evaluations, being conducted between 9th and 13th October (i.e. two weeks from now)?
  - The evaluation may take up to 2 hours, and you will be compensated for your time and assistance with a $100 Coles Myer gift voucher.
  - We have several times and dates available, but before we try to book you in, do you mind answering a couple of quick questions just to ensure that we have a range of participants?
    - What age bracket do you fall into?

      ❍ 25-30 ❍ 31-40 ❍ 41-50 ❍ 51+
    - In the past 2 years, how many holidays did you take within Australia?

      ❍ None ❍ 4 - 6 ❍ 12 or more
❍ 1 - 3 ❍ 6 - 12
    - Did you travel mostly interstate, within Victoria or both?
    - What was the average length of your stay?

      ❍ 1 - 4 days ❍ 2 weeks - 1 month ❍ Over 2 months
❍ 1 - 2 weeks ❍ 1 - 2 months ❍ Too variable to say
    - How likely would you be to use a travel service on your mobile phone (in Aust)?

      ❍ Not at all ❍ Unsure ❍ Definitely
❍ Unlikely ❍ Probably
- We'd love to have you participate if we can find a time/date that suits you. Those (still) available are …
- The evaluation will be held in the usability lab at Sensis – the address is 222 Lonsdale Street, Melbourne. It's part of the QV complex (which is on the corner of Swanston and Lonsdale Streets) and you enter Sensis off Lonsdale St – walk up until you see the sign and revolving door. The nearest train station is Melbourne Central.

For daytime evaluations:

- Being a large office complex, there are a few security procedures you'll have to follow when you arrive:
  - You must report to the concierge desk on the ground floor where you will need to provide your name, organisation (if applicable) and my name, Karen Wealands, as the person you are visiting. You will be given a temporary access pass which you must wear around your neck at all times within the building.
  - At this time you will also need to ask the concierge to contact me using my mobile phone number which they should already have, but just in case it is <phone number provided>. As soon as they contact me I will come down and meet you to take you to the usability lab.

For after-hours evaluations:

- Since the building is not open to the public after business hours, I will meet you on the ground floor. Simply come to the side door (next to the revolving door) on Lonsdale St, where I will let you in and take you up to the lab.

- I suggest that you allow 10-15 mins before the evaluation time to allow for public transport or parking (which is located under the QV complex).
- As a courtesy, would you like a reminder call approximately 2 hours before the interview time (preferably a mobile phone number)?
- I will email you all of the details you need shortly, including the building access we've talked about and a Plain Language Statement describing the research.
- You can email or call me prior to the evaluation to ask any questions you may have – my contact details will be at the bottom of the email.
- Finally, if you need to pull out of the evaluation, for whatever reason, that is completely fine. I'd appreciate though, it if you could let me know ASAP.
- Thanks for you time and willingness to participate. I look forward to meeting you next <date>.

D.2 Confirmation Email

Hi <name>,

Thanks for agreeing to take part in the next phase of our research into the usability of geospatial information on mobile devices. This is a joint project involving RMIT University, Sensis and Webraska Mobile Technologies. Please reply to this email in order to confirm that you received it and that the evaluation time stated below is in fact the time we agreed upon.

As we discussed over the phone, your interview is scheduled for <time> on <date>. It will take no more than 2 hours and is located at Sensis. The address is 222 Lonsdale Street, Melbourne – it is part of the QV complex, with entry off Lonsdale St (refer to the attached map). I would appreciate it if you could arrive just before the interview in order to allow for the required entry procedures, which are:

- You must report to the concierge desk on the ground floor where you will need to provide your name, organisation (if applicable) and my name, Karen Wealands, as the person you are visiting. You will be given a visitor access pass which you must wear around your neck at all times within the building.
- At this time you will also need to ask the concierge to contact me using my mobile phone number which they should already have, but just in case it is <phone number provided>.
- As soon as they contact me I will meet you to take you to the usability lab.

Or

- Since the building is not open after business hours, I will meet you on the ground floor.
- Simply come to the side door (next to the revolving door) on Lonsdale St, where I will let you in and take you up to the usability lab.

I suggest that you allow 10-15 minutes before the interview time to allow for public transport or parking (there is a car park located underneath the QV complex – see map for entrances). At your request, I will give you a reminder call on the day of the interview, approximately 2 hours before the scheduled time.

I have attached to this email two other documents: (1) the Plain Language Statement for this stage of the research, which will explain the purpose of the evaluations along with information regarding your privacy, and (2) a consent form which you will be required to sign – note the attachment is for your information only at this stage, I will provide a hard copy for your signature at the interview. If you require any further information, please don't hesitate to contact me.

I'd like to thank you again for agreeing to take part in the research and look forward to meeting you on <date> at <time>.

Regards,

Karen Wealands BGeom (Hons), BSc
PhD Candidate
Geospatial Science, RMIT University
<contact details provided>

<Attached map was identical to that in Appendix B, Section B.2>

D.3 Plain Language Statement

INVITATION TO PARTICIPATE IN A RESEARCH PROJECT
PROJECT INFORMATION STATEMENT

RMIT UNIVERSITY

School of Mathematical and Geospatial Sciences

Excellence in:
- GIS & Remote Sensing
- Measurement Science
- Multimedia & Visualisation
- Risk & Community Safety
- Sustainable Development

GPO Box 2476V
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Telephone + 61 3 9925 2213
Facsimile + 61 3 9663 2517
Email: geospatial@rmit.edu.au

Project Title
Representation models for the delivery of useful, interactive geospatial information services via the mobile Internet

Investigators
- Mrs Karen Wealands (PhD Student: School of Mathematical and Geospatial Sciences, RMIT University, <contact details provided>)
- Prof. William Cartwright (Project Supervisor: Professor, School of Mathematical and Geospatial Sciences, RMIT University, <contact details provided>)

Dear Participant,

I am writing to follow up on my invitation for you to participate in the next stage of a research project being conducted as part of my PhD research at RMIT University, in conjunction with Webraska Mobile Technologies and Sensis Pty. Ltd. This information sheet describes the project in straightforward language, or 'plain English'. Please read this sheet carefully and be confident that you understand its contents before deciding whether to participate. If you have any questions about the project, please ask one of the investigators.

Who is involved in this research project? Why is it being conducted?
My investigations come under the supervision of Professor William Cartwright, a lecturer and researcher in Geospatial Science at RMIT University, and with the involvement of a Sensis consultant, Ms Lesley Forsyth, User Experience Research Analyst (Interactive Consumer Experiences). The RMIT University Human Research Ethics Committee has given its approval to this project and Sensis has provided their approval and support for the entire research. This study is the basis of an Australian Research Council (ARC) Linkage project and as such is partly funded by its industry partner, Webraska.

Why have you been approached?
I contacted you some time ago in relation to an online "Travel & Technology" questionnaire, which you completed as part of the first stage of this project. Based on your responses to the questionnaire, as well as your previous registration of interest in assisting with Sensis product testing, I am contacting you again with respect to continuing your participation.

What is the project about? What are the questions being addressed?
Mobile Location-based services (mLBS), available on mobile phones and handheld computers, are becoming increasingly popular. Today, a growing number of people are accessing information 'on the go', in order to answer location-related questions such as "where is my nearest ATM?" and "how do I get home from here?" Despite the appeal of many of the services on offer, the speed with which they are becoming available reflects a general industry trend of design driven by the technology rather than the needs of the end user, with the usability of the services often suffering. This project aims to correct the situation by trialling different methods for representing spatial information within mLBS, based on the needs of actual users. The specific research questions being addressed by the study are:

1) How can mLBS improve the communication of spatial information over more traditional delivery mechanisms (e.g. paper maps)?
2) What factors impact the ability to communicate spatial information via mLBS in a useful manner?
3) What are the limitations and benefits associated with current techniques with respect to the communication of spatial information via mLBS?

4) What techniques should be exploited and which areas require further research and refinement?
5) Can a user-driven focus help to ensure the usefulness of spatial information communication via mLBS?
6) What techniques for spatial information representation, presentation and interaction do members of a selected user group consider useful?

If I agree to participate, what will I be required to do?

To help us with the final stage of the research project, we are seeking 10-15 previous participants willing to take part in the evaluation of a prototype mLBS service which caters to the spatial information needs of holiday-related travellers within Australia. Participation involves attendance at a one-on-one evaluation session where you will be asked to step through a scenario using a mobile phone-based prototype. Throughout the session you will be asked to express, out loud, your thoughts regarding the prototype. The session will take no longer than two (2) hours and will be conducted in a usability lab. All efforts will be made to meet at a time that is convenient to you. An observer will be present during the evaluation session, with your use of the prototype videotaped for later analysis, provided that you consent to this (note, no identifying features will be recorded). You are welcome to examine the evaluation materials before deciding to participate. Please contact one of the investigators should you wish to do so.

Note: you will be compensated for your time and any expenses associated with your participation – this will be in the form a $100 Coles Myer gift voucher.

What are the risks or disadvantages associated with participation?

There are minimal risks foreseen with participation in the research, with no threats outside your normal day-to-day activities. The following is intended to dispel any misgivings you may have about participating in an evaluation session undertaken using a mobile phone-based prototype:

- You may be concerned that the device used to evaluate the prototype contains a power source. This should not be a cause of distress, however, as the voltages involved are non-dangerous to humans and you will only come into contact with the device itself, regardless. To ensure that no difficulties arise, the device's battery will be connected and verified, prior to your evaluation session. You will also be trained in the operation of the device before undertaking any of the tasks. In the event of a problem with the power supply, the evaluation session will be discontinued. Any threat here is no different from the normal use of a personal mobile phone.

What are the benefits associated with participation?

A primary aim of this research is to apply User-Centred Design techniques to develop useful spatial representations for mLBS. Whilst you are not expected to experience any direct benefits from your participation, we hope that the research will pave the way for future mLBS that are highly useful and user-friendly, catering to the needs of people such as yourself.

What will happen to the information I provide?

From the moment that it is collected, your evaluation session data will identified via a code (rather than your name). All of the information that you provide will then be aggregated with that from other participants, prior to being analysed and presented at international conferences and/or published in international refereed journals. In addition, both Webraska and Sensis will be supplied with a report detailing the findings of the study, in aggregate form only. Hence no identifying details (including video images) will be made public as part of the presentation of the research findings. Any information that you provide can be disclosed only if (1) it is to protect you or others from harm, (2) a court order is produced, or (3) you provide the researchers with written permission.

Only my senior supervisor and I will have access to the collected information, which will be securely stored in the School of Mathematical and Geospatial Sciences, RMIT University for a period of five years prior to being destroyed, as prescribed by the Joint NHMRC/AVCC Statement and Guidelines on Research Practice.

What are my rights as a participant? Whom should I contact if I have any questions?

Please be aware that your participation in this research is considered entirely voluntary. As such you may withdraw it at any time, without prejudice, simply by notifying one of the investigators. You also have the right to have any unprocessed data withdrawn and destroyed, provided that it can be reliably identified. All of the relevant contact details are provided at the bottom of this letter. If you have any queries or would like to be informed of the aggregate research findings, please don't hesitate to contact us.

Yours sincerely,

Karen Wealands BGeom (Hons), BSc
PhD Candidate
<contact details provided>

Mail:
Attn: Karen Wealands
C/o Geospatial Science,
RMIT University
GPO Box 2476V,
Melbourne Victoria 3001

Prof William Cartwright BAppSc, DipAppSc, PhD, EdD, GradDip Education, GradDip Media Studies, GradDip Information and Communications Technology Education, GradDip Graphic Communication Education
<contact details provided>

Any complaints about your participation in this project may be directed to the Executive Officer, RMIT Human Research Ethics Committee, Research & Innovation, RMIT, GPO Box 2476V, Melbourne, 3001.
Details of the complaints procedure are available at: http://www.rmit.edu.au/rd/hrec_complaints

D.4 Consent Form

HREC Form No 2b

Prescribed Consent Form For Persons Participating In Research Projects Involving Interviews, Questionnaires or Disclosure of Personal Information

Portfolio	Science, Engineering and Technology
School of	Mathematical & Geospatial Sciences
Name of participant:	
Project Title:	Representation models for the delivery of useful, interactive geospatial information services via the mobile Internet
Name(s) of investigators:	**Karen Wealands** (Student Researcher) Phone: <provided>
	William Cartwright (Senior Supervisor) Phone: <provided>

1. I have received a statement explaining the evaluation involved in this project.
2. I consent to participate in the above project, the particulars of which - including details of the evaluation – have been explained to me.
3. I authorise the investigator or his or her assistant to interview me.
4. I acknowledge that:
   (a) Having read Plain Language Statement, I agree to the general purpose, methods and demands of the study.
   (b) I have been informed that I am free to withdraw from the project at any time and to withdraw any unprocessed data previously supplied.
   (c) The project is for the purpose of research and/or teaching. It may not be of direct benefit to me.
   (d) The privacy of the personal information I provide will be safeguarded and only disclosed where I have consented to the disclosure or as required by law.
   (e) The security of the research data is assured during and after completion of the study. The data collected during the study may be published, and a report of the project outcomes will be provided to Webraska Mobile Technologies and Sensis. Any information which will identify me will not be used.

Participant's Consent

Participant: ______________________ Date: __________
(Signature)

Witness: ______________________ Date: __________
(Signature)

Participants should be given a photocopy of this consent form after it has been signed.

Any complaints about your participation in this project may be directed to the Executive Officer, RMIT Human Research Ethics Committee, Research & Innovation, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 2251. Details of the complaints procedure are available from the above address.

D.5 Evaluation Script

<switch off GPRS signal on device>

Introduction

Welcome and thanks for agreeing to participate (and arriving on time). My name is Karen and I'm conducting this research in conjunction with RMIT, Sensis and Webraska into the usability of geospatial information on mobile devices.

The purpose of this study is to evaluate aspects of a prototype mobile travel service. Note that it is still a very early prototype and the data is largely simulated, therefore you will be asked to follow a fairly constrained path during your interaction with the service. And importantly, we are most interested in your feedback with respect to using the service to access **geospatial information**, so you may find the functionality and content lacking in terms of non-geospatial information.

This evaluation will take place here, in this specialist usability laboratory and will take no longer than 2 hours. During the evaluation you will be observed by 2 people. The first person, myself, will interact with you directly, while the other, Gita, will observe your actions. Gita is sitting behind the one-way mirror and is also in charge of videotaping the session. Please don't be intimidated by the "audience" as we are evaluating the prototype and not you.

Before we start, the first thing I need you to do is sign a couple of forms. The first is your consent to participate in the evaluation, which also confirms that you've read the Plain Language Statement I sent you prior to today. Feel free to read over this material now if you haven't already.

<sign form>

The second form relates to your consent to be videotaped throughout the evaluation. Assuming that you consent to being filmed, I would like to assure you that the videotape will be kept confidential and your personal details not associated with the data in any way – the main focus of the videotaping is to capture your interaction with the service. I'm also going to give you a $100 Coles Myer voucher to thank you for taking time out of your schedule to participate in this session. Your initials on the form will acknowledge your consent to be videotaped, whilst providing your address confirms that you are the person who received the voucher.

<fill in address and initial form>

<switch on microphone and commence videotaping>

During today's evaluation you will be asked to complete a number of tasks using the prototype. I will give you these one at a time. While completing each task, I'd like you to "think aloud". This means that you provide a commentary on what you are doing, experiencing and thinking as you complete the task. In particular I'd like you to articulate any problems you are having, things that you feel are missing and/or any suggestions for improvements. An example of think aloud may be something like: "I am clicking this button now. Now I see a list of options. I understand what each means but I'm not sure which one to choose. OR I just tried this option, but nothing happened". Basically I'd like to hear you say aloud anything that comes into your mind – good or bad – as you progress through each task. If at any stage you feel that you can't continue for some reason, please ask me an appropriate question. After each task, please indicate whether you were successful or not in accomplishing it by making a statement to this effect.

At the conclusion of a task, I may ask you to complete the task again using a slightly different path through the service. This is so that I can get you to compare different methods of inputting and outputting geospatial information. This will become clearer as we go along, but basically I'd like you to provide as many opinions and comments as you can regarding various different ways of accessing the same information. At the end of each task set I will ask you some questions to help you elaborate on your experience with the prototype.

Before we begin, I'd like to emphasis that we are not evaluating you or your performance today, but are interested in collecting your feedback on the service. The more input we receive regarding your experience with the service, the more successful we regard the evaluation as we can feed this into future refinements and improvements.

Brief Instructions
The prototype service, called Holiday Helper, runs within a WAP browser on a SmartPhone. The browser is a mini version of Internet Explorer and so operates in a similar fashion. The key controls are: <show operation guide>

Left soft-key – corresponds to what is on the bottom left screen button

Right soft-key – corresponds to what is on the bottom right screen button (can be used to refresh the screen – Menu)

Back button – used to go back to the previous page

Joystick navigation – used to move between the links on a page and/or to select a link

Keypad navigation – used to select specially-numbered links on a page

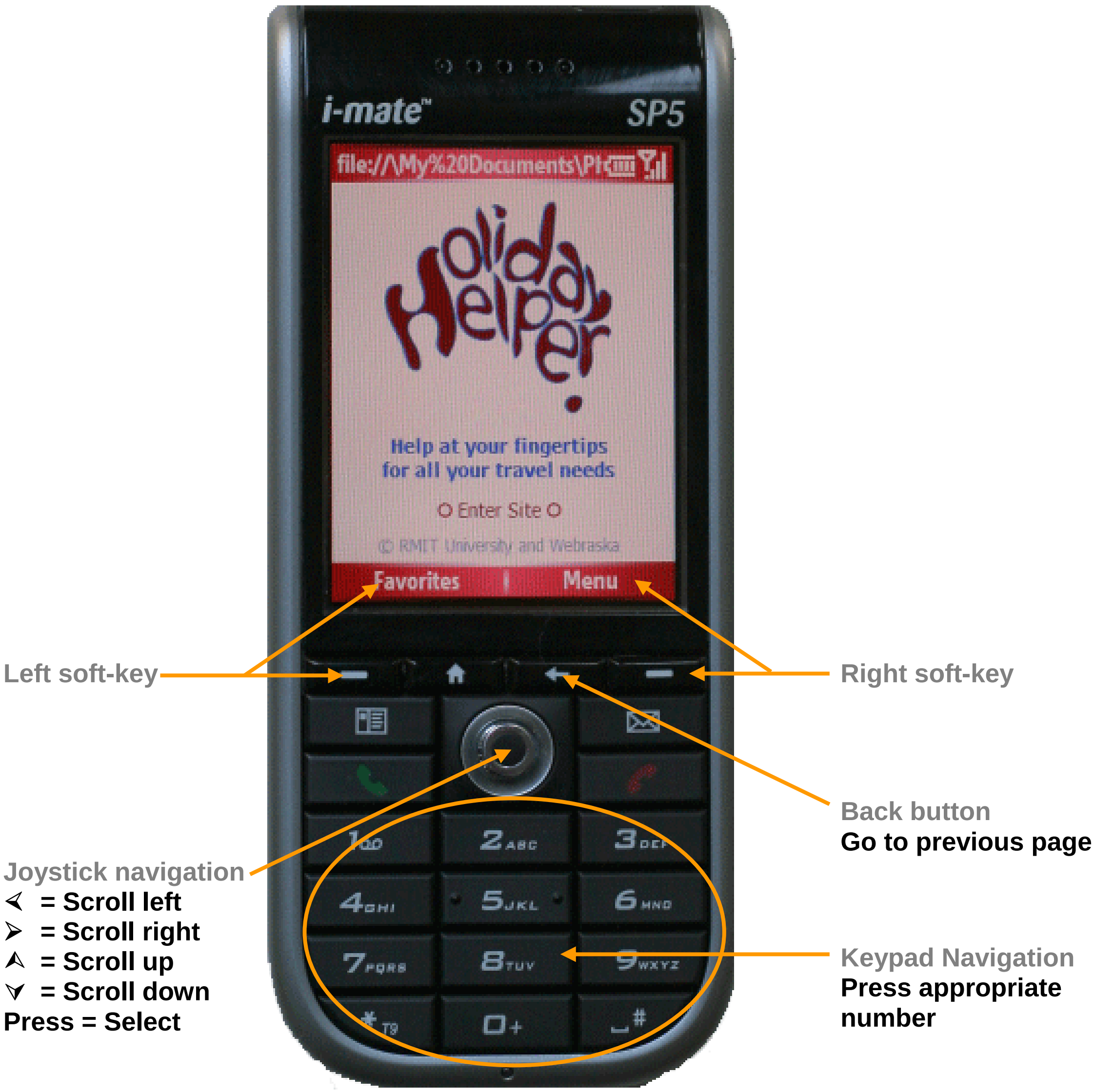
During the session, please try to hold the device above the red square that is taped to the table, to ensure that the camera can record your interaction with the prototype.

If at any time you don't feel comfortable, you're free to end the session and leave – you're not obligated to stay. (Help yourself to water, etc.)

Debrief
To finish off, I want to let you know that your data will be written up collectively with data from other participants and be used to help refine and improve the geospatial design of the Holiday Helper. It will also be presented in a progress report to both Sensis and Webraska.

Do you have any questions?
Thanks very much!

D.6 SmartPhone Operation Guide



Appendix E - Revised Design Evaluation Materials

E.1 Recruitment Script

- Hi, my name is Karen Wealands and I'm calling on behalf of RMIT University in conjunction with Sensis and Webraska Mobile Technologies.
- [Some time ago you participated in an online 'Travel and Technology' questionnaire for | I spoke to you about 5 months ago regarding] a project we're conducting into the usability of geospatial information on mobile devices.
- [At the end of the questionnaire you indicated that you were interested in participating in further activities related to our study and gave us your contact details | At that time you indicated that you may be available for the second set of evaluations].
- I'm now following up to see if you're still interested in continuing your participation in the next phase, which involves one-on-one evaluations of a prototype mobile travel service.
- *If no…*
  - Thankyou for your time.
- If yes…
  - Do you still live in Melbourne? *(If yes, continue)*
  - Would you be available to participate in the evaluations, being conducted between 22nd and 28th March (i.e. the end of this week and the beginning of the next)?
  - The evaluation will take around 2 hours, and you will be compensated for your time and assistance with a $100 Coles Myer gift voucher.
  - We have several times and dates available, but before we try to book you in, do you mind answering a couple of quick questions just to ensure that we have a range of participants?
    - What age bracket do you fall into?

      ❍ 25-30 ❍ 31-40 ❍ 41-50 ❍ 51+
    - In the past 2 years, how many holidays did you take within Australia?

      ❍ None ❍ 4 - 6 ❍ 12 or more
      ❍ 1 - 3 ❍ 6 - 12
    - Did you travel mostly interstate, within Victoria or both?
    - What was the average length of your stay?

      ❍ 1 - 4 days ❍ 2 weeks - 1 month ❍ Over 2 months
      ❍ 1 - 2 weeks ❍ 1 - 2 months ❍ Too variable to say
    - How likely would you be to use a travel service on your mobile phone (in Aust)?

      ❍ Not at all ❍ Unsure ❍ Definitely
      ❍ Unlikely ❍ Probably
- We'd love to have you participate if we can find a time/date that suits you. Those (still) available are …
- The evaluation will be held in the usability lab at Sensis – the address is 222 Lonsdale Street, Melbourne. It's part of the QV complex (which is on the corner of Swanston and Lonsdale Streets) and you enter Sensis off Lonsdale St – walk up until you see the sign and revolving door. The nearest train station is Melbourne Central.

For daytime evaluations:

- Being a large office complex, there are a few security procedures you'll have to follow when you arrive:
  - First you must report to the concierge desk on the ground floor where you will need to sign-in, providing my name (Karen Wealands) as the person you are visiting. You will be given a temporary access pass which you must wear around your neck at all times within the building.

- You will then need to proceed to Sensis reception on the 6th floor (swipe your pass on the sensor in the lift to get access to this level) and ask the person at the desk to call me on my mobile number which they should already have, but just in case it is <phone number provided>. As soon as they contact me I will come down and meet you to take you to the usability lab

For after-hours evaluations:

- Since the building is not open to the public after business hours, I will meet you on the ground floor. Simply come to the side door (to the left of the revolving door) on Lonsdale St, where I will let you in and take you up to the lab. If you do not see me for some reason, just give me a call on my mobile.
- I suggest that you allow 10-15 mins before the evaluation time to allow for public transport or parking (which is located under the QV complex).

- As a courtesy, would you like a reminder call approximately 2 hours before the session time (preferably a mobile phone number)?
- I will email you all of the details you need shortly, including the building access we've talked about and a Plain Language Statement describing the research.
- You can email or call me prior to the evaluation to ask any questions you may have – my contact details will be at the bottom of the email.
- Finally, if you need to pull out of the evaluation, for whatever reason, that is completely fine. I'd appreciate though, it if you could let me know ASAP.
- Thanks for you time and willingness to participate. I look forward to meeting you next <date>.

E.2 Confirmation Email

Hi <name>,

Thanks for agreeing to take part in the next phase of our research into the usability of geospatial information on mobile devices. This is a joint project involving RMIT University, Sensis and Webraska Mobile Technologies. *Please reply to this email in order to confirm that you received it and that the evaluation time stated below is in fact the time we agreed upon.*

As we discussed over the phone, your interview is scheduled for <time> on <date>. It will take no more than 2 hours and is located at Sensis. The address is 222 Lonsdale Street, Melbourne – it is part of the QV complex, with entry off Lonsdale St (refer to the attached map). I would appreciate it if you could arrive just before the interview in order to allow for the required entry procedures, which are:

- First, you must report to the concierge desk in the ground floor lobby where you will need to sign-in, providing my name (Karen Wealands) as the person you are visiting. You will be given a temporary access pass which you must wear around your neck at all times within the building.
- You will then need to proceed to Sensis reception on the 6th floor – make sure you swipe your pass in the lift to gain access to this level.
- Once at reception, ask the person at the desk to call me on my mobile number which they should already have, but just in case it is <phone number provided>. As soon as they contact me I will come down and meet you to take you to the usability lab.

Or

- Since the building is not open after business hours, I will meet you on the ground floor.
- Simply come to the side door (to the left of the revolving door) on Lonsdale St, where I will let you in and take you up to the usability lab.
- If for some reason I am not there when you arrive, I won't be far away – just wait a few minutes and/or call on my mobile phone (<phone number provided>)

I suggest that you allow 10-15 minutes before the interview time to allow for public transport or parking (there is a car park located underneath the QV complex – see map for entrances). <As requested, I will give you a reminder call on the day of the interview, approximately 2 hours before the scheduled time.>

I have attached to this email two other documents: (1) the Plain Language Statement for this stage of the research, which will explain the purpose of the evaluations along with information regarding your privacy, and (2) a consent form which you will be required to sign – note the attachment is for your information only at this stage, I will provide a hard copy for your signature at the interview. If you require any further information, please don't hesitate to contact me.

I'd like to thank you again for agreeing to take part in the research and look forward to meeting you on <date> at <time>.

Regards,

Karen Wealands BGeom (Hons), BSc
PhD Candidate
Geospatial Science, RMIT University
<contact details provided>

<Attached map was identical to that in Appendix B, Section B.2>

E.3 Plain Language Statement

INVITATION TO PARTICIPATE IN A RESEARCH PROJECT
PROJECT INFORMATION STATEMENT

RMIT UNIVERSITY

School of Mathematical and Geospatial Sciences

Excellence in:
- GIS & Remote Sensing
- Measurement Science
- Multimedia & Visualisation
- Risk & Community Safety
- Sustainable Development

GPO Box 2476V
Melbourne Australia 3001

Telephone + 61 3 9925 2213
Facsimile + 61 3 9663 2517
Email: geospatial@rmit.edu.au

Project Title
Representation models for the delivery of useful, interactive geospatial information services via the mobile Internet

Investigators
- Mrs Karen Wealands (PhD Student: School of Mathematical and Geospatial Sciences, RMIT University, <contact details provided>)
- Prof. William Cartwright (Project Supervisor: Professor, School of Mathematical and Geospatial Sciences, RMIT University, <contact details provided>)

Dear Participant,

I am writing to follow up on my invitation for you to participate in the next stage of a research project being conducted as part of my PhD research at RMIT University, in conjunction with Webraska Mobile Technologies and Sensis Pty. Ltd. This information sheet describes the project in straightforward language, or 'plain English'. Please read this sheet carefully and be confident that you understand its contents before deciding whether to participate. If you have any questions about the project, please ask one of the investigators.

Who is involved in this research project? Why is it being conducted?
My investigations come under the supervision of Professor William Cartwright, a lecturer and researcher in Geospatial Science at RMIT University, and with the involvement of a Sensis consultant, Mr Ryan Percival, Designer – Concept and Design (Interactive Consumer Experiences). The RMIT University Human Research Ethics Committee has given its approval to this project and Sensis has provided their approval and support for the entire research. This study is the basis of an Australian Research Council (ARC) Linkage project and as such is partly funded by its industry partner, Webraska.

Why have you been approached?
I contacted you some time ago in relation to an online "Travel & Technology" questionnaire, which you completed as part of the first stage of this project. Based on your responses to the questionnaire, as well as your previous registration of interest in assisting with Sensis product testing, I am contacting you again with respect to continuing your participation.

What is the project about? What are the questions being addressed?
Mobile Location-based services (mLBS), available on mobile phones and handheld computers, are becoming increasingly popular. Today, a growing number of people are accessing information 'on the go', in order to answer location-related questions such as "where is my nearest ATM?" and "how do I get home from here?" Despite the appeal of many of the services on offer, the speed with which they are becoming available reflects a general industry trend of design driven by the technology rather than the needs of the end user, with the usability of the services often suffering. This project aims to correct the situation by trialling different methods for representing spatial information within mLBS, based on the needs of actual users. The specific research questions being addressed by the study are:

- How can mLBS improve the communication of spatial information over more traditional delivery mechanisms (e.g. paper maps)?
- What factors impact the ability to communicate spatial information via mLBS in a useful manner?

- What are the limitations and benefits associated with current techniques with respect to the communication of spatial information via mLBS?
- What techniques should be exploited and which areas require further research and refinement?
- Can a user-driven focus help to ensure the usefulness of spatial information communication via mLBS?
- What techniques for spatial information representation, presentation and interaction do members of a selected user group consider useful?

If I agree to participate, what will I be required to do?

To help us with the final stage of the research project, we are seeking 10-15 previous participants willing to take part in the evaluation of a prototype mLBS service which caters to the spatial information needs of holiday-related travellers within Australia. Participation involves attendance at a one-on-one evaluation session where you will be asked to step through a scenario using a mobile phone-based prototype. Throughout the session you will be asked to express, out loud, your thoughts regarding the prototype. The session will take no longer than two (2) hours and will be conducted in a usability lab. All efforts will be made to meet at a time that is convenient to you. An observer will be present during the evaluation session, with your use of the prototype videotaped for later analysis, provided that you consent to this (note, no identifying features will be recorded). You are welcome to examine the evaluation materials before deciding to participate. Please contact one of the investigators should you wish to do so.

Note: you will be compensated for your time and any expenses associated with your participation – this will be in the form a $100 Coles Myer gift voucher.

What are the risks or disadvantages associated with participation?

There are minimal risks foreseen with participation in the research, with no threats outside your normal day-to-day activities. The following is intended to dispel any misgivings you may have about participating in an evaluation session undertaken using a mobile phone-based prototype:

- You may be concerned that the device used to evaluate the prototype contains a power source. This should not be a cause of distress, however, as the voltages involved are non-dangerous to humans and you will only come into contact with the device itself, regardless. To ensure that no difficulties arise, the device's battery will be connected and verified, prior to your evaluation session. You will also be trained in the operation of the device before undertaking any of the tasks. In the event of a problem with the power supply, the evaluation session will be discontinued. Any threat here is no different from the normal use of a personal mobile phone.

What are the benefits associated with participation?

A primary aim of this research is to apply User-Centred Design techniques to develop useful spatial representations for mLBS. Whilst you are not expected to experience any direct benefits from your participation, we hope that the research will pave the way for future mLBS that are highly useful and user-friendly, catering to the needs of people such as yourself.

What will happen to the information I provide?

From the moment that it is collected, your evaluation session data will identified via a code (rather than your name). All of the information that you provide will then be aggregated with that from other participants, prior to being analysed and presented at international conferences and/or published in international refereed journals. In addition, both Webraska and Sensis will be supplied with a report detailing the findings of the study, in aggregate form only. Hence no identifying details (including video images) will be made public as part of the presentation of the research findings. Any information that you provide can be disclosed only if (1) it is to protect you or others from harm, (2) a court order is produced, or (3) you provide the researchers with written permission.

Only my senior supervisor and I will have access to the collected information, which will be securely stored in the School of Mathematical and Geospatial Sciences, RMIT University for a period of five years prior to being destroyed, as prescribed by the Joint NHMRC/AVCC Statement and Guidelines on Research Practice.

What are my rights as a participant? Whom should I contact if I have any questions?
Please be aware that your participation in this research is considered entirely voluntary. As such you may withdraw it at any time, without prejudice, simply by notifying one of the investigators. You also have the right to have any unprocessed data withdrawn and destroyed, provided that it can be reliably identified. All of the relevant contact details are provided at the bottom of this letter. If you have any queries or would like to be informed of the aggregate research findings, please don't hesitate to contact us.

Yours sincerely,

Karen Wealands BGeom (Hons), BSc
PhD Candidate
<contact details provided>

Mail:
Attn: Karen Wealands
C/o Geospatial Science,
RMIT University
GPO Box 2476V,
Melbourne Victoria 3001

Prof William Cartwright BAppSc, DipAppSc, PhD, EdD, GradDip Education, GradDip Media Studies, GradDip Information and Communications Technology Education, GradDip Graphic Communication Education
<contact details provided>

Any complaints about your participation in this project may be directed to the Executive Officer, RMIT Human Research Ethics Committee, Research & Innovation, RMIT, GPO Box 2476V, Melbourne, 3001.
Details of the complaints procedure are available at: http://www.rmit.edu.au/rd/hrec_complaints

E.4 Consent Form

HREC Form No 2b

Prescribed Consent Form For Persons Participating In Research Projects Involving Interviews, Questionnaires or Disclosure of Personal Information

Portfolio	Science, Engineering and Technology
School of	Mathematical & Geospatial Sciences
Name of participant:	
Project Title:	Representation models for the delivery of useful, interactive geospatial information services via the mobile Internet
Name(s) of investigators:	**Karen Wealands** (Student Researcher) Phone: <provided>
	William Cartwright (Senior Supervisor) Phone: <provided>

1. I have received a statement explaining the evaluation involved in this project.

2. I consent to participate in the above project, the particulars of which - including details of the evaluation – have been explained to me.

3. I authorise the investigator or his or her assistant to interview me.

4. I acknowledge that:

   (a) Having read Plain Language Statement, I agree to the general purpose, methods and demands of the study.
   (b) I have been informed that I am free to withdraw from the project at any time and to withdraw any unprocessed data previously supplied.
   (c) The project is for the purpose of research and/or teaching. It may not be of direct benefit to me.
   (d) The privacy of the personal information I provide will be safeguarded and only disclosed where I have consented to the disclosure or as required by law.
   (e) The security of the research data is assured during and after completion of the study. The data collected during the study may be published, and a report of the project outcomes will be provided to Webraska Mobile Technologies and Sensis. Any information which will identify me will not be used.

Participant's Consent

Participant: ______________________ Date: __________
(Signature)

Witness: ______________________ Date: __________
(Signature)

Participants should be given a photocopy of this consent form after it has been signed.

Any complaints about your participation in this project may be directed to the Executive Officer, RMIT Human Research Ethics Committee, Research & Innovation, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 2251. Details of the complaints procedure are available from the above address.

E.5 My Profile Information Sheet

MY PROFILE

Configurations

You have previously saved the following settings to *My Profile*. These come into effect each time you use the Holiday Helper service:

❖ **My Categories**

- ☑ Adventure Parks
- ☐ Arts & Crafts
- ☑ Beaches
- ☐ Bird Watching
- ☐ Camping
- ☐ Cycling
- ☐ Dining
- ☐ Extreme Sports
- ☐ Fishing
- ☐ Galleries
- ☑ Hiking
- ☑ Historic Sites
- ☑ Markets
- ☑ Museums
- ☐ Music
- ☑ National & State Parks
- ☐ Parks & Gardens
- ☐ Scenic Driving
- ☐ Shopping
- ☐ Sports
- ☐ Walks & Views
- ☐ Water Sports
- ☐ Wineries

Notes:

- The above relates to the search and display of attractions/activities within the service.
- Categories 'ticked' here comprise the default list within the service.
- Note, when using the service you may also access the categories not selected here by clicking on the 'See more categories' link (where it appears)

❖ **Voice Outputs**

- ○ Play all voice outputs automatically
- ⦿ Allow me to play voice outputs on demand

Notes:

- Regardless of the option selected above, you are able to stop any voice output within the service once it has begun.

❖ **Weather Warnings**

- ⦿ Automatically alert me
- ○ Do not alert me

Favourites

Various ‘favourites’ lists are maintained for you by the service and are available each time you log in. You can add and remove items to/from these lists while using Holiday Helper:

- **My Destinations** – may include any towns, cities or regions for which you have accessed information.
- **My Attractions/Activities** – may include any attractions and/or activities for which you have accessed information.
- **My Addresses** – may include any street addresses which you have typed in or searched for using the service. Note, custom names are used to describe addresses.
- [**My Accommodation** – may include any accommodation for which you have accessed information]
- [**My Routes** – may include any routes which you have used the service to generate]

E.6 Evaluation Script

<switch off GPRS signal on device>

Introduction

Welcome and thanks for agreeing to participate (and arriving on time). I'm conducting this research in conjunction with RMIT, Sensis and Webraska into the usability of geospatial information on mobile devices.

The purpose of this study is to evaluate aspects of a prototype mobile travel service. Note that it is still only a prototype and the data is largely simulated, therefore you may be asked to follow a fairly constrained path during your interaction with the service. And importantly, we are most interested in your feedback with respect to using the service to access **geospatial information**, so you may find the functionality and content lacking in terms of non-geospatial information.

This evaluation will take place here, in this specialist usability laboratory and will take no longer than 2 hours. During the evaluation you will be observed by 2 people. The first person, myself, will interact with you directly, while the other, Steve, will observe your actions. Steve is sitting behind the one-way mirror and is also in charge of videotaping the session. Please don't be intimidated by the "audience" as we are evaluating the prototype and not you.

Before we start, the first thing I need you to do is sign a couple of forms. The first is your consent to participate in the evaluation, which also confirms that you've read the Plain Language Statement I sent you prior to today. Feel free to read over this material now if you haven't already.

<sign form>

The second form relates to your consent to be videotaped throughout the evaluation. Assuming that you consent to being filmed, I would like to assure you that the videotape will be kept confidential and your personal details not associated with the data in any way – the main focus of the videotaping is to capture your interaction with the service. I'm also going to give you a $100 Coles Myer voucher to thank you for taking time out of your schedule to participate in this session. Your initials on the form will acknowledge your consent to be videotaped, whilst providing your address confirms that you are the person who received the voucher.

<fill in address and initial form>

During today's evaluation you will be asked to complete a number of tasks using the prototype. I will give you these one at a time. While completing each task, I'd like you to "think aloud". This means that you provide a commentary on what you are doing, experiencing and thinking as you complete the task. In particular I'd like you to articulate any problems you are having, things that you feel are missing and/or any suggestions for improvements. An example of think aloud may be something like: "I am clicking this button now. Now I see a list of options. I understand what each means but I'm not sure which one to choose. OR I just tried this option, but nothing happened". Basically I'd like to hear you say aloud anything that comes into your mind – good or bad – as you progress through each task. If at any stage you feel that you can't continue for some reason, please ask me an appropriate question. After each task, please indicate whether you were successful or not in accomplishing it by making a statement to this effect.

At the conclusion of a task, I may ask you to complete the task again using a slightly different path through the service. This is so that I can get you to compare different methods of inputting and outputting geospatial information. This will become clearer as we go along, but basically I'd like you to provide as many opinions and comments as you can regarding various different ways of accessing the same information. At the end of each task set I will ask you some questions to help you elaborate on your experience with the prototype.

Before we begin, I'd like to emphasis that we are not evaluating you or your performance today, but are interested in collecting your feedback on the service. The more input we receive regarding your experience with the service, the more successful we regard the evaluation as we can feed this into future refinements and improvements.

<switch on microphone and commence videotaping>

Brief Instructions

- The prototype service, called Holiday Helper, runs within a WAP browser on a SmartPhone. The browser is a mini version of Internet Explorer and so operates in a similar fashion. The key controls are: <show operation guide>

  Left soft-key – corresponds to what is on the bottom left screen button

  Right soft-key – corresponds to what is on the bottom right screen button (can be used to refresh the screen – Menu)

  Back button – used to go back to the previous page

  Joystick navigation – used to move between the links on a page and/or to select a link

  Keypad navigation – used to select specially-numbered links on a page

- Please hold the phone over the red square during use.

- The service is designed to incorporate an additional feature which has not been explicitly included in the prototype, but which will impact on your use of it today. This is known as My Profile and is essentially a 'user profile' which you can set up in advance using, for example, a desktop-based interface. In the final implementation, users will be able to edit the settings they've stored in My Profile, while they are using the service. You will likely notice instances of when and how this might be done today. Since you're My Profile settings will play a part in today's evaluation, please read this sheet which describes the relevant configurations that have been made. It also defines some of the key components of My Profile, which you may find useful.

Finally, if at any time you don't feel comfortable, you're free to end the session and leave – you're not obligated to stay. (Help yourself to water, etc.)

Debrief

To finish off, I want to let you know that your data will be written up collectively with data from other participants and be used to help refine and improve the geospatial design of the Holiday Helper. It will also be presented in a progress report to both Sensis and Webraska.

Do you have any questions?
Thanks very much!