The Design and Application of the Stop-Specific Bus Map

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Since the 1970s, there has been a significant increase in private car usage mirrored by a significant decrease in Public Transport usage. This over-reliance on the private car has given rise to serious levels of congestion and its associated socio-economic and environmental effects. There have been numerous initiatives to reverse this imbalance by reducing the reliance on the private car whilst improving and promoting Public Transport as an attractive and viable mode of transport. There are many potential factors that can influence travel behaviour and choices, one of these being the level and quality of information that is made available to the public about the Public Transport services on offer. However, the main focus of information provision has primarily been on timetabling i.e. **when** the service is due, especially with the recent developments in the provision of real-time departures, as opposed to providing route mapping i.e. to **where** a service is actually travelling.

This study investigates the potential of the Stop-Specific Bus Map and whether this new form of mapping information can simplify the planning process involved when travelling by bus. To begin, a detailed analysis of the need for Public Transport information and why existing mapping information requires improving highlights a significant opportunity for providing Stop-Specific Bus Maps. A robust sampling methodology is then presented which ensures the sampling of the test towns and test bus stops is rigorous and unbiased, before the stages adopted for the manual design of the individual Stop-Specific Bus Maps are discussed.

Analysis of the on-street field tests indicates that the Stop-Specific Bus Maps do have a significant advantage over existing forms of information, with respect to the percentage of correct answers obtained, the time taken to reach an answer and the level of user confidence that a chosen bus service will take someone to their desired destination. From these findings, this research highlights a lack of understanding of Public Transport mapping and the need for more research into the benefits this information can bring. It is envisaged that by increasing the level of understanding about to where bus services operate, and not just existing services an individual is familiar with, there is potential for encouraging people to make journeys by bus which may have previously been made using the car. This research is therefore a call to policy makers, transport planners and operators to give serious consideration to improving the design and dissemination of Public Transport mapping information.

I owe a great deal of gratitude to Dr. David Forrest and Dr. Alastair Morrison for their sage guidance, knowledge and enthusiasm for this study. The past five years have been enjoyable, testing, intriguing and highly rewarding, but without their support this study would not be at the finished stage it is today. Dr. Morrison has spent a substantial amount of time researching the field of Public Transport mapping and has been gracious enough to guide me in developing my own research in this domain – I hope I have done it some justice.

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I originally left home and moved to Newcastle to begin my University career. Who would have thought that the best part of a decade later, I'd be completing a PhD? I would also like to thank my brother, Mark, for providing an unofficial IT support role on occasions, and for his encouragement and interest in this research and also to my wider family for their love and encouragement. Thanks go to my extended family, to Elaine, Roddy and Louise, and to Chick and Beth for their support.

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Finally, I am indebted to Eve, my fiancée, for her love, immense support and encouragement from day one of this study. Her continued belief in me and my ability to complete this study, her support at times when things were not going quite to plan, her understanding of the personal nature of a PhD, all of these have made this study possible. Eve is now in the middle of her PhD, and if I can provide half the support she has provided to me, I will be doing extremely well. I would also like to thank Jess (our cat) who came into our lives late on in my PhD, but has since provided us with endless hours of love, company, fun and amusement, especially when everything was getting slightly fraught in the latter stages.

There are numerous individuals whom I have encountered throughout the duration of this study – I hope I have managed to thank everyone here. Please accept my sincerest apologies for anyone I have missed: your support, encouragement and camaraderie over the years have been greatly appreciated. However, I am proud to say to you all that this *thing* I seem to have been working on, for what seems like an eternity… well, it's finished now!

Gareth Evans, November 2010

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ATCO	Association of Transport Co-ordinating Officers
BSA	British Social Attitudes
BVPI	Best Value Performance Indicator
CBI	Confederation of Business Industry
CfIT	Commission for Integrated Transport
DfT	Department for Transport
EU	European Union
GIS	Geographic Information System
ICA	International Cartographic Association
ITA	Integrated Transport Authority
LA(s)	Local Authority(ies)
LGA	Local Government Act
LTA	Local Transport Act
NaPTAN	National Public Transport Access Node
NBC	National Bus Company
NCC	National Consumer Council
NTS07	National Travel Survey 2007
O:D	Origin:Destination
PT	Public Transport
PTE	Public Transport Executive
PTI	Public Transport Information
RTA	Road Traffic Act
SBC	Scottish Bus Company
SPT	Strathclyde Partnership for Transport
SSBM	Stop-Specific Bus Map
T(S)A	Transport (Scotland) Act

TA	Transport Act
TfL	Transport for London
TGP	Transport Green Paper
TWP	Transport White Paper
UITP	International Association for Public Transport
UK	United Kingdom

Declaration of Originality

I declare that, except where explicit reference is made to the contribution of others, this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

Signature

Printed Name Gareth David Evans

Date 10th November 2010

1.1 In this Chapter

This Chapter presents the background to this research and goes on to outline the intended aims and objectives of the study. The scope of this project is also clarified, as the Public Transport (PT) information domain is one that has many aspects and issues of interest, far more than is possible to encompass in an individual PhD study. Finally, the methodology of this study is presented at the end of this Chapter.

1.2 Transport in the 21st Century

At the time of the fieldwork carried out for this study, the corresponding edition of Transport Statistics Great Britain (DfT, 2008c) showed that in every year since 2000, 85% of personal trips were made by private car. Since the 1960s, car ownership and availability has dramatically increased, allowing us to make more journeys, and travel over longer distances in great comfort. As car dependency increased, land use patterns adapted to meet the rising needs of the car user, increasing the demand for cars to reach new out-of-town facilities for work and leisure purposes (Simpson, 1994). Those without access to a car were further disadvantaged, but falling patronage levels meant that PT operators were reluctant to finance a suitable response. The net result has been a significant increase in car use mirrored by a substantial decrease in PT use (Figures 1.1 and 1.2).

1.2.1 Addicted to Our Cars?

In today's society, cars are viewed as a necessity and are treated like an everyday commodity, but they are also a measure of wealth and a symbol of status. Cars have become engrained in our psyche, so much so that "if there is one object that has become an icon of the twentieth century, it is the car and it is difficult to see how that will change" (Banister, 2005, p.5). In contrast, PT is often viewed in a poor light, "widely regarded as being something to avoid by anyone who has private transport" (Simpson, 1994, p.8), and is now a means of transport for "the poorer and least powerful sections of the community... women, the elderly and young people" (Hepworth and Ducatel, 1992, p.141).

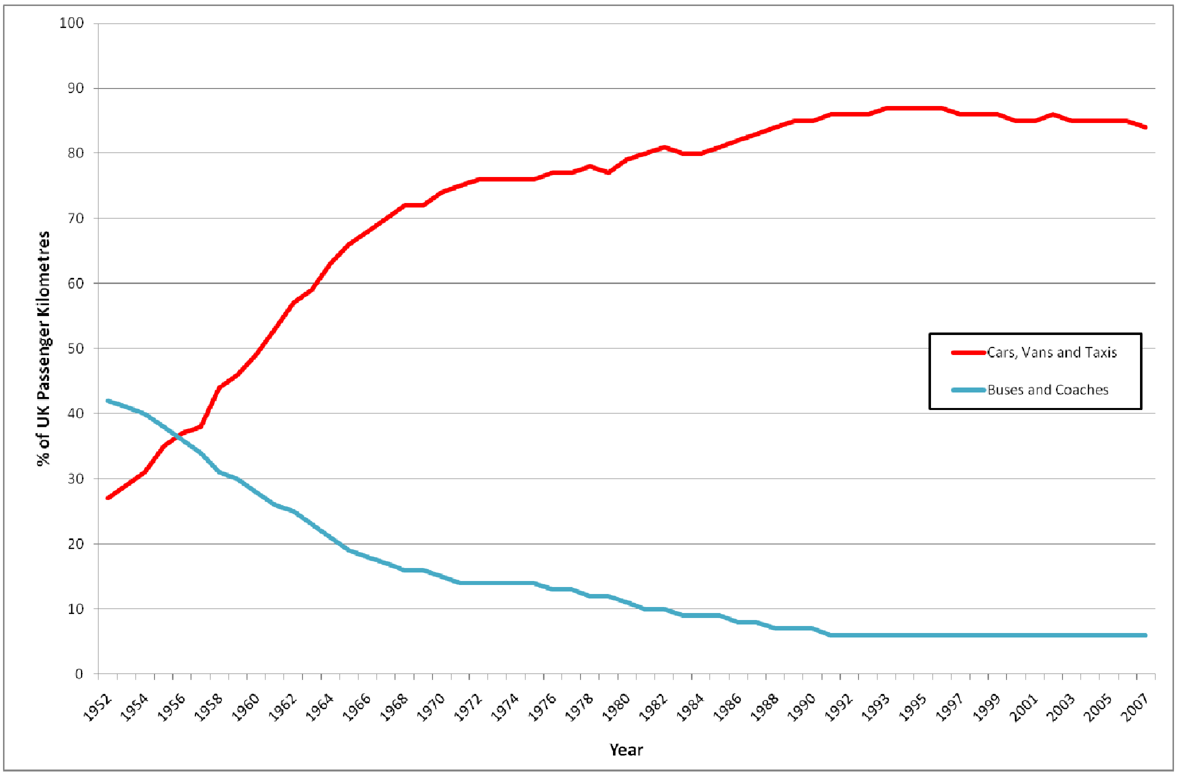


Figure 1.1: UK Car Use versus Bus Use Graph, 1952-2007. (DfT, 2008c)

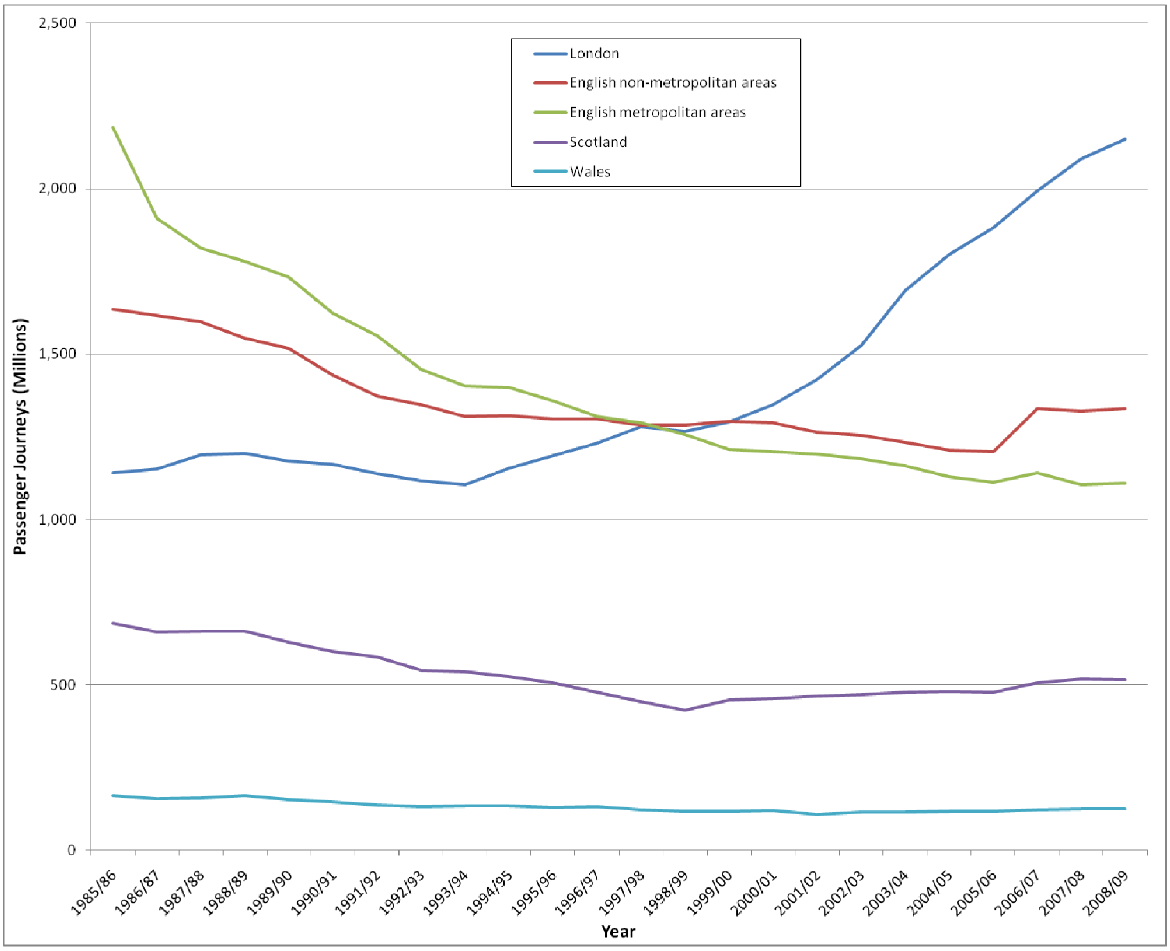


Figure 1.2: Bus Patronage in the UK since Deregulation, 1984-2006/07. (DfT, 2008c)

Whilst it cannot be denied that the car provides people with freedom and personal mobility, the recent over-reliance on the car has given rise to serious levels of traffic congestion. A report by the Commission for Integrated Transport (CfIT, 2001) found that although car ownership levels in the UK (404 cars per 1000 people) were lower than the EU15 average (451 cars) congestion levels were amongst the severest and most extensive of all European countries surveyed. Whilst the exact definition of congestion is a complex one, it is widely accepted that it has a diverse range of socio-economic and environmental impacts. The Confederation of Business Industry (CBI) puts an estimate of £20 billion on the total economic cost of congestion to the UK economy although this value is subject to some dispute (Grant-Muller and Laird, 2007). The UK also has a fairly poor record in terms of CO_2 and NO_x emissions which is attributed to "our dependence on motorised transport and, in particular, our high use of the car" (CfIT, 2001, p.49).

1.2.2 Changing Travel Habits

The issues of increased car dependency and the potential for changing travel habits have become regular features in the annual British Social Attitudes (BSA) reports (Stokes and Taylor, 1995; Christie and Jarvis, 2000; Exley and Christie, 2003, 2004; Jones, Christodoulou and Whibley, 2006; Stradling *et al.* 2008). The BSA reports have investigated the changing attitudes towards how people travel in the UK and there are some significant findings related to current travel habits, the over-reliance upon car travel and the associated environmental impacts. Cars are clearly valued in our daily lives. Does this means that we should be allowed to use them without any restrictions, regardless of the damage to the environment?

The BSA reports asked respondents whether they agree, disagree or have no opinion with the following statement: *"People should be allowed to use their cars as much as they like, even if it causes damage to the environment t."* As Table 1.1 suggests, there is a general acceptance that car use should be limited, which is encouraging. However this should not detract from the fact that despite widespread knowledge on the impacts of excessive car use, "there is a group – currently numbering just under a quarter of the adult population [respondents in 2006] – that believes people should be able to use their cars as much as they like" (Stradling *et al*., 2008, p.149).

Table 1.1: Attitudes Towards Unlimited Car Use

Year	*1991*	*1994*	*1997*	*2000*	*2002*	*2003*	*2004*	*2006*
Agree	19	17	15	20	20	22	16	23
Neutral	38	30	34	34	25	31	29	33
Disagree	43	48	49	42	48	41	49	39
Base	*1224*	*975*	*1080*	*972*	*989*	*972*	*872*	*930*

Figures are percentages. Source: BSA24 (2008), Table 7.6, p.149

Closer examination of the annual results in Table 1.1 reveals that the latest available results (those from 2006) have the highest percentage of those who agree (23%) and the lowest percentage of those who disagree (39%) with the original statement. Whilst this could indicate a shift in attitudes towards car travel, it is now acknowledged that continued growth in car use levels is simply unsustainable. Although there is a general acceptance that it is important to control our car use, the findings of the BSA studies also suggest that the way forward is not through 'stick' policies – ones which are intended to make car use less attractive – but through 'carrot' policies – ones which make the alternative options (such as PT, walking and cycling) more attractive (Stradling *et al.*, 2008). It has been identified that in many major cities, there is a relationship between the quality of PT services and the level of growth in car ownership (White, 2008), but in the UK, PT systems have suffered from decades of underinvestment and now face an uphill struggle in order to reach a level which can compete with the comfort and convenience of the car.

As Figures 1.1 and 1.2 suggest, it is only in recent years that the general decline in PT patronage is finally being stemmed but research suggests that persuading more car drivers to leave their vehicles behind in favour of PT will not be an easy task. In a survey on attitudes to car use and modal shift in Scotland (Anderson and Stradling, 2004) it was found that of all the car drivers questioned, only 23% were *willing* to switch from car to bus, but of this 23%, only 7% felt they were *able* to make the switch. Conversely, of the remaining 77% who were *unwilling* to switch, 23% said they were perhaps *able* to do so, but they just did not want to. Despite this apparent reluctance of car drivers to switch modes, the general consensus is that things cannot continue as they are for much longer.

A diverse range of hard and soft incentives have been introduced in an attempt to reverse this modal imbalance, promoting PT as an attractive and viable alternative to the car. Hard incentives typically include improvements to road infrastructure (e.g. new bus lanes, bus priority at signalised junctions), which can be costly to implement in terms of time and financial outlay. Therefore, soft incentives are viewed by many as a more suitable solution in the short- and medium-terms. One soft incentive identified as key in promoting PT to a wider audience is improving the amount and quality of information that is made available to the traveller. However, over the previous two decades there has been little guidance in the national transport legislation as to what PT information should be provided, and by whom.

1.3 UK Public Transport Legislation and the Provision of Information

> Good information is regarded as important. But it is generally accepted that this is the Achilles heel of the Public Transport industry, and that this has been so for far too long."
>
> (Hibbs, 1999, p.28).

The legislative structure behind PT services in the UK was rather static for most of the 20th Century. However, as a result of deregulation in the 1980s and issues surrounding an increase in car use, the provision of an adequate PT system has become an important socio-political topic in the last twenty-or-so years. In light of this newfound importance, the legislation behind PT systems has come under intense scrutiny and undergone a number of revisions. A full discussion is clearly beyond the scope of this project, but it is important to understand how today's fragmented PT system came to be and, key to understanding the motivation for this research, the impact these developments have had on the provision of PT information to the travelling public.

The first legislation concerning public bus services was introduced to Local Authorities (LAs) in 1889, but it was not until the passing of the 1930 Road Traffic Act that public bus services were brought under a regulated structure. The Act was introduced because of increasing concerns about pirate operators (who operated irregular services at peak times along the most profitable routes) and a duplication of services between bus and tram/trolley bus services (Savage, 1985).

This regulated structure of the bus industry introduced through the 1930 Act was to remain in place for half a century (Pickup *et al.*, 1991). During this time, the market in which the bus companies were operating was to change substantially, in particular because of increased competition from the private car. Following the end of World War II, technological advances and changes in social structure gave rise to an increased demand for personal mobility (Banister, 2002). As a result, the latter half of the 20th Century saw a significant increase in private road travel (car, vans and taxis), whilst public road travel (buses and coaches) entered a period of general decline. Bus travel began to lose its market dominance of overall road travel, as shown by Figure 1.1, where buses accounted for 42% of all passenger kilometres travelled in the UK in 1952, but in just over a decade (by 1964) this proportion had halved to only 21% (DfT, 2008c). Nevertheless, the regulated structure of the bus industry remained remarkably constant throughout.

Falling patronage led to a deficit in revenues coupled with increased operating costs, fares and subsidies. By the start of the 1980s, the required level of financial support was such that the Government decided the public bus sector was no longer economically viable and so deregulation and privatisation were put forward to shift the cost of running bus services away from the pockets of the taxpayer. Bus services in the UK were deregulated through the 1980 Transport Act (express coach services) and the 1985 Transport Act (local bus services, excepting London and Northern Ireland), and now financial constraints of commercial operations meant that poorly performing routes were not always sustained through cross-subsidy and could be easily discontinued. To ensure the continued provision of services which were not commercially viable, the 1985 Act permitted LAs to identify those services which were socially desirable but commercially unviable, and provide financial support through a system of competitive tendering. All these changes gave rise to a fragmented bus network that was inherently flexible and constantly open to new competition.

Overall responsibility for providing bus services was transferred from the LAs to the operators, and it was assumed that providing information about services would also be the responsibility of the operators. However there was no clear stipulation in the 1985 Act that this would be the case, and the lack of clear responsibility for providing PT information is now recognised as one of the greatest gaps in this legislation. Critics often point to the instability of bus services and the poor level of information provision as significant negative effects of deregulation that were introduced into the bus system following the 1985 Act (White, 1995; Mackie and Preston, 1996).

A review of post-deregulation passenger information practices by the National Consumer Council (NCC) and Buswatch (reported in Cahm, 1990) found there was much confusion as to who should actually provide information, and who was best placed to provide information, the result of which was a continuous game of ‘passing the buck’ between LAs and the operators. In general, the PT operators felt that LAs were the only bodies who were in a position to provide comprehensive information about all services, whilst from the LAs perspective, the changes brought in by the 1985 Act meant they were now faced with a (potentially unwanted) responsibility for providing impartial information about all bus services in their area, even though they had lost overall control over the provision of bus services. Despite their impartial position, the 1985 Act only gave LAs a statutory *power* to publish PT information if they so desired: they had no direct *duty* to do anything with respect to the provision of PT information (Poole, 1999).

Another early deregulation-era review of Western European information provision practices conducted for FWT, found that British PT information provision practices were "substantially different to that of the rest of Europe" (Greenwood, 1993, p.20) and there was a large amount of duplication of efforts between the LAs and the PT operators. Regarding mapping information, the majority of PT systems outwith the UK viewed the provision of a system map as "a key item of publicity… almost all maps and guides deal with all public transport facilities in the area" (ibid., p.19) whereas the British system was one where mapping was almost exclusively unimodal, an offshoot of the fragmented networks created by deregulation.

In the latter half of the 1990s, the thinking behind national transport policy began to change, recognising the impacts that increased car use was having on society and the need to address the social, economic and environmental issues of traffic congestion. The five years from 1995 to 2000 saw a number of significant developments in the UK's transport legislation, including the publication of a guidance document, 'Better Information for Bus Passengers: A Guide to Good Practice' (DfT, 1996). Encouragingly, the content of 'Better Information for Bus Passengers' was not wholly focussed upon the provision of timetable information, and had sections dedicated to mapping information (albeit rather short sections). It identified that there was a need for comprehensive, impartial whole network maps: "As a minimum, each area should have an all-operator public transport guide, containing a route map" (ibid., p.8), and for mapping information to appear at key locations: "In bus stations and at other major interchanges, more comprehensive displays are desirable, including route maps" (ibid., p.12). There is even a call for schematic route maps to be used to complement and help simplify the information contained in numerous timetables at an individual stop.

In 1998, the Transport White Paper 'A New Deal for Transport: Better for Everyone' was published (DfT, 1998). This set out the new Labour Government's vision for changing the way we view and use transport, and outlined their proposals for how these changes would be implemented. It was identified that continued growth in private car use could not continue at current levels and attractive, alternative means of travel were required, including improved PT services and the White Paper finally recognised the role that PT information can play in promoting PT services as an attractive and viable alternative. It also highlighted the fact that practices were inconsistent across the UK and it was apparent that passengers were experiencing a degree of uncertainty when attempting to plan a bus journey yet "if we can reduce the information needs of the bus user, we can thus reduce the uncertainty about use of this mode" (White, 1995, p.137). The White Paper can be criticised for using the term 'information' in a generic sense, giving no specific requirements for the provision of mapping information. However, it did identify the need for better overall information provision and gave LAs a duty in the provision of information, thus resolving the confusion created in the 1985 Act.

Following all the consultations, reviews and proposals, the primary legislation was put into practice with the passing of the 2000 Transport Act (UK Parliament, 2000), the first major change to the national transport legislation for 15 years. In light of the devolution of powers to the Scottish Government, similar changes to the legislation came into force in Scotland, through the 2001 Transport (Scotland) Act. In both Acts, the role of the LAs as primary PT information providers, and their ability to recover costs from the operators for the provision of comprehensive information (where necessary) are explicitly defined:

> In this section "local bus information", in relation to a local transport authority, means -
> (a) information about routes and timetabling of local services to, from and within the authority's area,
> (b) information about fares for journeys on such local services, and
> (c) such other information about facilities for disabled persons, travel concessions, connections with other public passenger transport services or other matters of value to the public as the authority consider appropriate in relation to their area.

2000 Act, Section 139(6); 2001 Scotland Act, Section 33(5)

Again, mapping information is not specifically mentioned in the content of the Acts, but the need for 'information about routes' does suggest that there is a requirement for mapping information, albeit without complete commitment to graphical forms of PTI as this could also be applies to textual descriptions of routes (such as lists of street names followed by each route).

Following a rather turbulent decade of change in the national transport legislation, the 2000s have so far been a time of relative stability, as the impacts of the legislation introduced by the 2000/2001 Acts have taken effect. However in 2006, two decades after the emergence of the deregulated bus market (outside of London), two independent reviews into the current state of, and potential future options for, UK bus services were published (ATCO, 2006; House of Commons Transport Committee, 2006). Both reviews were highly critical of the way in which local bus provision was heading despite all the promises of improvements to bus services outlined in the 2000/2001 Act, and warned that the national picture was being grossly distorted by the relative successes of London and in the few areas of the UK in which co-operation between the LA and the PT operators had continued to prove worthwhile to all parties.

In terms of information provision, the ATCO report commented on the continued disparity between regions:

> Obtaining information about local bus services from roadside information displays is often the first experience of bus travel that customers and, significantly, potential customers have. The quality of this information varies greatly across the country. Best practice can be found in London, some PTE and other local authority areas where it is provided by the authority, but in many areas standards are poor and a considerable obstacle to increasing patronage and encouraging modal shift.
>
> Not surprisingly, there are many people [who] have never travelled by bus and do not know how to use one.

(ATCO, 2006, p.3)

In light of these reviews and general concerns, the Government undertook a ‘long, hard look’ at bus services across the UK, investigating the “issues affecting bus patronage and the options available to bring about a positive change to the provision of bus services (in England)” (DfT, 2006, p.10). The main message that arose from this study was that the way forward was to give greater emphasis on the development of partnership working between LAs and the operators, but without going as far as re-regulating the industry.

The resulting report, 'Putting Passengers First' (DfT, 2006) outlined how the regulatory framework introduced by the previous Act was to be revised and contribute to the 2008 Local Transport Act. Given that LAs still had a statutory duty regarding information provision, the 2008 Act did not directly enforce any changes to the existing situation but from consultation with a range of stakeholders it was identified that "there is a general need for better marketing of bus services, including clearer and more easily accessible information on routes and timetables" (DfT, 2006, p.31). At the time of writing, the 2008 Act is still in its infancy and the changes introduced through new partnership working between LAs and operators are slowly emerging.

This review of the historical developments in UK transport legislation has shown that, whilst information provision was initially overlooked in the 1985 Act, subsequent legislative developments have taken steps in the right direction. Information provision is now widely acknowledged as an important part of the overall bus service, and we have clear guidance as to who should take primary responsibility for overseeing the provision of information about all services in an area. Analysis of the statistics from quarterly DfT Bus Satisfaction Survey (Figure 1.3) shows that, since the passing of the 2000 Act, satisfaction with bus stop information has seen a marked increase compared to the other measures.

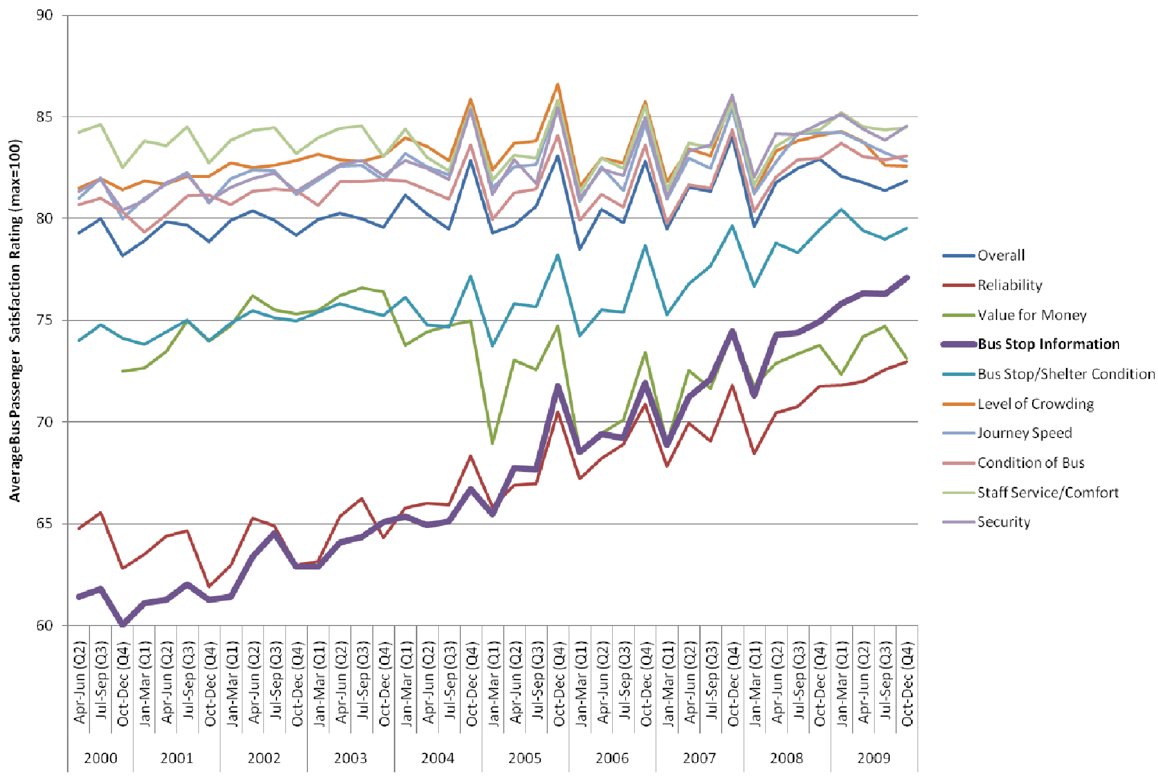


Figure 1.3: Changes in DfT Bus Satisfaction Survey Metrics, 2000-2009
(Data supplied directly from DfT Statistics Department)

Although average satisfaction ratings of bus stop information have risen from the lowest ranked measure in 2000 to third-lowest by 2009, the magnitude of the increase (15.6 percentage points) is by far the largest increase of all the measures recorded by the DfT. Despite this increase in satisfaction, the provision of information is still not as complete as one would hope; the quality of PT mapping information provision still varies from area-to-area and there are many different cartographic designs now available, as illustrated by recent reviews by Morrison (2007) and Scrimgeour and Forrest (2008).

It is unfortunate that mapping information rarely gets a specific mention in the legislation and associated documents, particularly as all documents discussed in this section do mention the need to provide information on *routes*. This suggests that mapping information is needed but more often than not, maps are only considered as supplementary information to timetables. As the Literature Review (Section 2.4) identifies, mapping information is more desirable for journey planning purposes, yet recent investments into information systems typically focus on timetables.

1.4 The Provision of Mapping Information for Public Transport

It is now widely acknowledged that a lack of accessible information which is presented in a clear, concise and current manner is a significant barrier to PT use:

> Difficulty in finding out which buses run when **and where** can only discourage people from using the bus, and make the private car seem more attractive
>
> (My emphasis, DfT, 1999, p.26)

This statement comes from the highest UK Transport Authority but it merely hints at a need for mapping information. The earlier review of the developments in national PT legislation shows that adequate provision of information is essential for overcoming the problems caused by a fragmented PT system. Whilst great efforts have been made towards the production of comprehensive *timetable* information for all services, regardless of the operator, there still appears to be a lack of integrated thinking with respect to the provision of mapping information.

1.4.1 Is there a Need for Public Transport Mapping Information?

When planning a PT journey, there are two main types of information required, namely '*where* does each service go?' and '*when* does it depart/arrive?' Clearly the '*where*' element of PTI is an essential pre-requisite to the '*when*' element, yet the majority of efforts into PTI provision have, peculiarly, been focussed on the latter. A detailed discussion of the need for mapping information can be found in the Literature Review (Chapter 2), but the general conclusion of previous research into this area is that passengers prefer mapping information for planning their PT journeys.

1.4.2 Modal Differences in Public Transport Mapping

It is important to distinguish between different modal characteristics and the impact these can have on how PT mapping information is designed and disseminated to the travelling public. Avelar (2008) presents a summary table for the main transport modes (Table 1.2) which outlines the key differences in the requirements and restrictions of mapping for bus networks compared to that for rail-based modes of travel.

In general, rail-based services operate to and from a set of stations which are clearly defined in geographic space and have unique names. This allows for all stations (even those seemingly inaccessible, located in the remotest of areas such as Corrour or Altnabreac in Highland Scotland) to be clearly represented on maps, and timetables are able to list them in a sequential order for cross-referencing with the mapping information. When travelling by rail-based PT modes, it is common to see a wide variety of maps prominently displayed across a system, within station concourses, on platforms and in the carriages themselves. The abundance of mapping information means that most passengers should be able to plan a journey between two stations on a rail network with relative ease.

For example, consider a typical journey on the London Underground, where passengers have a range of maps at their disposal, with a different map at each stage of the journey:

1. Upon arriving at a station, they can consult a network diagram in the entrance to locate their intended destination station and then plan a suitable route.
2. After they have bought their ticket, they can readily identify the required line and the correct direction of travel, and then make their way to the

corresponding platform by using the colour coded strip maps which are placed at convenient points within stations and at the entrance to each platform.

3. Once on the first train, there are more strip maps of each line showing interchanges with the other lines, providing reassurance to the passenger that they are heading in the right direction.
4. If an interchange is required, there are colour coded signs throughout stations to guide the passenger through the labyrinth of walkways, followed by more strip maps at each platform entrance.
5. Upon arriving at the destination station, there is a street map of the local area, to allow the passenger to plan their onward route to their ultimate destination.

Whilst the London Underground is an example of the provision of excellent mapping information across a whole system, a similar situation exists for the majority of heavy- and light-rail systems. In comparison, the operational characteristics of bus networks (a variety of operators, service variations depending on the time of day, routes with a higher sinuosity etc.) combined with a higher spatial density of bus stops gives rise to different challenges for mapping information. It is evident that the mapping possibilities enjoyed by rail passengers are not as applicable to bus travel. Although bus services do operate to and from a set of bus stops which, similar to rail stations, are clearly defined in geographic space, it is not common practice for all bus stops to be given specific names, despite Avelar stating they are, or at least should be, named (Table 1.2).

The spatial density of bus stops often results in the distance between individual bus stops being as little as 100 metres which makes it difficult to represent individual stops on smaller scale maps. Assigning each stop a unique name relies upon using the names of little-known side streets as reference points which do not feature in everyday use e.g. High Street at West Road. If a local reference point is available, such as a shop, church or pub, this is typically used in the bus stop name, but people still need to know where these local reference points are located. This problem of naming bus stops is further compounded as even when bus stops have unique names, they often do not appear in conspicuous fashion at the stop, or on information literature. Therefore, good mapping information for bus services is essential in allowing passengers to plan a journey and then undertake their journey with confidence.

Table 1.2: Difference in Mapping Requirements for Different Modes of Transport, modified from Avelar (2008) Table 1, p.139.

Cartographic Design Elements	Transport Mode			
	Bus	**Tram**	**Underground/Metro**	**Train**
Transport Lines	Simplified lines	Schematic or simplified lines	Schematic lines	Schematic or simplified lines
Background Information and Base Map Detail	Generalised features: streets, hydrography, parks, reference places, hill shading	Possibly some generalised street detail, simplified hydrographic features	Typically plain background, simplified hydrographic features and overground railway networks	Simplified rivers and Lakes
Representation of Individual Routes	One route per service or for coincident services together	One route per service or for coincident services together	One route per service or for coincident services together	One route per service or for coincident services together
Stops	Named, but difficult to represent individual stops across a whole network or area	Named, possibly difficult to represent individual stops in City Centres	Named, representing individual stops easily achieved	Named, representing individual stops easily achieved
Labels	Main streets, reference places, rivers, lakes, services alongside lines	Services alongside lines or at line termini	Services alongside lines or at line termini	Services alongside lines or at line termini

1.5 The Stop-Specific Bus Map Concept

The previous sections have shown that PT mapping information perhaps does not receive the attention it deserves and there is a need for PT mapping to be made more available. However, it is also believed that whilst the traditional network design of map is useful to the traveller, there is also a need to reduce the complexity of these maps to provide more relevant mapping information at the point of use. This could be in the form of area maps (e.g. TfL's SpiderMap) or even further focussed to provide information specific to each stop, equivalent to timetable information practice in some areas. This section outlines the main tool for this research, namely the Stop-Specific Bus Map (SSBM) as proposed by Morrison (1996c).

1.5.1 What is a Stop-Specific Bus Map?

A Stop-Specific Bus Map (SSBM) only shows the forward-sections of *all* routes of *all* services that call at an *individual* bus stop on a *single* map or diagram (Figure 1.4). Previous sections of the calling services are omitted, as it is not possible to travel to these destinations from the stop. The same omission condition applies to those services passing by, but not calling at the stop, including those services calling at other bus stops in the vicinity of the stop in question. Limited-operation services, such as unidirectional peak services, school services, those which operate on specific days, or at irregular frequencies may be omitted from the SSBM, especially on more complex maps where space on the map face is at a premium.

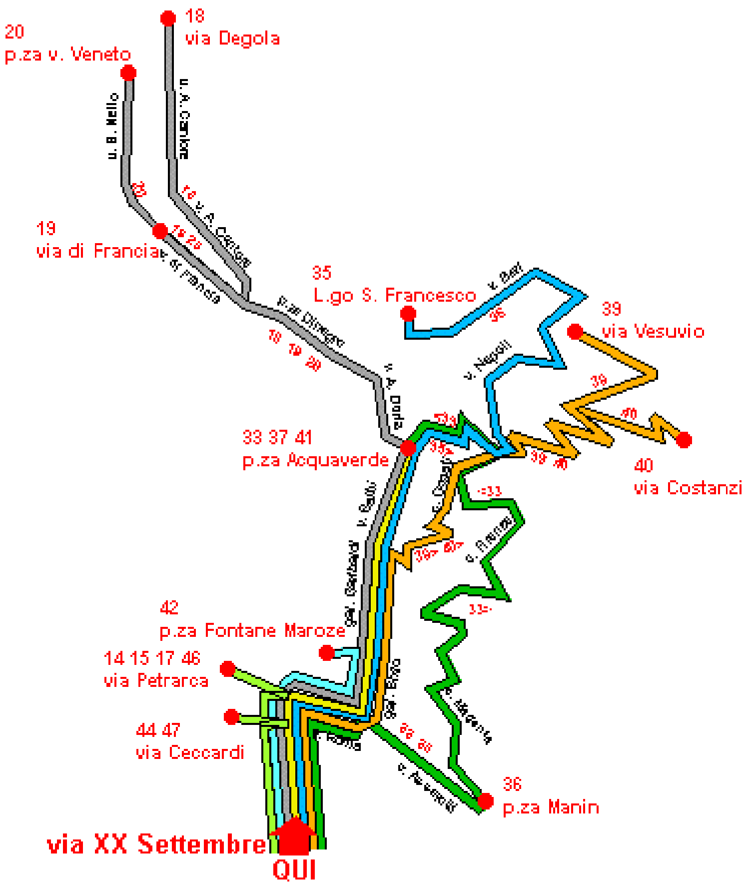


Figure 1.4: Example of a Stop-Specific Bus Map for 'via XX Settembre', in Genoa, Italy.

(© A. Morrison)

This would be of particular use to travellers unfamiliar with the services, as it would assist them in identifying whether the approaching bus will actually call at the stop in question: "That's a very basic thing that you need to know – that your bus actually goes from that stop, otherwise you stand there with your hand out like an idiot" (Audit Commission, 1999; quoted in National Consumer Council, 1999, p.32).

The main feature of a SSBM is that it explicitly tells passengers to where they can travel using *only the services calling at that particular stop*. This is especially beneficial where there are a number of possible services that can be used to reach the desired destination, as passengers may not be aware of all the possibilities. For example, in Figure 1.4, if the desired destination was Piazza Acquaverde (located in the centre of the map) then passengers have the option of taking services 18, 19, 20, 33, 35, 37 or 41, although it is apparent that service 33 (dark green) takes a longer, winding route and so may not be the most convenient service to board if in a hurry.

As the name suggests, Stop-Specific Bus Maps are unique to their particular stop and cannot (and should not) be transferred to any other stop, unlike generic whole network maps which could (and perhaps should) be displayed at all stops across an area. One reason why such maps are used is that they can be economically produced *en masse* – multiple copies of a single map are cheaper to produce compared to producing single copies of a number of individual maps. However, a SSBM is not intended to completely replace existing whole network mapping, but to complement them instead. A SSBM is designed to only be displayed and used at the relevant stop, providing reassurance to passengers that they are at the correct stop, their intended service will call at the stop and take them in the right direction of travel towards their final destination. A SSBM is designed to be displayed at one stop and one stop only, and it serves little purpose away from this location. Logic suggests that to manually produce a unique map for each and every stop in an area would be a very time consuming procedure indeed.

This research is attempting to evaluate the effectiveness of the SSBM concept and add weight to the argument for the development of an automated system, as proposed in a specification by Morrison (undated), to generate these maps from a GIS database.

1.5.2 What are the Advantages of Stop-Specific Bus Maps?

A SSBM is essentially a reduction of a whole network map, removing all the extraneous information and only showing the information relevant to the user at the current point of use i.e. their current location, the routes which call at the stop and the different destinations to which they can travel.

If we consider the processes involved with the cartographic communication model (Figure 1.5), real world information, e.g. the routes of a bus network, ***(I)*** is transformed by the cartographer into the map product, ***(I')***. The user then studies the map and interprets the data to build up their own mental representation ***(I'')*** of the existing real world situation. The smaller the amount of information the user has to take from the map and mentally process (***I' → I''*** in Figure 1.4), then the clearer and truer the final message ***(I'')*** should be. A good map should result in the user's final message being as close to the original information as possible i.e. ***(I'' ≈ I)***.

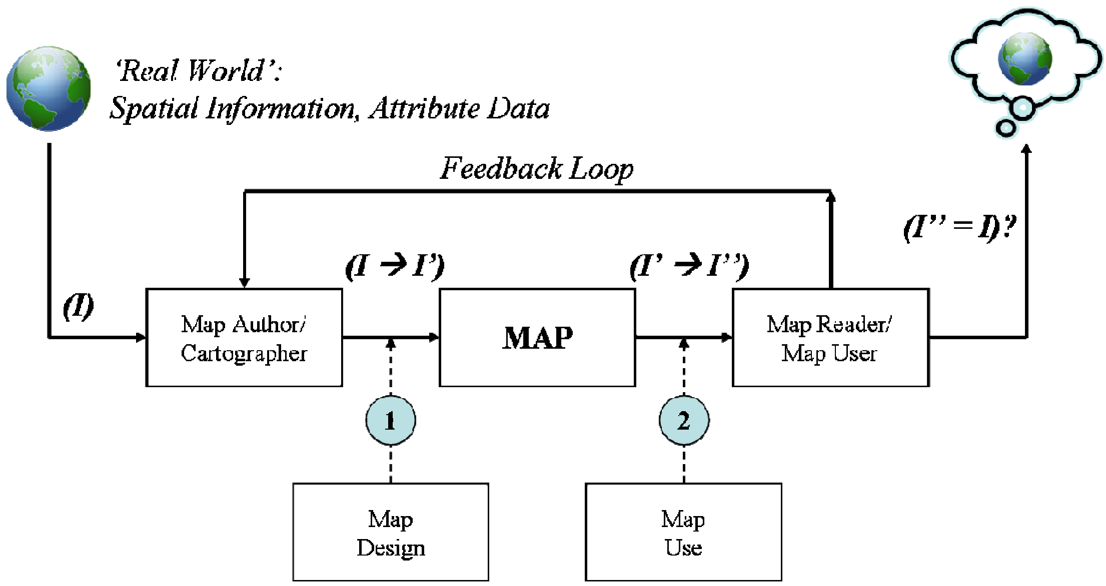


Figure 1.5: Cartographic Communication Model,
derived from Dent (1996) and Kraak and Ormeling (2003)

One of the primary roles of the SSBM is to enable the user to quickly identify the full list of services which they could board in order to travel (close) to their intended destination. This may be as many as three or four individual services, from a potential list of upwards of 20 or more buses which call at that particular stop. It is hoped that this would make the bus system appear more accessible and less daunting, especially to new or unfamiliar users, who have a limited cognitive map of their current surroundings and the PT services available to them. SSBMs are also intended to provide reassurance to the user during their journey. Research indicates that passengers want a PT system that is simple to use, with clear instructions, and is one in which they feel confident and in control (Lodden, 2002; Bus Partnership Forum, 2003). Bartram (1984) introduces the concept of a PT system's 'legibility' where "a 'legible' system is one in which a passenger can get from one point to another easily and without any anxiety about getting lost" (p.299). This idea of simplicity and legibility forms the basis of the SSBM concept. Simple and legible information is essential in providing passengers with a PT system that they can use and will want to use, as opposed to one which is only considered as a last resort. By simplifying the amount of mapping information provided to the user through SSBMs, it is hoped that they will understand where they are, which services will call at the stop in question, and the range of destinations to which they can travel, all with greater ease than if presented with a set of timetables and/or a whole network map.

From a passenger's point of view, SSBMs certainly appear to have a number of advantages. However, LAs and the PT operators will want to know whether the greater adoption of SSBMs could have any positive effects on modal shift (from car to bus), future patronage levels and future revenues. This research will attempt to provide some answers to the first two points, and it can be assumed that the third point will be directly correlated with the second. The answers to all three points will only be truly revealed if SSBMs are displayed at bus stops and future patronage and revenue figures are monitored, something not possible to achieve within the timeframe of this project. Nevertheless, SSBMs could potentially have some operational advantages. The current legislation (Section 1.3.4) allows operators to alter their services with only 42 days notice, so an area's bus network is subject to numerous alterations, usually at irregular intervals.

As the ATCO review identifies:

> Frequent changes to services, especially at short notice, place an extra burden on Local Authorities' publicity and information budgets and increases the workload involved in maintaining up-to-date information for Traveline, Transport Direct and other information systems.
>
> (ATCO, 2006, p.5)

This inherent flexibility of bus networks can result in a rather frustrating and inefficient production process for mapping information – as soon as the updates to the latest version of a whole network map are approved and the final proof sent to the printers, a new revision of the map could be required the very next week, depending on when a service alteration was registered. From an information currency point of view, SSBMs should be easier to keep up-to-date, as any changes to a single bus route would only require the affected SSBMs to be altered and redistributed to the affected stops. Compared to updating, printing and redistributing an entire stock of whole network maps, this should be (theoretically speaking) a more efficient process.

1.5.3 What are the Disadvantages of Stop-Specific Bus Maps?

Perhaps the most obvious criticism that could be directed at the SSBM concept is that they do not show the complete PT network in an area – but they are not intended to do so. It is important to understand that there are a number of different styles and designs of bus maps, and there should not be a 'one size fits all' approach to the provision of mapping information. As Balcombe and Vance (1998) suggest, "perhaps there are different roles for different types of map, at different stages in planning and making a journey" (p.31), a notion supported by Caiafa and Tyler (2002) who introduce the idea of the 'Journey Chain'.

Fendley (2009) introduces the notion of 'progressive disclosure', providing people with the right amount of information at the relevant decision point to assist them when planning and making a journey: "give pedestrians [or Public Transport passengers] only the information they need at any given time and don't overload them with any more… a route [or journey] is littered with decision points and a method to edit directions into memorable and useful collections is needed" (ibid, p.102). A SSBM is only meant to be displayed and used at the relevant stop – it has little use at any other location in the network, be it at another bus stop or even in a user's home or office. To provide information about the bus services in a specific area, a design similar to the Octobus (Morrison, 1996b) or TfL's SpiderMap would perhaps be more suitable.

By only showing the forward-portions of the routes of the calling services, a user would only be able to plan direct journeys from the stop in question. The addition of connecting services from stops further along the routes could be considered but this would be moving away from the true SSBM concept. At this point, it seems appropriate to reiterate the point that SSBMs are *not* intended to completely replace whole network maps, but are designed to be a complementary source of information. In an ideal situation, the user would have both types of map available to them at bus stops but at present, SSBMs have to be produced manually for each individual bus stop. Whilst this is acceptable for this research, in reality this would be a highly inefficient process, given the number of bus stops in an area. For example, the NaPTAN (National Public Transport Access Node) dataset for Glasgow City has more than 3000 bus stops and so the manual production of a SSBM for every stop in Glasgow would be very costly without the development of a software system to generate SSBMs automatically.

1.6 Research Aims and Tasks

This research will investigate whether SSBMs are viewed by the public as a useful piece of information, and there are two aims underpinning the focus and direction of this research.

1.6.1 Research Aims

The initial aim of this study is to establish whether satisfactory SSBMs can be *manually* designed for bus stops, based upon an existing specification developed by Morrison (undated) for guidance, and utilizing readily available geospatial digital datasets and desktop software. Morrison's existing specification is for the *automated* production of SSBMs and had previously only been tried out on less than 10 individual maps, for bus stops that were deliberately selected, using data which was digitised for the specific purpose using basic graphics software from the early 1990s (A. Morrison, 2010, *pers. comm.*).

Before any work is undertaken into creating automated development systems for producing these maps, it is worthwhile to ascertain whether the SSBM concept does indeed have some value. Therefore, the next aim of the study is to investigate the effectiveness of the SSBM concept compared to existing PT information provision for assisting people in planning a bus journey. If this research can show the SSBM concept to be beneficial, it would add weight to the argument not only for further research into the detailed cartographic design of SSBMs, but for dedicated research and development into a software system to automatically generate SSBMs from a GIS or other database with geospatial capabilities, making the process more efficient and economically viable.

One final aim of the work will attempt to provide some evidence on whether the greater adoption of SSBMs could potentially play a role in promoting increased bus patronage. Whilst the results of the SSBM tests may show that they are easier to use and can assist users plan their journeys, from an operational and cost perspective it is important to identify whether the additional investment (in terms of both time and financial outlay) into developing SSBMs could actually pay dividends through increasing patronage and thus increasing revenues.

1.6.2 Research Tasks

To meet the above aims, the following tasks are required.

1. An investigation into the current issues surrounding the provision of spatial information about bus services. This was achieved by undertaking a detailed Literature Review of existing good practice relevant to conveying passenger information about *to where* buses operate.

Previous work by the author (Evans, 2004) found that the existing body of work specifically on the topic of bus mapping is rather limited. The review for this work looked at the general topic of Public Transport Information, highlighting the key issues surrounding mapping information where appropriate. The review in this current project consists of published literature and will also seek out unpublished results (aka 'grey' literature) of market research or consultants' reports from bus companies, mapping companies, Local Authorities, ITAs and other relevant organisations.

2. The preparation of an experimental design which ensured that the SSBMs were tested in a variety of different towns, to account for geographic variations in PT and PTI provision and bus networks thereby representing typical British towns and cities (as was practically possible within the confines of this research), and at different bus stops randomly sampled so that the overall sample was representative of general bus stop attributes. These attributes were variables such as bus stop location (urban or suburban), number of calling services (one, a small number, a large number), general direction of travel (away from an urban centre, towards an urban centre, circumferential routes).

3. Compilation of route data from a variety of sources (online and paper literature) which was used to design SSBMs for the selected bus stops using graphical software (Adobe Illustrator, CorelDraw etc.) for the cartographic element of the design, along with a Geographic Information System (ArcGIS 9.2) to store the route data, bus stop information and other cartographic inputs. All software used was available through the Department of Geographical and Earth Sciences.

4. Conducting outdoor tests to investigate the effectiveness of the Stop-Specific Bus Maps by asking a carefully considered sample of travellers at bus stops which bus(es) one could take to get to a particular destination, and recording the time taken to return a correct response. The responses obtained when the SSBMs are available to the participants have been compared with those obtained using traditional information available to the passenger, namely at-stop information and publically available Network Maps. The participants were also asked additional questions about how effective they perceived the SSBMs to be, their current PT usage and whether they would consider making greater use of bus services should SSBMs be displayed at some or all stops across a network.

From this research, the SSBM concept will be evaluated compared to current mapping practices by members of the travelling public. If shown to be effective, this will hopefully lead to the widespread adoption of these maps in many towns and cities.

2.1 In this Chapter

Previous studies have identified that there is a relatively limited body of work in the specific area of bus mapping. Therefore this Chapter contains a review of existing literature about a variety of issues surrounding Public Transport (PT) information in general, highlighting the key points relating to PT mapping information. Indeed, one purpose of this review is to highlight the need for more work in the area of bus mapping.

The Chapter begins with a discussion about the possible reasons behind the limited existence of study-specific research, and the subsequent need to initially expand the scope of the review, followed by the review itself.

2.2 Scope of the Literature Review

One research task identified in the introduction was a review of existing work relevant to conveying passenger information about **to where** buses operate. However, attempting to categorise 'bus mapping' as a discrete study area in its own right is difficult, as it can be classified under both transport and cartography which are quite distinct areas of study. Mapping and Public Transport have also found their way into other areas such as sociology and cognitive psychology (the implications of the latter for this study are discussed in Section 2.4.1), so the potential range of issues that could be explored through this review is quite extensive. Previous work by the author (Evans, 2004) found that the body of literature specifically on bus maps was relatively limited. The primary reason is largely that mapping is perceived as a minor component of the overall PT information package, especially in relation to the attention given to timetable information. Through a review of existing PT information, Cartledge (1984) identified that PT mapping practices across the UK were "far from universal" (p.6) and that maps were "generally a complement to timetables as a source of information, rather than a substitute for them" (ibid, p.10). Dobies (1996) reached a similar conclusion following his review of PT information practices in the USA, stating that "route maps are used in displays by some agencies, but not as frequently as schedule information … some agencies use route maps only when additional space remains in a display panel after schedule [timetable] information is displayed" (p.13).

These findings are supported by other literature reviews (Hall, 1983; Balcombe and Vance, 1998; Turnbull and Pratt, 2003; White, 2005), who all comment on the limited volume of work in this domain. White (2005) is particularly critical of the level of academic attention afforded to PT information research, and also comments on the bias towards timetable information: "even less research has been conducted on route maps and diagrams, as opposed to timetable displays, and in most studies bus maps or route descriptions occupy little attention" (p.6). Other reasons for the lack of 'study-specific' research can be attributed to buses being only one mode of PT, and PT information is itself only one part of the overall PT service.

In Chapter 1, it was noted that the provision of PT information was somewhat neglected in earlier 20th Century legislation. Perhaps this is also a contributing factor to the lack of studies specifically on bus mapping – can it be assumed that these maps 'just happen', and so this is an adequate situation where no further action or research is deemed necessary? The general conclusion is that PT information research is a rather fuzzy area. Although there are studies on a variety of aspects relating to general PT information, their scope, aims and overall content are so diverse that "results may not be compatible or comparable, and it is not surprising that they are sometimes contradictory" (Balcombe and Vance, 1998, p.3). Based on these findings it is clear that there is a significant gap in the knowledge specifically about PT mapping information. Given the apparent lack of 'study-specific' work, the scope of the literature review conducted by Evans (2004) had to be extended to incorporate studies into general PT information, highlighting any significant points relating to PT mapping and this approach has also been adopted for this review.

2.3 Why do we need Public Transport Information?

It has long been acknowledged that a lack of information is a significant disincentive to travelling by PT (Suen and Geehan, 1986; Cahm, 1990; Balcombe and Vance, 1998; DfT, 1999; Brög, 2000; Cain, 2007) and so the majority of studies in this domain usually begin by asking 'why do we need PTI?' In attempting to provide an answer to this question, it is important to consider the need for PTI from three different points of view, namely the passenger, the PT operators and the Government/LAs. Each of these user groups has different needs and requirements and so PTI has many functions to fulfil. It is useful to explore these functions and how they relate.

2.3.1 The Passengers' Point of View

Passengers require PTI in order to successfully use PT services. Lyons (2006, p.200) identifies three important roles for PT information:

1. It makes the individual aware of the travel options available to them for a particular journey.
2. It empowers the individual to make more fully informed travel choices.
3. It assists the individual in being able to successfully undertake and complete the journey.

If PT is viewed as a 'product', then information forms the 'instructions' about how to use the product. Without any instructions, it is often difficult to find out how a product works and when comparing the process of using the PT product with that of its main modal rival, the car (Table 2.1), it is apparent that information plays an important role when attempting to make PT travel at least as attractive as car travel to the general public.

Table 2.1: Comparison of the Travel Process between Car and Public Transport (Evans, 2004)

Travelling by Car	***Travelling by Public Transport***
Door-to-door journey	Initially need to access the PT network and exit it at the other end
Only limited to the road network available to the public	Limited to those road/rail links served by PT services
Can take any route, adjusting for traffic disruptions and delays	Limited to where PT services go, have to tolerate disruptions
Road maps are designed to assist planning of optimum routes	Range of mapping options available - difficult to plan an optimum journey
Direct journey - no need for interchanges	Not always possible to make a direct journey - need for interchanges
If mistakes are made, can easily correct errors	If mistakes are made, can be difficult to correct errors quickly
Can depart at any time and can predict arrival time	Must depart at specific times, can predict arrival time
Control speed of travel (up to 70mph)	Cannot control speed of travel
Only directly perceived cost is fuel	Only directly perceived cost is fares

Passengers intending to use PT need to gather a large amount of information in order to successfully make their journey. A number of questions need to be answered before they can even begin their journey, as shown by Evans' (2004) thought process map (Figure 2.1). However, the majority of PT users will make the *same* journey from the *same* origin to the *same* destination, at the *same* time of day, using the *same* service(s), five days a week (Garland, Haynes and Grubb, 1979).

This repetitive nature of travel means that these users will know the specific details of their journey off by heart and therefore have little, if any, requirements for PTI and so their journey through the journey planning thought process map is likely to take the shortest path possible.

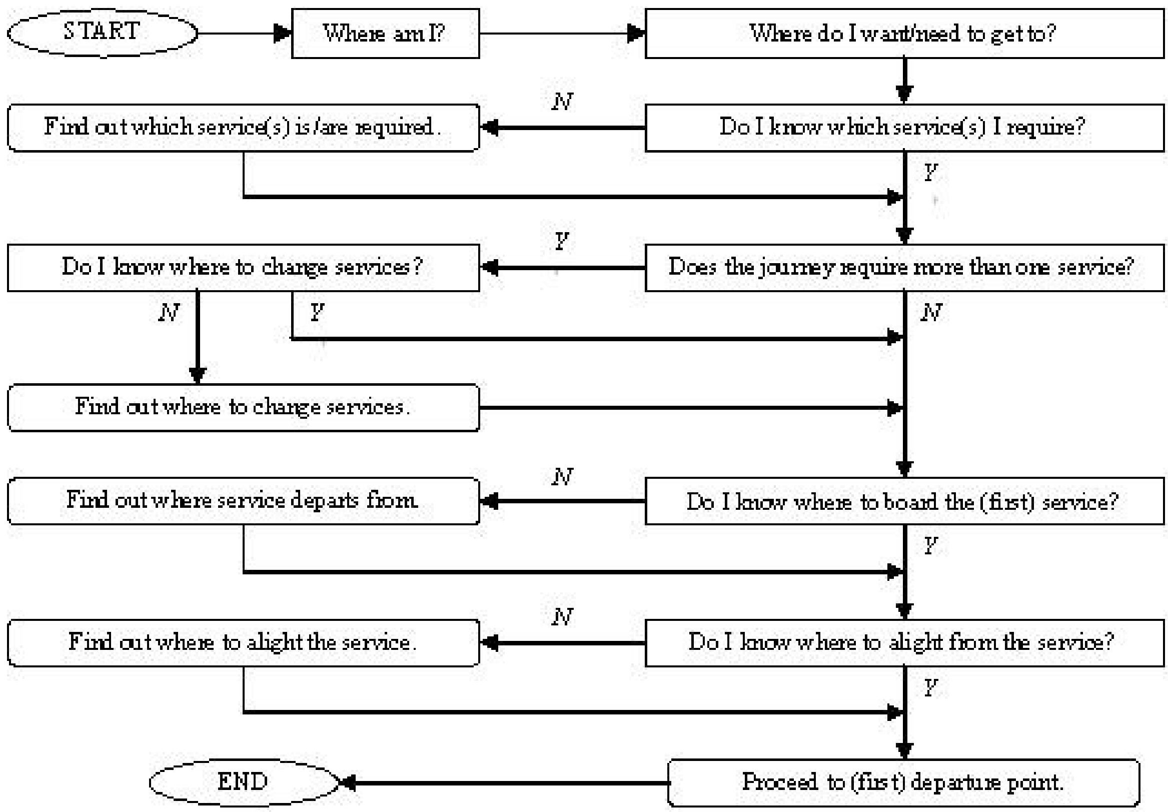


Figure 2.1: Journey Planning Thought Process Map (Evans, 2004)

This therefore raises the question ‘Is there any need for Public Transport information?’ In the case of the regular user, perhaps not, unless the service(s) they use are altered. Only when the route or timetable of a service is drastically changed, or a whole service is discontinued altogether, does a regular traveller find themselves in need of new information. In such circumstances, their path through the Thought Process Map will be temporarily altered from their usual one, until they can acquire the new information for their revised journey.

However regular travellers are not the only users of Public Transport: Suen and Geehan (1986) suggest that whilst the information needs of the regular traveller may be minimal, it is probably more important to consider the information needs of the occasional PT user, who can be classified into one (or more) of the following categories:

- Unacquainted – strangers to the city, unfamiliar with the geography and transport systems on offer
- Exceptional – those who use PT only when they have no other choice
- Foreign – may have some language barriers
- Disabled – may have certain functional limitations to either their information use, or which modes of transport they can access

As occasional user will require much more detailed PTI, their journey through Evans' journey planning thought process map will probably take the longest path possible and even with the necessary information to hand, occasional users will be subject to some degree of uncertainty throughout the journey. In addition to Suen and Geehan's passenger classification, Balcombe and Vance (1998) identify three types of journey – regular, occasional and new – each category having its own level of information requirements. A significant finding of their study was the 83% of respondents who claimed not to need any information before making a regular journey. When the same question was posed about making an occasional journey, about two-thirds of respondents claimed they would not require any information whilst when making a new journey, only 7% of respondents said they would not require any information.

Further complications arise here because these categorisations of PT user and journey types are not fixed. All regular passengers had to be a new passenger at one point, gradually becoming more and more familiar with the journey each time it is made. A regular passenger may also want to make the occasional journey to a different destination, the location of which they may know from previous visits, but they may be unsure about which PT services will take them there. Until they have been able to successfully find the right answer to their query, this state of uncertainty still applies and there is a chance that the journey might not be made using PT. Previous studies (Lodden, 2002; Bus Partnership Forum, 2003) indicate that regardless of their level of familiarity and frequency of use, passengers want a PT system that is simple to use, has clear instructions, and is one in which they feel confident and in control. Lodden (2002, p.23) states that:

> It should not matter how complicated trips passengers choose *(sic)*, how far they choose to travel, how familiar they are with the system or how many different operating companies there is *(sic)*. The public transport system must appear as a complete and simple service.

In terms of information provision, Lodden is critical of existing situations: "Information… is sometimes hard to fully comprehend. The information is often poorly formulated, so that the transport system may seem unclear and difficult to interpret" (ibid). Information also has a role to play in maintaining what Bartram (1984) defines as a PT system's 'legibility', where "a 'legible' system is one in which a passenger can get from one point to another easily and without any anxiety about getting lost" (p.299). Simple and legible information is essential in providing passengers with a PT system that they will understand and are able to navigate their way (wayfind) through successfully. Good information is essential in creating a PT system that passengers *can* use and will *want* to use, as opposed to one which is only considered as a last resort. This requirement for simple, comprehensive PTI is paramount as summarised by DHC (2003, p.60):

> People need to feel confident about using public transport and good information can be one of the cheapest ways to change perceptions of whether transport meets their needs… until these seemingly small issues are resolved by public transport providers, people will continue to be sceptical that they can trust public transport

Finally, Lodden (2002, p.24) poses the ultimate question underpinning this research:

Do people refrain from travelling by Public Transport because they have limited knowledge of the services available?

2.3.2 Public Transport Operators

As operators require passengers to generate revenue, they need to encourage people to use their services by presenting a user-friendly image, a service that is accessible to all, easy and convenient to use. However, in today's status-driven society, owning a car is seen by many as an essential commodity in their life, a measure of success from which individuals derive a number of psychosocial benefits (Ellaway *et al*. 2003; Beirão and Sarsfield Cabral, 2007) whilst the image presented by PT is one of discomfort, inconvenience and deprivation, a mode of travel generally associated with the poor, students and the elderly (Stradling *et al*. 2007). This view is epitomised by Margaret Thatcher's (now infamous) quote: "A man who, beyond the age of 26, finds himself on a bus can count himself as a failure." A car offers privacy, comfort, convenience and flexibility. PT is used by other members of the public, runs on fixed routes to pre-defined schedules, and users are limited to destinations within close proximity to the stops served (Gardner and Abraham, 2006).

Although bus operators are competing with each other for patronage, the bus *industry* is competing with the car. It is now recognised that if the bus industry is to reverse this modal imbalance, persuading people out of their cars, then the bus product needs to be made more attractive to the potential user (Ahern, 2002; Stradling, 2002). Bunting (2004) argues that in order to make the bus more attractive, we first need to break the psychological association that "cars are fun, buses are not" (p.55) and Bunting believes that the bus industry can do more to improve its customer relations in order to attract more custom. Whilst there are many ways in which this can be done, one of the simplest ways is to provide people with the right information at the right time. Not only would this present a customer-friendly image of an accessible bus system, it would to allow people to understand the services on offer and make informed choices (Lyons, 2006). Obviously, improving information alone will not be enough as the actual bus services provided need to be attractive and meet the passengers' needs, as identified by Balcombe and Vance (1998, p.1): "good information will not sell bad services".

Improving information plays a key role in wider PT marketing schemes, and research has shown that operators can gain from improved information through increased patronage and higher revenues. A report from the International Association for Public Transport (UITP, 2003) found that improved information contributed to between a 5% and 25% increase in patronage levels. In the UK, Enoch and Potter (2002) comment on how route branding in Brighton and Hove led to an 8% annual increase in patronage on its five core 'Metro' routes, whilst in Glasgow, the adoption of the Overground network concept gave rise to a 4% annual increase in patronage. Cairns *et al.* (2004) also comment on the success stories in Brighton and Hove, and point out the relevant successes of a marketing programme in Nottingham, which included information improvements. The programme stemmed the long-standing 1% annual decline in local bus patronage and generated a 1.8% annual increase in figures.

The increase in patronage figures can bring financial benefits to operators. Work by Ellson and Tebb (1978a, 1981b) and Enoch and Potter (2002) into the various aspects of PT marketing found that promoting PT services and improving information can bring financial returns in the region of 3:1, whilst Paulley *et al.* (2006) found that printed PTI available at home was valued at between 2p and 6p per trip, whilst the same information made available at bus stops was valued at between 4p and 10p per trip. Nee and Levinson (2004, p.24) conducted a Stated Preference survey into users' willingness to pay for PTI and found that "the most valuable piece of information, on average, was a route map and schedule. Respondents were willing to pay an additional $1.00 [approximately 50p at the time of writing] per trip for this information."

Good information is also a suitable way of introducing people to the bus system, and if done correctly, will encourage future patronage and continued use. Unfortunately, despite the potential benefits and returns, operators are reluctant to invest heavily in improving information as they have a number of financial outgoings and overheads to maintain. As the majority of passengers are regular travellers and thus require very little information, this apparent lack of additional information requirements has led to some people in the bus industry adopting a rather dismissive stance on providing extra information (Enoch and Potter, 2002).

The situation appears to be one where most operators are happy with the information that already exists, relying on "the assumption that customers will simply 'get on with it'" (White, 2005, p.1). This problem is particularly evident with the smaller operators, who have a limited budget to provide information, as illustrated by Figure 2.2. Not only does this lack of complete information create uncertainty amongst passengers, but it also presents a poor image of the bus industry in general.

Figure 2.2: Graffiti on a timetable display at Clarkston Toll in Glasgow's Southside. (Taken by the author.)

Therefore it is not just the passengers than can benefit from improved PT information. Improving information can be a "win-win" scenario, and if increased revenues can be reinvested into further improvements in PT information, there is potential for a virtuous circle to be created (Figure 2.3) which, as some areas in the UK have demonstrated, may go some way to reversing the historical decline in bus use.

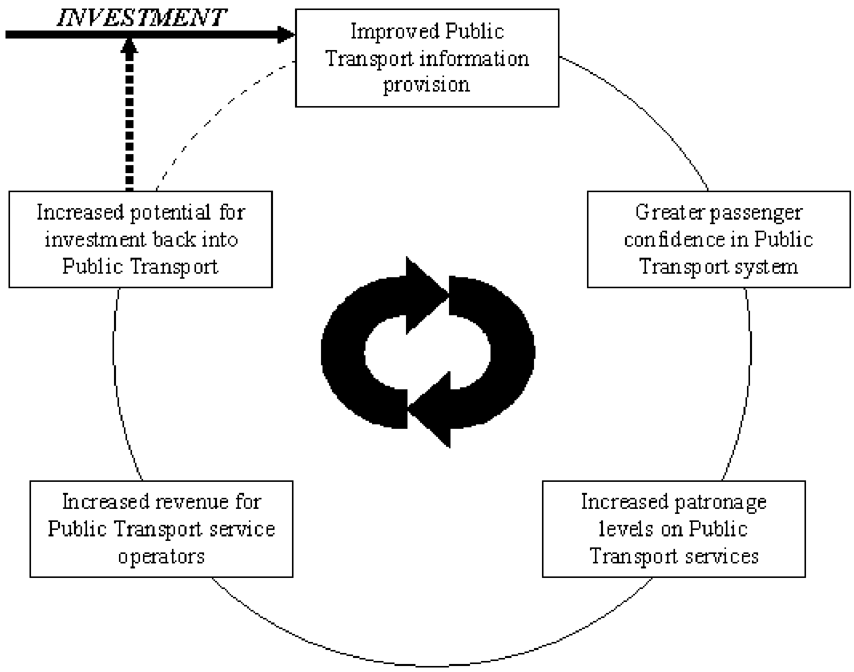


Figure 2.3: Investing in Improving Public Transport Information: a Virtuous Circle?

2.3.3 Government and Local Authorities

> The provision of information that is accurate and easy to use is the main factor that underpins any successful Public Transport strategy. This is of paramount importance.
>
> (FWT, 2002)

The changes in legislation (Chapter 1) set out clear guidelines as to who should take overall responsibility for the provision of PT information for passengers. However, Local Authorities (LAs) have a substantial information requirement about PT services that goes beyond providing timetables and mapping information for passengers, such as network coverage and accessibility to services (Franzen, 1999, quoted in Fairbairn, 2005). Concerning the provision of passenger information, LAs now have a *duty* to ensure that passenger PT information in their local area is *adequately* provided and many now have a specific Bus Information Provision Strategy (BIPS) which outlines their future plans and investments into PTI. In previous work by the author (Evans, 2004), a survey of 48 LAs found that 38 (79%) produced a BIPS or equivalent policy document. A slightly lower figure was recorded in a study of marketing departments within US transit organisations (Cronin and Hightower, 2004), where only 64.5% had a written marketing plan, but these results do demonstrate an awareness in LAs of the benefits and impacts that PTI can have. From the LAs' perspective, it is important to ensure that PTI is available for all services in their area and that people can access this information at a variety of locations, both while they are using the PT system, and when they are planning a journey away from the PT system. In the deregulated environment, this can be a difficult task and often LAs need to take a direct initiative about the provision of PTI which can help address key issues.

The first relates to the wider issue of increased car use, the impacts of congestion and the promotion of alternative modes. In the introduction to this study, it was shown how car use in the UK has continued to increase since the 1950s whilst local bus use has continued to decrease (Figure 1.1). Improved PT is seen as one of the key instruments in changing how we travel and although buses are not seen by many in a positive light, they are the main mode of PT for the majority of the UK (Enoch and Potter, 2002) and are likely to remain the main mode for some time to come. It has been shown that improvements to bus networks and services can be a quicker, more cost-effective solution and can deliver comparable results to that of Light Rail systems if services are delivered along dedicated corridors at high-frequencies (Ben-Akiva and Morikawa, 2002).

However, without adequate PTI it is very difficult for passengers to use PT services. If the predicted growth in car use is to be controlled then the alternative options must be easy to use and so LAs must ensure that enough information is available. Simpson (1994) observes how many bus services could be improved a great deal by taking the simple measures of displaying timetables and route maps at all stops, as the current situation is one where "many bus stops exist merely as an indicator that a bus route passes by, but at what point in time a bus may arrive and to where it is heading remains a mystery except to those with previous experience and knowledge" (Evans, 2004, p.3). This statement is supported by recent study (Morris, Ison and Enoch, 2005) which found that there was "a lack of organisational consistency within the authorities surveyed and uncertainty as to who is responsible for bus promotion" (p.36).

Despite the clear direction set out as to who should provide PTI, perhaps we now need clear guidance as to exactly what PTI is needed, how it should be provided, and how it should be funded. This is especially important as analysis of data collected as part of the Local Government's Best Value Performance Indicators (BVPI) in 2003/04 suggests that there is a strong positive correlation (r^2 = +0.7868) between the level of satisfaction with bus stop information (BVPI103), and the level of satisfaction with bus services in general (BVPI104), as shown by Figure 2.4.

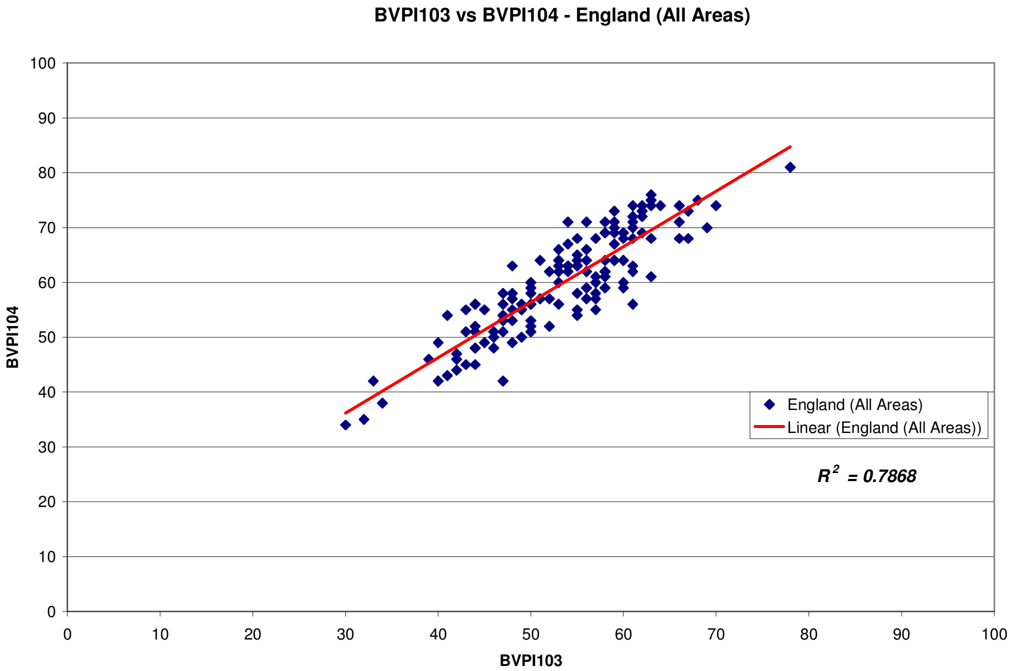


Figure 2.4: BVPI103, Satisfaction with Bus Stop Information, versus BVPI104, Satisfaction with Bus Services in General (Audit Commission, 2004)

A previous survey of LA Transport Committee Chairpersons, Principal Transport Officers and independent transport academics (Ison and Wall, 2002) found that improving PT was believed to be *essential* in the fight to alleviate urban transport problems. 90% of respondents thought that 'improving the frequency and reliability of PT' was a 'fairly or totally effective' policy instrument, 95.5% of respondents stating that this approach was a 'fairly or totally acceptable' policy option. To achieve this, Wright and Egan (2000) put forward a proposal to 'de-market' the car by reducing its image as a status symbol and necessary commodity for everyday life, with a view to influencing general attitudes towards cars and over-reliance on car use amongst the next generation of drivers. As commendable as this stance is, it could take some time for such attitudes to actually filter through and for people to act upon them.

Gärling and Schuitema (2007) identify that "voluntary, non-coercive TDM [travel demand management] measures, such as public information campaigns, may not be effective in reducing current car use. Coercive measures, such as prohibition of car traffic, are likely to be more effective than are non-coercive measures" (p.150) but these coercive measures are not likely to be popular with motorists and thus politically unfeasible. Improving PTI is one non-coercive measure which would benefit LAs without any political danger of angering the influential motoring organisations.

Another key role LAs play is the subsidisation of socially necessary services that operators are unable (or possibly unwilling) to run on a purely commercial basis. These services are often a vital link to areas which would otherwise have no bus service at all, so encouraging and maintaining patronage on these services is important in order to ensure they continue operating. Again, information is a key tool in raising the awareness of the existence of these services. These socially necessary services are also important in reducing the effects of social exclusion, and there is now a widely acknowledged link between the effects of poor transport provision on the level of social exclusion in the poorest areas (Hine, 2007; Lucas, Tyler and Christodoulou, 2008). This lack of awareness of the opportunities that PT services can provide is a general problem amongst most bus passengers. Balcombe and Vance (1998) suggest that one of the key problems facing information providers is that a large percentage of users are unable to access and use information effectively. They are simply unaware of what information is available, where they are able to obtain information from and if they are able to obtain some information, they often misunderstand its content - but crucially, they do not realise it is actually *their* error that causes the confusion. Clearly, taking action to ensure that PTI is available at a wide range of locations, including at the point of use (i.e. bus stops), would be appropriate action for LAs in an attempt to allay some of the problems outlined above.

The latest figures for England (at the time of writing) show that bus stop information is still ranked as one of the poorer performing elements of the overall bus services (Figure 2.5), a situation that has gradually improved since 2000 (Figure 1.3). It is encouraging to note that bus stop information satisfaction ratings are now reasonably consistent across all areas of England, and at their highest levels since 2000 (Table 2.2).

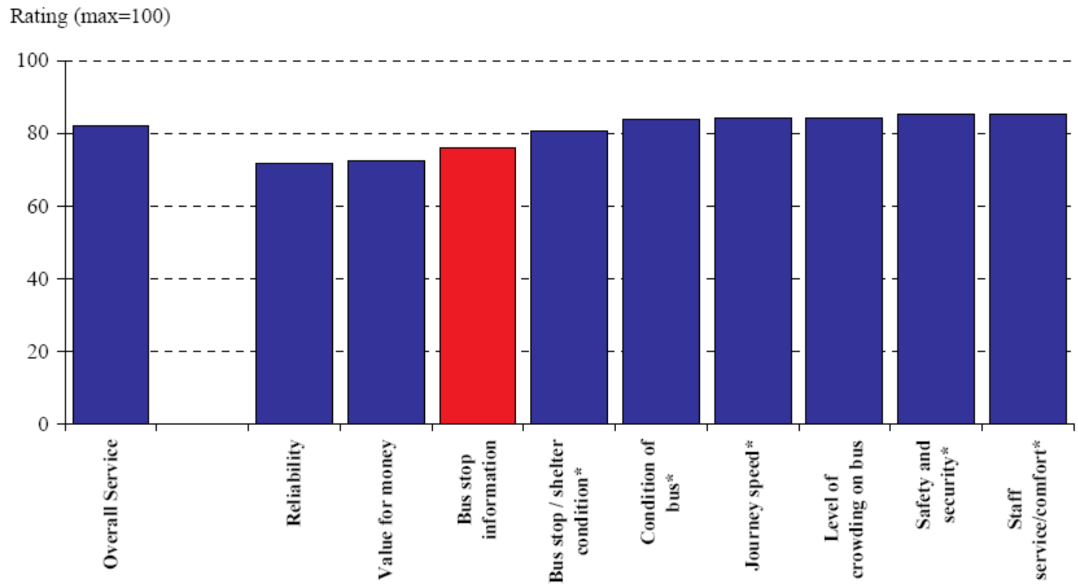


Figure 2.5: Bus Passenger Satisfaction Ratings for England, Winter 2008/09

Table 2.2: Average Satisfaction Ratings for Bus Stop Information (DfT, 2009)

Year	England	Metropolitan	Non-Metropolitan	London
2000/01	61	54	55	72
2001/02	61	55	56	71
2002/03	63	58	58	72
2003/04	65	59	59	72
2004/05	66	59	61	73
2005/06	69	65	64	74
2006/07	70	67	66	74
2007/08	72	73	70	77
2008/09	75	74	71	77

During his studies across Western Europe in the 1990s, Morrison found that the quantity and quality of spatial information provision for bus passengers was generally poor compared to that of other PT modes, especially rail-based modes (Morrison, 2000a). In Britain, the average score for buses was only 28% of the possible total score, compared to an average of 34% for the rest of the (non-British) European cities in the survey. In towns where scores were particularly low, many bus stops had no form of spatial information provided (Morrison, *pers. comm.*). Morrison's results also highlight the difference between London and the rest of the Britain in the amount and quality of spatial information for bus services, as London scores 35%, on par with the European average. London is often quoted as an area where the provision of bus information is excellent and could be used as a model for the rest of the UK to follow (Hendy, 2005). If LAs want to change how we travel and if we are to be persuaded out of our cars, then improving bus services is essential. One of the quickest, and possibly most cost-effective, means of doing so is to invest in improved information.

The general conclusion that can be taken from this section is that there is a definite need for PTI, from the passengers', PT operators' and LA/Government's perspective. PTI is key in allowing users to understand how the PT product works and without it we are more likely to continue being over-reliant on our cars, considering PT only as a last resort. PTI does improve the image of PT, both through changing attitudes towards PT and improving the level of confidence people have in the system. Research has shown that financial gains can be had from investing in information, and there is a general correlation between the level of satisfaction with PTI and the overall level of satisfaction with PT services.

2.4 The Need for Public Transport Maps

It is useful to think of a PT journey as a series of successive steps, defined as the 'Journey Chain' by Caiafa and Tyler (2002) who identify three general PT information categories:

- Pre-trip information: helps the user to plan routes and connections
- In-trip information: assists users at each decision (interchange) point during the journey
- Supportive/Confirming information: repeats and informs data and decisions, giving the passenger a sense of confidence that they are on the correct service to the correct destination

Caiafa and Tyler present a table (p.244) which lists the available types of PTI and defines what information each type of PTI could provide, cannot provide, which stage of the Journey Chain the information can be applied and who is excluded from (or would have difficulty) using the information in question. The following is suggested with respect to PT mapping:

- Could provide
    - Spatial relationship of landmarks, routes and connections
    - Schematic view of the whole journey
    - An overall picture of the transport system
    - Flexibility for changing plans
    - Supportive information during the trip
    - Portable information useful for both pre-trip and in trip planning

- Cannot provide
    - Easy availability (the map is a physical object that must be obtained before trip planning can begin)
    - Straightforward information (map reading presents difficulties for many people)

- Time or point of access
    - Pre-trip
    - In-trip
    - At interchanges

- Who is excluded
    - People with vision difficulties (unless in tactile form)
    - People have difficulties with spatial information
    - People with learning difficulties
    - People with dexterity problems

Mapping information definitely has a lot to offer the user, with the proviso that they are able to obtain the correct type of map for their current needs. One important feature of the table with respect to PT maps is that they are applicable to all stages of the Journey Chain but this requires a number of different PT maps to be obtained or consulted throughout the journey, each having a specific purpose. This need for different maps is highlighted by Balcombe and Vance (1998, p.31) who suggest that "perhaps there are different roles for different types of map, at different stages in planning and making a journey." When it comes to PT mapping, it is not a case of 'one size fits all', and the range of PT maps and associated design issues are discussed in greater detail in a later section in this review.

2.4.1 Cognitive Maps and Public Transport Journeys

One key point raised by Caiafa and Tyler is that map reading can be a difficult task for some people. The cognitive processes involved with map reading are complex, and conveying an accurate message depicting a real world situation onto the user's mental map via a paper map is subject to a number of data translations (as shown in the previous chapter, Figure 1.7) and it is often during the map reading stage where the message can be lost or misunderstood.

Cognitive mapping both draws from, and touches upon, a variety of different research domains and disciplines (Portugali, 1996; Hannes, Janssens and Wets, 2006), and is itself a very complex area of study as it "involves a multiplicity of sensational and informational modes… [and therefore] does not fall into any single traditional cognitive field" (Portugali, 1996, p.1). Kitchin (1994) gives a detailed analysis of what cognitive maps are and why they are worthy of study, concluding that "… cognitive mapping has a role to play in spatial behaviour, spatial decision making, learning and acquisition, theory making and in real world applications" (p.14). There has been great interest in how cognitive processes can be related to developing improved cartographic output (Eastman, 1985; Peterson, 1987; MacEachren, 1991; Liben, 2009). For a general overview of the research in this domain, Montello (2002) provides an excellent and highly detailed historical review of the developments in cognitive map design research through the 20th Century, highlighting the well-established notion that cartographic maps "do not present the world directly… but *re*-present the world by providing versions of truth for human minds to apprehend" (p. 283).

The roots of cognitive mapping research can be found in Arthur Robinson's *'The Look of Maps'*, now noted as a seminal piece of cartographic work, in which it was proposed that "… to understand and improve map function, cartographers need to understand the effects of design decisions on the minds of map users" (ibid., p.285). There are now many definitions of 'a cognitive map', two such examples being:

> an abstraction covering those cognitive or mental abilities that enable us to collect, organise, store, recall and manipulate information about the spatial environment… it is the way in which we come to grips with and comprehend the world around us

(Downs and Stea, 1977, p.6)

> a cognitive map… codes the Euclidean relations (straight line distances and directions) among behaviourally relevant landmarks within a coordinate reference system centred on the environment. Cognitive maps function to support navigation, and, in turn, are created by navigation and exploration of space

(Sholl, 1996, p.157)

It is therefore important to consider the links between cognitive mapping and the processes involved when travelling by PT. Sholl's statement helps to develop the relationship between cognitive mapping, travel patterns and decisions, and this is supported by Stern and Portugali (1999, p.100) who state that "urban navigation [travel] is a sequential process of decision making concerning route choice, whose essence is to match internal [cognitive] with external information as it becomes available”.

When we travel, we rely upon information previously gathered and stored in our memories to assist us in making decisions, and the amount and quality of this information is associated with the mode of transport most frequently used and the level of interaction we have with the surrounding environment as we travel (Mondschein, Blumenberg and Taylor, 2007). In return, the process of travelling helps to further develop our existing mental maps as we undertake new journeys, explore new routes and mentally store additional spatial reference points and landmarks (Weston and Handy, 2004; Hannes, Janssens and Wets, 2006). This relationship is cyclical, as illustrated in Figure 2.6:

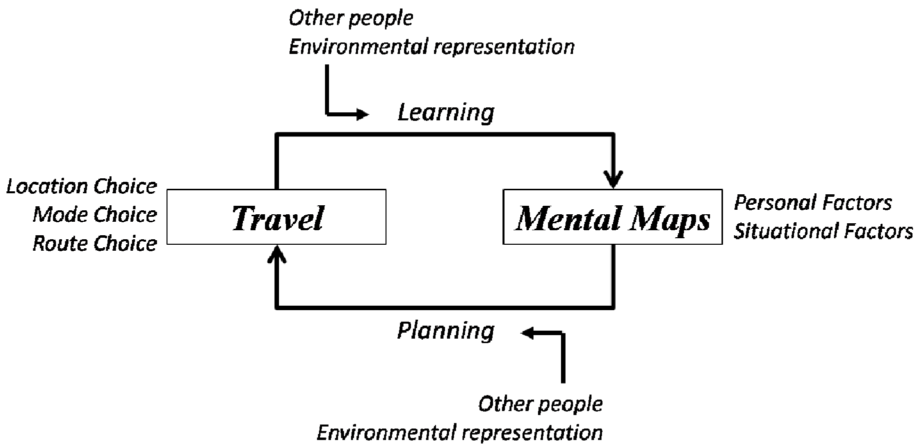


Figure 2.6: The Cyclical Relationship between Travel and Mental Maps (Hannes, Janssens and Wets, 2006)

Regarding individuals’ cognitive knowledge and representations of existing transport networks, it has been suggested that the average cognitive map is “but partial and quite minimal” (Golledge and Gärling, 2004, p.503) and so we have to rely upon the features of the environment around us to help locate and reassure ourselves as we travel: “in both cognitive mapping and wayfinding, environmental anchors play an important role” (ibid, p.504). Indeed, most people have a cognitive map of an area which is subject to systematic distortions, which are a result of information being stored through cognitive hierarchies, application of perspective and cognitive reference points (Tversky, 1992) and these in turn have some influence on why different people have different levels of wayfinding and navigational abilities (Allen, 1999).

However, when undertaking a travel activity, “an individual need not have a correctly encoded and cartographically ‘correct’ map stored in memory to be able to successfully follow a route” (Golledge and Gärling, 2004, p.505) as long as the route can be related and referred to the various environmental anchors (landmarks) along the journey. Nevertheless, particularly in unfamiliar areas or when undertaking a new journey (where the individual’s cognitive map of the location may be non-existent), people still need mapping information to assist them in identifying which bus(es) they require to travel to specific locations, as well as information from drivers or other passengers about when to alight from the vehicle.

Given the apparent reliance upon existing cognitive information when travelling, it is also notable that physical cartographic maps are only required when making an unfamiliar or new journey as “the bulk of human travel is repetitive and relatively invariant in time and space. It would be unusual for humans to consult a cartographic map of an environment prior to every trip” (ibid., p.501). This is supported by the findings of Balcombe and Vance (1998) who identified the different levels of information requirements when making regular, occasional and new journeys by PT.

The notion of a PT system’s legibility (Bartram, 1984) is closely related to the notion of wayfinding, a significant area of research in both the cognitive psychology and information design domains. From an information design perspective, “the objective of information design for wayfinding is not to design signs, but to help people move efficiently to their chosen destination” (Passini, 1999, p.87), but the term ‘wayfinding’ is often used in place of, or perhaps confused with, navigation. For clarity, Golledge and Gärling (2004) define ‘navigation’ to be “a route to be followed [which] is predetermined [and] deliberately calculated” (p.506) whereas ‘wayfinding’ is not as strict as navigation, being “the process of finding a path (not necessarily previously travelled) in an actual environment between an origin and destination that have previously not necessarily been visited” (ibid.)

Definitions aside, both navigation and wayfinding have their place in the act of travelling and in understanding individual travel behaviour. It could be said that when undertaking a journey for the very first time, the elements of uncertainty, exploration and discovery are more akin to the act of wayfinding, yet as the level of familiarity with the particular journey increases (the route taken, location of environmental anchors, the departure time of services and so on), the definition shifts to one more closely associated with the navigation of a particular journey.

Nevertheless, mapping and other PTI form a substantial part of the wayfinding/navigation process in PT systems (Berger, 2005; Gibson, 2009) although it can be said that it is the passengers who are responsible for wayfinding whilst graphic designers, sign writers, information providers, cartographers and building engineers are all responsible for wayshowing where “the purpose of wayshowing is to facilitate wayfinding” (Mollerup, 2005, p.11).

Once a journey has been decided upon (using either a pre-planned route or otherwise), and the undertaking of the actual journey has commenced, the initial task facing the traveller is to orientate themselves in their surrounding environment and locate their position. For those with previous experience, this location can take place within the spatial reference frame in their minds; for those with little or no experience, they have to proceed by dynamically learning the location of environmental anchors as they progress. In unfamiliar situations, users may have access to a physical map of the area, the information on which may be cross-checked from time-to-time for confirmation and reassurance purposes (Stern and Portugali, 1999). In fact, if maps were designed to reflect individual levels of cognitive understanding about the geography of an area “it is possible that, strategically, the types of map used by a newcomer to an area might be designed differently from those used by people having long-standing local knowledge” (Sandamas and Foreman, 2007, p.42).

However, Thorndyke and Hayes-Roth (1982) identify that information gleaned from maps only really gives the user a birds’ eye view which is better suited for global (overall) knowledge of an area, whereas wayfinding/navigation develops an individual’s spatial judgement of different areas, which is better suited towards the orientation within a network. This finding is supported by MacEachren (1991) who noted a difference in the orientation of cognitive information derived from maps (orientation fixed) compared to that learned from the surrounding environment (orientation free).

Along the journey, the traveller encounters different decision points. In this study, the key decision point relating to the Stop-Specific Bus Map concept begins when arriving at a bus stop. Here, the traveller needs to determine whether the stop in question is served by a bus which will take them towards their intended destination, and for this, needs to have an idea of the geospatial relations between their current location, the direction of travel of each bus service, the location of their intended destination and integrate all of these pieces of information within the limitations of their own cognitive map of the area.

The issue of orientation within the system requires some degree of cognitive rotation, especially when consulting PT maps, and therefore the individual's cognitive map is therefore "part of information processing… possible sources of information for making and executing decisions" (Passini, 1999, pp.88-89). Without being immersed in the actual environment, it is difficult for the individual to truly orientate themselves in relation to their cognitive map as "the internal and external representations, and thus the individual's cognitive maps, are constructed when the individual interacts with the environment" (Stern and Portugali, 1999, pp.117-118). The implicit relationship between internal cognitive representation and the external physical surroundings, landmarks and relative direction of travel will have implications for how the SSBMs should be tested to truly reflect how they would be used if posted at a bus stop, and this issue is discussed in greater detail in Section 3.2.2.

2.4.2 Can People Use Public Transport Maps?

For some people, maps are 'just one of those things I cannot do' and many people have limited map reading skills or are simply not confident when using maps. It is important to note that map reading education in schools varies between countries, so the different levels of subjects' spatial abilities may contribute to the overall results of previous cartographic use research, depending on where the research was undertaken (A. Morrison, 2007, *pers. comm.*) Streeter and Vitello (1986) found that 64% - essentially 2 in every 3 - of the US adult population have some difficulty with map reading. Around the same time, Blades and Spencer (1987) conducted a review of studies which assessed maps specifically designed for navigational purposes and found that "people often have difficulties using maps and often prefer to rely on other sources of information when travelling through unfamiliar environments" (p.73).

More recently, studies have shown that only 1% of 1000 UK drivers tested would be able to successfully complete tasks required for the Cub Scout Map Reading Badge, awarded for undertaking a series of basic map reading exercises which are designed for those aged six to seventeen years old, using standard Ordnance Survey mapping (Massey, 2007). The potential implications of the findings of these studies needs us to ask an important question – if so many people appear to have difficulty with map reading and spatial comprehension tasks, should we be providing PT maps at all?

It is important to try to understand whether people are actually able to use PT mapping, and if this form of PTI allows people to better plan their journeys, compared to timetables and other textual information. One would expect that this would be the case, as mapping information is so often associated with navigation and journey planning, but a study into the effects on navigational performance (in a virtual environment) of graphical versus textual information (Schlender, Peters and Wienhöfer, 2000) revealed that there was no observed difference between the overall performance of those with maps compared to those with textual information. Respondents were given one of five information conditions (maps available throughout; maps shown for 90 seconds prior to testing; textual information throughout; textual information for 90 seconds prior to testing; no information at all) and were asked to navigate in the virtual environment between four points in a predetermined order and by the shortest distance possible. All tests were achievable regardless of the information conditions, and then subjects were asked, post-test, to sketch out the route taken from memory. Analysis of the sketches revealed that those who had a map for the entire test performed significantly better ($\mu = 9.5$ (out of 10), $\sigma = 0.84$) in this task than those who only had textual information ($\mu = 6.0$ (out of 10), $\sigma = 3.35$).

This indicates that continued exposure to mapping information has a greater impact on the development of peoples' mental maps. A study by Vertesi (2008), found that Londoners' continued exposure to the London Underground map had a substantial influence on their mental maps of London. When asked to sketch out a map of 'their London', subjects often used underground lines or stations as geographical reference points (environmental anchors), and one quite significant finding was that areas without underground stations were considered to be 'off the map', not just in a cartographic sense, but also in a socio-political sense. It must be noted that the London Underground map is like no other PT map in terms of its design history, its influence on PT mapping across the world, and its general worldwide recognition as a symbolic icon of London (Garland, 1994; Ovenden, 2005; Roberts, 2005).

These findings relate back to Caiafa and Tyler's view that maps can and should be used at various points throughout a PT journey. Providing suitable mapping information is vital in order to provide continuous reassurance to the passenger about their current location, reinforcing their previous decisions so that they know they are on the right service and they are heading in the right direction. A number of studies have specifically looked at the journey planning issues encountered when planning and undertaking a PT journey, and we now turn to the findings of these works in order to guide the direction and eventual methodologies used for this study. As discussed, there has been an apparent lack of this study-specific work which is reflected in the age of some of this research, some of the studies being at least 25 years old. Nevertheless, the studies do indicate the need for good mapping information in order to allow users to plan suitable PT journeys.

Bartram (1980) compared the performance of users in planning a journey requiring one, two and three changes of bus, using four different forms of information:

- Alphabetic list of stops
- Sequential list of stop (as per a timetable)
- Geographically-true network map
- Schematic equivalent of the network map

In contrast to the findings of Schlender, Peters and Wienhöfer (2000), Bartram's study found that respondents were significantly faster at planning correct journeys using mapping information, and that using the schematic map was faster than its geographically true equivalent. What is interesting is that the schematic map's performance was remarkably consistent for all journeys, regardless of the number of changes required and both forms of mapping information were clearly superior to the textual (list) information where three changes of bus were required. It is important to note that the test journeys in Bartram's study were conducted across a relatively simple bus network (7 individual bus services covering a small area of East London) and were between clearly defined bus stops, essentially reducing the task to the same planning problem as that of a rail journey. Therefore, one key limitation of this study's methodology is that it does not truly represent the typical problems faced by actual bus travellers, where journey origins and destinations are not normally specific bus stops, and usually travellers will be required to mentally interpolate their final destination in relation to the stops and locations shown on the map.

Bartram does identify that for actual bus networks which have a significant number of services, mapping information would have an advantage over its textual counterparts because of the additional cognitive spatial encoding needed when using the required amount of timetable information.

> List-type formats [timetables] would become increasingly difficult to use as the size of the system increased… in general, the whole of a complex public transport system can be portrayed on a single map or a small set of maps
>
> (Bartram, 1980, p.110)

It is also suggested that although the schematic map performed better in the tests, its distortion from geographic reality would disadvantage those not familiar with an area and who are relying on a street plan to locate their destination. It is proposed that a compromise between the geographically-true and schematic style of representation might be the most suitable solution, and the schematic versus geographic map design issues raised by Bartram are considered in a later section of this review.

In light of a redesign to the New York Subway Map, Bronzaft, Dobrow and O'Hanlon (1976) looked at how 20 people (who were unfamiliar with New York) used the new maps to carry out an unsupervised journey between five stations across the NY Subway system. Although it can be argued that planning a point-to-point journey on a rail-based system is somewhat easier than for a bus-based system given rail's more defined structure, this study still reveals some interesting findings about how people use graphical spatial information to navigate their way through a PT system.

Subjects were given one of two journeys to complete, each leg being classified as easy if it only required one (direct) train, or hard if it required more than one train and thus an interchange. On their return, subjects were given a short interview and questionnaire to gather their personal experiences and perceptions of the journeys they made. Although the sample used was slightly unrepresentative of the average subway user, this is one of the few studies into how people use PTI where the tests were actually undertaken within the PT system and not in laboratory conditions, reflecting how the PTI would be used in the actual planning and completion of a journey.

Journeys were broken down into the four legs which were then categorised into acceptable or unacceptable, and the results show that no subject was able to plan a wholly acceptable journey, as under half of all journey legs were completed using a route that was deemed to be acceptable. When the authors examined the potential sources of error, they came to the conclusion that it was a combination of poor map design (for example, confusing interchange symbology, necessary information contained on a map legend on the reverse side of the map), human error and the subjects' relative inexperience with using the overall system that contributed to the poor results. This finding appears to disagree with the original statement of the Chairman of the New York Metropolitan Transit Authority, who boasted that "we have tried to make the New York subway map as easy as following the yellow brick road" (ibid., p.579).

The post-journey questionnaires and interviews also revealed some interesting findings. It was apparent that any route would suffice as long as it gets people to their destination, as typified by one quote: "I'd rather stay on a train longer and not get lost" (ibid., p.591). Where a route had been found, it was usually followed without any consideration being given to finding a better solution, yet when a number of potential routes were initially considered, subjects reported that it was difficult to ascertain which route was the *optimal* route from the map alone. A number of subjects also reported feeling 'very insecure' when travelling through the system and were unable to reinforce their route choice by consulting additional information provided in the system. This insecurity was further compounded by the fact that what they thought was a correct, acceptable solution did not actually take them to their intended destination or interchange station.

Hall (1983) expanded upon the findings of the Bronzaft, Dobrow and O'Hanlon study by comparing the whole journey planning and execution process for three different levels of information provision:

- Those with no information
- Those with maps only
- Those with maps and bus schedules

The test required subjects to plan and undertake a journey from the University of California's Berkeley campus to a local library, and all journeys were observed throughout by an interviewer. All subjects were University students (and therefore have a higher intelligence than the average PT traveller) but were new to the local area and unfamiliar with the given destination, incorporating the unfamiliarity aspect of planning a new PT journey. However, criticisms of this approach are that it does not account for those travellers who have previous geographic knowledge of the area, and by only using a single origin-destination pairing, the testing does not fully explore the effects of different journey types and possible destinations that are available to new PT travellers.

Instead, it would perhaps have been beneficial if more than one destination could have been given to a wider range of subjects in a controlled, stratified manner. Again, the tests were carried out in real world conditions but one key feature of Hall's study was that a proportion of the sample did not have any information initially provided to them, but were instead told that they were able to consult any form of PTI provided at stops or being carried by other people around them. This use of the PTI already provided is the closest example to how people would access and use information for a typical, everyday PT journey.

Similar to the findings from Bartram's study, subjects provided with maps were 13.7% faster in completing their journeys than those with no information at all. The range and standard deviation of the overall travel time for those only with maps was much smaller than for those without any information *and* for those provided with schedule information in addition to the maps. However, the majority (87%) of those with maps used them as their primary source of information but did not use them *efficiently*, many finding an acceptable route but not one that would be considered as the optimum route. This supports the result found in the previous study by Bronzaft, Dobrow and O'Hanlon. Observing the journeys identified that for some, route learning was a dynamic process, involving the adaption of earlier decisions as the journey progressed: of the 30 subjects given maps, 21 (70%) spent some time planning an initial route but only 12 (40%) actually completed the route as they had planned.

What is also apparent from Hall's analysis is that the maps provided were confusing to a number of subjects, but this is partially attributed to their poor design whereby all local bus services were shown by lines of the same colour. Only one subject was actually able to identify service 7, which was the closest of all available services passing by the University campus and went directly to the Library. This was further compounded by a spatial mismatch between the user's mental map of where the destination was in relation to their current position, and the initial direction of travel – "the idea of boarding a bus heading south or west, when wanting to go north, seemed to bewilder subjects" (ibid, p.186).

This returns us to the notions that not only do people need to align their cognitive map with the external environment when making a journey, but many are unable to fully comprehend mapping information, especially the amount of information provided on a typical PT network map. For some, maps proved to be a distraction and they would have been better off without any information at all:

> One person spent a full 24 minutes reading maps and still walked a route one mile longer than necessary. Had he not had maps, he would have been forced to ask others for directions, and probably been sent on the right path
>
> (ibid, p.187).

Around the same time as Hall's study, Garland, Haynes and Grubb (1979) conducted an investigation into the relative effects that the use of colour and base map detail had on users' trip planning abilities. Subjects were given a street plan at Fort Worth, Texas and one of four bus maps, each having variations in their use of colour and base detail, and were asked to plan a bus journey between three clearly marked points on the street map using the bus map they were given. The final journey plans were broken down into individual legs which were analysed for errors, and each subject was given an accuracy score based upon the number of errors they made, ranging from 0 (no errors) up to 18 (maximum errors). The average number of errors across all the maps was 6.18 ($\sigma = 4.14$), indicating that subjects did experience some difficulty when planning their journey but were able to plan the majority of it successfully. The authors do comment on how their sample was made up entirely of college students (something which appears to be a common theme in studies of this nature) and is therefore unrepresentative of bus users in general, but continue to note that a more typical sample of bus users may actually make an even greater number of errors during the task.

Subjects were also asked to judge their own performance during the planning exercise. They were first asked to indicate on a 20-point bipolar scale how difficult they found the task, where it is assumed that 1 = 'extremely easy' and 20 = 'extremely difficult'. In general, it appeared that subjects found the tasks manageable, but neither extremely easy nor extremely difficult. The average difficulty score given to finding the start and end of the journey was 12.71 ($\sigma = 5.31$); finding the correct bus route was 8.82 ($\sigma = 4.69$); and finding street names was 11.91 ($\sigma = 6.03$), all intermediate scores on the scale, suggesting most people found the tasks reasonable in their difficulty, although the standard deviations suggest there is some spread in how each individual rated their performance.

Subjects were then asked how frustrated they felt during the task, again on a 20-point bipolar scale. Frustration is a difficult feeling to measure accurately and the average frustration score was 11.51 (σ = 6.40), suggesting that people did find the task frustrating but not to the extent that they could not complete the task. Finally, subjects were asked to rate how confident they were that they had found the best bus routes for the journey, in a similar vein to Bronzaft, Dobrow and O'Hanlon's acceptable/unacceptable route choice classifications. Again a 20-point bipolar scale was used, and the average confidence score was 9.08 (σ = 6.61) suggesting that, in general, people were perhaps slightly under-confident in their route choice, but some were clearly more confident than others.

As with all questions which ask subjects to rate their own performance, any personal scores must be treated with a slight degree of caution as it is common for people to overstate their scores in order to not appear as unintelligent and so that they do not feel embarrassed by their own poor performance. However, the general conclusion of Garland, Haynes and Grubb's study (with respect to map use ability) supports the findings of the other studies "that there are probably a great number of individuals in this society who cannot effectively comprehend or utilise transit system maps in trip planning" (p.184), and this holds true for a range of map designs. What is also notable is the spread of the individual performance ratings for ease of use, frustration and confidence, as this further illustrates the variation in how people are able to use PT maps.

The above studies are all from the late 1970s to the early 1980s, so although they are slightly dated, they still provide useful evidence in the argument for providing PT maps. There appears to be a gap in the research in this domain until the late 1990s when computer mapping was being introduced into PT. A more recent research programme into PT use and the impacts of PTI has been undertaken by the National Centre for Transit Research (NCTR) at the University of South Florida. The initial research project of the programme (Hardin, Tucker and Callejas, 2001) assessed the operational barriers and impediments faced by people wanting to use PT services, including the provision of PTI. For the final user tests, PTI collected from 18 systems across Florida was used to assess how unfamiliar and infrequent users were able to use PTI to plan a journey. The study used a mall interception technique to recruit participants to a specified demographic quota, and different shopping malls were used in order to obtain a wide range of demographic characteristics from the overall population.

The final study sample used in the test phase of the study consisted of 80 participants which, despite the controlled demographic quota employed, is low for a study of this nature and perhaps unrepresentative of the wider travelling population. Participants were given a set of PTI (network maps, timetables and individual route maps) along with verbal instructions to explain the content of the PTI. They were then asked to plan two journeys, the destinations of which were assigned at random from a list in order to reduce bias. The tests used both a simple journey which required no interchange, and a complex one which required one interchange. Similar to the Bartram study, the test journeys might not be considered entirely representative of a typical bus journey as:

> All trip origins and destinations were clearly marked points of interest on the systemwide [network] bus route maps presented to participants or, in the cases of extensive transit systems [examples included Miami-Dade Transit and LYNX in Orlando], were depicted on the materials using adhesive dots
>
> (ibid., p.61).

However, the authors argue that this method was adopted in order to make the test journeys accessible, claiming that "time points were used as bus stops in the assigned transit trip plans because the task of conceptualizing the location of an unlisted bus stop was considered to be too difficult for individuals with little to no transit experience" (ibid.). It is debatable as to whether this is a suitable method to use, as outwith test conditions, users are likely to find themselves in such a situation where their current location is not specifically marked on the map and so they would need to conceptualise their location onto the map. The counterargument is that in test conditions, there is little point in asking users to undertake a task that many would find overly difficult and frustrating, the likely outcome being that they simply give up and thus no usable results are obtained.

The results show that the overall scores for the planning tasks (using both maps and timetables) were low, an average score of 9.25 out of 21 (44%) using an unweighted system, and 10.70 out of 25 (43%) using a weighted system, where the weighting was added to account for the attributes deemed most important when planning a journey. Qualitative analysis of a post-test questionnaire revealed a mixed picture about opinions on PT mapping information. As in the other studies in this section, it was found that many people were unable to use the mapping information provided to them to its full capacity:

> The systemwide [network] bus route maps and individual bus route maps also were cited as problematic for many field test participants. In 43 specific instances, respondents indicated that they had some difficulty using system maps and/or individual bus route maps. There were an additional 15 negative comments related to system maps and/or individual route maps offered in response to questioning regarding the participants' general impressions of the transit information materials
>
> (ibid., p.100)

Many participants commented on the poor design of the maps where the colour scheme meant they found it difficult to use the map properly. Problems encountered included difficulty in identifying the actual routes taken by the individual services, uncertainty as to the location of the terminating points of individual services and distinguishing the actual bus routes clearly from the base map detail. One reason for the general poor performance in the tests is that the PTI used has "not been designed in such a way as to help spatially orient passengers…" but instead was designed "…from a marketing perspective with an eye toward being aesthetically pleasing for users. Less attention appears to be paid to ensuring that layouts are spatially accurate" (ibid., pp.117-118). This relates back to the concept of the individual's orientation with a PT system and the perceived legibility of the system, where users are able to find their way without fear of getting hopelessly lost. As noted, good PTI provision is key in instilling this confidence, even in the unfamiliar user, as stated by Hardin, Tucker and Callejas: "such [spatial] accuracy [in PTI design] assists passengers and potential passengers and makes the transit trip planning and travel phases less intimidating for those with little transit experience" (ibid., p.118).

Two further research projects were carried out at NCTR following on from the Hardin, Tucker and Callejas study. Foreman and Tucker (2003) conducted an intermediate study, which carried out a detailed assessment of a wide range of PTI media to ascertain exactly which of the design elements were most effective in assisting unfamiliar users in planning a PT journey. Cain (2004) further developed the work conducted by the above NCTR studies, the main motivation of Cain's study being:

> …to identify those design elements of printed transit information materials that provide the greatest utility to non-users and users when participating in transit trip planning, and to incorporate those design elements into prototype materials to serve as a model to transit agencies.
>
> (p.1).

One important area that Cain considered was the different information requirements of each stage of the journey planning process, and which stage, if any, of the process caused the greatest problems in the overall planning flowline. The study used a carefully designed sample to account for a number of test variants to be used in the analysis and had a target sample size of 180 subjects to ensure that subsequent *F*-tests would be statistically valid whilst enabling the survey to encompass a wide variety of user demographics.

What is notable about Cain's study is that the tests were broken down into a number of stages, and analysed on a discrete basis. This allows for the usability and views of each individual form of PTI to be assessed, and allows some findings to be drawn specifically on how people use PT maps. The first stage of the test required subjects to use a system (network) map to locate the origin and destination points of the given journey which was immediately followed by stage 2, which required subjects to identify which bus routes would enable them to undertake this journey and, if necessary, the location of interchange points. On average, subjects took 95.16 seconds to identify both the origin and destination points although the maximum time take for this was 411 seconds (i.e. 6 minutes and 51 seconds). Subjects were asked to rate how difficult they found this task on a 7-point scale, and the average score for all respondents of 3.36 suggests that most people found this task achievable.

No other statistical information (standard deviation, range etc.) is available to help identify the spread of the individual scores. However, additional analysis (Table 2.3) disaggregating the results by the number of correct routes identified (0, 1 or 2) indicates a relationship between the ability to use PTI and the level of perceived easiness:

Table 2.3 - Relationship between Ability to use Public Transport Information and the Level of Perceived Easiness (Cain, 2004)

Number of Correct Routes	**Number of individuals**	**Percentage of individuals**	**Mean time taken (seconds)**	**Average difficulty rating**
0	4	1.1	162.5	4.75
1	19	5.3	152.4	3.72
2	335	93.6	91.1	3.32
Total	358	100.0	95.16	3.36

Having selected the necessary routes from the network map, subjects were then required to use this map again in conjunction with individual route maps (stage 3) in order to locate the nearest timing point bus stops to the origin and destination, and a suitable location to make the transfer between the routes. This required a total of four separate bus stops to be located on the maps, and nearly three-quarters of the sample (262 out of 358, 73.2%) were able to fully complete this task successfully. The final two stages of the test required subjects to use timetable information to plan a bus journey from the origin to the destination, via the interchange point identified in the earlier stages of the test. Here the overall performance was not as strong with only 199 out of the 358 (55.6%) subjects being able to plan a complete and correct journey.

Cain's results revealed that just over half of all subjects were able to successfully complete all stages of the test. Breaking down the journey planning process into the five distinct stages reveals that maps were the easier form of PTI for respondents to use, as shown in Table 2.4 below.

Table 2.4: Success Rate for Each Stage of Planning a Journey (Cain, 2004)

Stage	Task	Information	Success (%)
1	Locate origin and destination	System Map	93.6
2	Selecting bus routes and transfer points	System Map	
3	Locating closest timing points	System &Route Maps	73.2
4	Identifying correct parts of timetable	Route Map/TT	55.6
5	Using timetable to identify times	Timetable	
Overall	Plan a bus journey	Maps/TT	52.5

A study into the effectiveness of different designs of PT map was conducted by White (2005). As mentioned, White was particularly critical about the lack of existing work in this domain, and the apparent bias towards timetable information, so the focus of this work was specifically on mapping information. It is proposed that mapping information is more suited to addressing "the fundamental question for passengers, 'How can I get to where I want to go to?'" (p.5). In order to provide some evidence behind this argument, the research compared the ability of people to use a traditional geographically-true network map, a schematic TfL-style SpiderMap and a strip map for planning two separate journeys in the Leeds area.

One criticism of the information used is that there is some inconsistency between the information provided on each map, as the network map only covered a portion of Leeds whilst the SpiderMap and strip maps covered the routes running through this area in full. To represent how network maps would be used when planning a journey, it would have been beneficial to have given users the complete network map. Also, the journey planning tasks asked of the respondents were not consistent between maps, as each form of mapping information had a different origin and destination pairs (for two separate journeys) assigned to them, both of which were clearly marked on the map. It would perhaps have been more appropriate to have asked respondents about a limited series of journeys, which were consistent across the set of maps used in the tests.

Initially, White proposed to conduct at-stop interviews with the travelling public to assess peoples' opinions about the various maps on offer, but a pilot study in London revealed that attempting to conduct at-stop tests was a difficult task to achieve successfully due to a number of external factors. Instead, a mail-back survey technique was employed in which questionnaires were distributed at bus stops along with a pre-paid self-address envelope. Questionnaires were distributed at a number of locations across Leeds, both in the suburbs and in the city centre, with the intention to capture the views of both frequent and infrequent PT users.

Using such an approach has its benefits as it allows responses to be gathered from a potentially large number of individuals, even on a quota controlled basis, within a short space of time and with limited human resources. However, these benefits are often outweighed by the disadvantages. The main problem with this technique is that respondents were completing the questionnaires and planning their journeys in the comfort of their homes, far removed from any external at-stop distractions. Whilst this could be a suitable approach for the network map, SpiderMaps and strip maps are only of real use when actually at a bus stop, and this is also true of SSBMs which will have implications for how SSBMs should be tested and evaluated.

Another limitation of this approach was that subjects were not directly observed by an interviewer, so there is no guarantee that they undertook the tasks by themselves. It is also not clear how long they took to complete the questionnaire and if they struggled with the tasks, or whether they consulted additional information to assist them, such as a local street plan. Mail-back surveys often receive a low response rate as many people obtain a questionnaire, forget about it until a later date and then disregard it, especially if they feel it is not relevant or of interest to them anymore. So despite this method being achievable with limited human resources, the financial outlay required to produce the questionnaires and cover the cost of postage can potentially result in an eventual large loss of resources.

Nevertheless, as in the Bartram (1980) study, White's results indicated that users found the more diagrammatic forms of map easier to use with a greater number of correct responses across both journeys (Table 2.5). Subjects were asked to rate on a Likert scale how easy they found using each form of information and again, the diagrammatic maps were rated as easier to use. This is perhaps unsurprising, given the limited amount of information provided on these maps compared to the network map.

Table 2.5: Breakdown of Responses to Journey Planning Tasks using Different Forms of Public Transport Information (White, 2005)

Map Style	**Question 1**		**Question 2**		**Average**	
	% Correct	% Incorrect	% Correct	% Incorrect	% Correct	% Incorrect
Geographic	56.6	43.4	86.3	13.8	71.4	28.6
SpiderMap	98.9	1.1	95.4	4.6	97.1	2.9
Strip Map	100.0	0.0	95.2	4.8	97.6	2.4

Additional questions asked subjects about their preferences for each map. They were asked to state which map they would like to see displayed at bus stops and the SpiderMap design was the preferred map, 48% of all respondents claiming this would be their preferred choice. As White rightly acknowledges, this does not mean users did not like the geographical network map, but they felt it was not overly suited for display at a bus stop. This supports the view that there are indeed different maps for different points in a PT journey.

Overall, the existing body of work specifically on PT map use has revealed a number of significant findings. It is believed that mapping information should be the preferred information medium for planning a PT journey and the general conclusion that can be drawn from the findings of the studies supports this view. Where people have been able to use PT maps correctly, this has had a positive impact on their personal beliefs that PT is actually not that difficult to use, when given the right information. Reported benefits include increased confidence in peoples' own abilities to plan a journey using PT and a general rise in the overall opinions about PT as a whole.

Although the majority of people are able to use mapping information to good effect, a key finding was that few people are able to use this information *efficiently* However, "the problem with network representations… is that there is often a conflict between the user's need to see an overall view of the network and the need to pick out details within the network" (Mooney and Winstanley, 2001, pp.13-14). When planning a journey users want "… to see both points of origination and destination and all the alternative routes" (ibid., p.14) but the results of the map tests suggest it is not overly clear which of these potential routes are actually the most suitable. Clearly, something can be done from a design aspect in order to further improve the usability of PT maps, and these issues are discussed in the next section.

2.5 Public Transport Map Design Issues

This section of the review focuses on the different design aspects and issues surrounding PT maps and investigates whether there is an opportunity for simpler mapping designs to be adopted. The cartographic literature offers relatively little when it comes to bus mapping, with the vast majority of existing work coming from Morrison's research into Public Transport Maps in Western Europe, conducted during the latter half of the 1990s. To provide a more complete picture, the findings of additional literature from sources outwith the cartographic domain will also be consulted in this section.

2.5.1 Static versus Online Mapping

One of the first areas that must be addressed is how people actually obtain PT mapping information. We now have a conflict between the availability of PT maps via the internet versus the traditional static, printed versions of PT maps. In an ideal world, static PT maps would also be posted at numerous locations throughout the PT network but in Britain, this practice is far from standard for bus systems. Today, users can access PTI about any location they choose from anywhere in the World as long as they have access to the Internet, but this excludes passengers waiting at bus stops unless they have access to the Internet via a mobile device.

However, this is a study into the Stop-Specific Bus Map which, for the purposes of this research, is a static, printed map only to be displayed as a single, unique copy at the relevant bus stop. It would be wrong to completely ignore the options and functionality that the Internet and other electronic methods of information dissemination (including mobile devices) can offer the PT user as they undertake their journeys, including the potential for disseminating Stop-Specific Bus Maps. These issues and the research behind them will be returned to in a later chapter, but for now, this review will focus primarily on the issues surrounding static PT maps in printed form.

2.5.2 Different Styles of Public Transport Mapping

"There is no universally applicable manual for transport map design – circumstances depend widely upon the local geography and the variety of services to be portrayed" (Anon, 1985, p.639). Today, there are many different PT maps available to the traveller, depending on the area they are in, the availability of different PT modes and which mode(s) of PT they are intending to use, so every map will have its own unique details and design intricacies. As part of his work into Western European PT maps, Morrison (1994) found that the PT maps in France all followed a single, distinctive style, whilst there was much more variation in the PT maps used throughout Germany and Spain. Morrison (1996a) took the opportunity to expand this research across the rest of Western Europe and has reviewed a diverse range of the different PT maps available. From this, it was identified that four main PT map styles existed (for reference and examples of each style, see Morrison, 1996a):

- Classic – one line style for all routes, service numbers labelled along each link (where possible). This style was traditionally found amongst British network maps, where the bus roads were depicted as thick red lines, their names reversed out in white (also known as the 'Penrose' style).
- French – one line style for each route (as per the London Underground map), individual service numbers labelled at termini only. This was the only style to be found in France, and many French speaking areas in other countries also adopted this style for their PT maps.
- Scandinavian – a derivative of the 'Classic' style where different sub-divisions of the PT network are represented by a unique line style. Examples given by Morrison are primarily used to distinguish between different PT modes, such as underground, tram, and bus; or, where there are only bus services available, between different service patterns (local, regional, express etc.)
    - Dutch – a particular case of the Scandinavian style, designed so that the number of lines along any one street is kept to a minimum.
- Iberian (not described nor depicted in Morrison, 1996a, but added as a style later, Morrison, 2004, *pers. comm.*) – routes are grouped by directionality from the urban centre, such as radial north, radial south, transverse, circumferential, and each group is given its own line style.

There are no hard, fast rules in terms of the PT map styles to be used, but Morrison (1996a) does give some detailed guidelines as to how to select the most appropriate style. This is especially important where a multi-modal PT map is to be designed, as it is important to clearly distinguish between the different modes and their service characteristics so that someone intending to board a bus does not look at the map, misinterpret a subway line as being a bus route and then attempt to board this non-existent bus at a stop above ground.

Very little has been written on how the different styles of bus map were devised. The first London bus maps were designed in the 1890s, and were essentially a street plan with bus numbers written alongside the relevant streets (Anon, 1985), now defined by Morrison (1996a) as the 'Classic' style. This design appears to have influenced the work conducted by Penrose in the 1960s and still forms the design standard for the majority of British bus maps today, however, the Penrose examples of Morrison's 'Classic' style appear to be unique to the UK. Braidwood (1981) comments on how up until the 1980s, the 'Classic' style appears to have been the only design used for bus maps, although some designs also included additional geographic information such as the location of major landmarks, parks and other open spaces, allowing the user to better position themselves on the map.

Around this time, it was recognised (by London Transport) that there was a "need to improve the means by which it tells people about its bus services. This is why it has been looking for a new bus map" (Braidwood, 1981, p.53). The final design chosen by LT was devised by Andrew Holmes who, in a similar way to Harry Beck's schematic treatment of the London Underground map, shifted the focus of his map away from the traditional representation whereby the individual services along each road link and the general road layout were most important, and instead emphasised the intersections and applied four individual colours to represent groups of routes, based on their general directionality. Holmes' design is one of the first examples of bus map to move away from the traditional 'Classic' design and instead adopt a design that is more closely related to the 'Iberian' style of mapping, through the use of colour to indicate the general direction of travel of services.

2.5.3 Schematic Maps

One of the prime design debates in PT mapping is that of the use of schematic maps, in particular for bus networks. In order to distinguish between a true schematic map, and a simplified map that has undergone some cartographic generalisation and simplification, Morrison's definition shall be used here which defines a schematic map as "one which has all transport lines drawn as straight lines which are horizontal, vertical or at 45 degrees… usually, but not necessarily, straight lines are connected by smooth, circular arcs" (1996a, p.97). A simplified or generalised map will still maintain the overall geography of the area *and* the topology of the PT networks but will not be as far removed from the geographic reality as its schematic equivalent.

Schematic maps for PT systems were made popular following the development of Beck's London Underground map in the 1930s. Beck realised that when using the system, passengers only really needed to know how to travel between stations and where to change lines if necessary (Garland, 1994; Roberts, 2005). Another reason for such maps was that a proportion of the journey was likely to be underground where there are no spatial reference points to allow passengers to identify their location and orientate themselves within the system. So successful was Beck's schematic design that it has been adopted across the World for many subway and light rail systems (Ovenden, 2005), as it neatly lends itself to the inherent linear nature of rail-based PT modes and their defined stations as the only access and exit points to and from the system.

For bus travel, the use of schematic maps is not as straightforward. Bus systems are less defined in a spatial sense: bus stops are rarely named or shown on general street maps, whilst bus routes run through an area at a higher spatial density than is physically possible with rail-based modes. Attempts have also been made to apply the design rules of a schematic map to bus systems, and it is debatable as to whether they are truly successful. When redesigning the Central London Bus Map, an attempt was made to 'undergroundize' *(sic)* the map, the motivation behind this notion being that such a map might achieve the same level of appeal and recognition for bus services in London as the Underground received thanks to its system map (Anon, 1985).

In an earlier section of this review, it was found that as part of an overall marketing scheme designed to improve bus patronage, schematic maps were used to simplify the appearance of the network and make bus travel more accessible, and this contributed to successful results through increased patronage levels (Enoch and Potter, 2002; Cairns *et al*. 2004; Ten Percent Club, 2006). Schematic maps also provide the main mapping behind all of FirstGroup's Overground networks, which are intended to provide simple bus services on a turn-up-and-go basis, again possibly drawing inspiration from light rail and metro systems. Fairbairn (2005, p.518) identified that "there has been little other guidance for cartographic designers on the creation of schematics, beyond the advice to reflect "real-world" locations of landmarks and street names."

Recent research (Avelar and Hurni, 2006) has attempted to further the cartographic knowledge surrounding schematic map design. Compared to Morrison's (1996a) definition, Avelar and Hurni do not give a definition of what a schematic map actually is, but they generally refer to simplified maps that are "highly generalised" (2006, p.218). Definitions aside, Avelar and Hurni believe that "for public transport networks, schematic [generalised] maps offer a visual tool for communicating spatial concepts for a quicker and safer orientation task" (ibid., p.218) and argue for a greater adoption of schematic maps: "… in complex transportation systems, wayfinding should be supported to a greater extent by schematic [generalised] maps" (ibid).

This widespread use of schematic maps clearly demonstrates a demand for such a design to exist but as identified by Bartram (1980), schematic maps are a distorted representation of geographic reality and are thus not suitable for someone who is trying to use a street map in order to find their ultimate destination. This is supported by Morrison (1996a, pp.97-98) who argues that "schematic maps are definitely not suitable for bus maps… as the diagrammatic representation of routes cannot be easily related to the reality of the street plan of the city which forms the bus traveller's mental map". Morrison cites examples from several towns in his study where a schematic PT map design was adopted only for it to be quickly rejected following complaints from users that they could not understand it enough to make their journeys successfully.

However, Morrison does also acknowledge that schematic maps do have some advantages. In particular, they emphasis the topology (connectivity) of a PT network and thus make it easier to follow the route of an individual service than on a geographically true map. In design terms, schematics could also be easier to manipulate given their relative lack of geographical constraints – as long as the general topology of the network is preserved, the designer has a significant amount of 'artistic licence' to create their design – and can accommodate changes to the network with greater ease than their geographically-true counterparts, although Morrison does comment on how "a small route change… may involve the redesign of a substantial surrounding area [on a schematic map]" (1996a, p.98).

Overall, the available literature appears to suggest that although schematic maps are more suited in assisting passengers find out how to get from one stop/station to another, their abstraction of geographic reality is not wholly applicable to bus mapping and is instead more suitable for rail-based modes, which have an inherently linear nature in the users' mental representation. Nevertheless, schematic maps are now a mainstream form of PT map, including mapping information for bus networks.

2.5.4 Disadvantages of Whole Network Maps

Throughout this section of the review, where mention is given to a PT map it is implied that this is a map depicting the whole bus network of an operator or area. This traditional form of PT map usually attempts to show an entire PT network across an area on a single piece of paper, utilising insets and other detailed information where necessary. Schematic representation is often used to show a network in its entirety on manageable sizes of paper. Whilst this is useful in providing the traveller with an overview of all PT services in an area and allows them to plan a wide range of journeys, these maps do have their disadvantages.

For smaller PT networks with fewer than 15 individual routes, the amount of information provided by a network map is probably about manageable for one person to visually and mentally digest. Morrison identifies that above this limit, the amount of information "will be difficult to use because of the larger number of different services on it" (1996b, p.37). This was evident in the results of some of the map use studies discussed earlier (e.g. Bronzaft, Dobrow and O'Hanlon, 1976; Hardin, Tucker and Callejas, 2001), which found that people were unable to identify an optimum route from the mapping information provided to them. Clearly, the vast amount of information was overwhelming and people were not able to use it to its full potential. Also, when using these maps, the user needs to pick out the necessary pieces of information from the multitude of information presented to them (Mooney and Winstanley, 2001). Unless they are intending to make a complex journey involving many different services, the majority of this information is essentially redundant to them.

From a cartographic design perspective, designing a whole network map requires some compromise between the level of clarity and the physical size of map. Morrison (1996a) discusses the various sizes of network map that are available and suggests that to show the full geographical extent of a complex PT network in great detail requires a map size which would be difficult to use when in-transit or at a (windy) bus stop, but would be suitable when planning a journey at home or in the office. Maps to be used in-transit should be much smaller to allow them to be stored in a pocket and used in the confines of a vehicle or at a bus stop. The smaller size means that the level of detail has to be reduced accordingly, either by omitting some lesser services or by employing cartographic simplification and generalisation techniques, in order to produce a legible product. Again, this reinforces the view of Balcombe and Vance (1998) that there are different types of bus map for different locations and situations.

Another problem with network maps, in Britain especially, is that of the information's currency. In today's deregulated environment, current legislation allows operators to alter or even discontinue poorly performing services by giving as little as 42 days (6 weeks) notice to the Traffic Commissioner. From a cartographic point of view, the potential for frequent changes to the bus network at irregular intervals can mean that time and money invested into producing a correct, up-to-date network map can go to waste within a short period of time. The Internet has gone some way to resolving this issue as a revised map can be uploaded to a website within minutes of its final approval, but this is of little use to the passenger currently standing at a bus stop holding an out-of-date paper map in their hand.

Operators need to promote their services over their competitors' services, and so it is common to see network maps which only show the services provided by one operator. Maps are also produced for subsets of a single operator's services, for example the Overground maps produced by First Group, which only show their network of frequent services (those having an average headway of less than 10 to 15 minutes), omitting their minor services. The main restriction of these operator-specific network maps is that they often present an incomplete picture of an area's PT services. If a potential traveller obtains an operator-specific map and their desired destination is not shown, then it could be incorrectly assumed that it is simply not possible to use PT to travel to this area.

Local Authorities (LAs) are the only organisations who are in a position to provide impartial information about *all* PT services in their area. A number of LAs do produce whole network maps showing all services regardless of the operator, but this then raises issues as to who should take overall responsibility for the provision of PT information. The 2000 Transport Act made it a duty for LAs to provide complete, impartial PT information yet this can result in a duplication of effort with the PT operators. A study conducted by the TAS Partnership for FWT Studios (Greenwood, 1993) found that this duplication of effort between LAs and the PT operators was a ‘very British thing’, whilst on the continent there was a much greater level of co-operation between LAs and PT operators with respect to producing PT information.

An extreme example of this mapping duplication can be found in Derby. At the time of writing, Derby City Council provided a network map showing all routes within Derby City (in Morrison’s ‘French’ style), whilst Derbyshire County Council also provided their own PT map of Derby City (in Morrison’s ‘Classic’ style). Incidentally, both maps have different production dates and are produced by the same cartographic company. Then there are the maps provided by the PT operators in Derby and the surrounding areas, which naturally only show their services. It should be noted that Derby has only been used as an example here, and there are other areas in the UK where a similar situation exists, but the main issue raised is where do potential travellers begin to look for information? If they manage to obtain a PT map, can they be certain that a) it is correct, b) it is current and c) it is complete?

One beneficial feature of PT maps produced by LAs is that they are often the only opportunity for minor operators’ services to appear on mapping information, creating a more balanced market with respect to information provision. However, whilst some minor operators do provide services that operate on independent routes, there are instances where a minor operator ‘mirrors’ all, or part, of a service already provided by a major operator. Where this route mirroring occurs, the minor operator often uses an identical or similar service number to that of the major operator.

From a cartographic design perspective, this duplication of service numbers means it can become difficult to show all services provided by all operators without producing a cluttered map. This is especially true on ‘Classic’ style maps where the actual number of service numbers to be labelled along each link is increased and so the font size used has to be decreased in certain areas. This can also lead to confusion for the user, as where identical services numbers are used the map has to list more than one instance of the same number. Without some symbolic method of distinguishing one number 5 from another number 5, this provides the user with a difficult map to use.

On 'French' style maps, the main design issue to be solved is how to represent the different route extents of both the major and minor operators' services in such a way as to provide users with a map that is comprehensible yet uncluttered. As the minor operator runs services along an identical route to that of the major operator, should 'French' style maps represent both these routes with a single line, showing the different termini points for each operator?

Figure 2.7 highlights the potential problem of route mirroring. Company X operates a service 123 between A-B-C-D (shown in red on the diagram). A smaller Company Y also operate a service 123 along the same route as Company X **but only** between B and C (shown in blue on the diagram). Company X produces company specific maps (as discussed earlier in this section) on which the Company Y service 123 does not feature but Company Y cannot afford to produce their own map. If a passenger is at a stop between B and C and wants to travel to a destination outwith these stops (i.e. between A and B, or between C and D) then they can only use the service 123 provided by Company X. However, they may board a Company Y service 123 in error believing it to be a Company X service as there is little information to distinguish the two either at the bus stop, or on Company X's map.

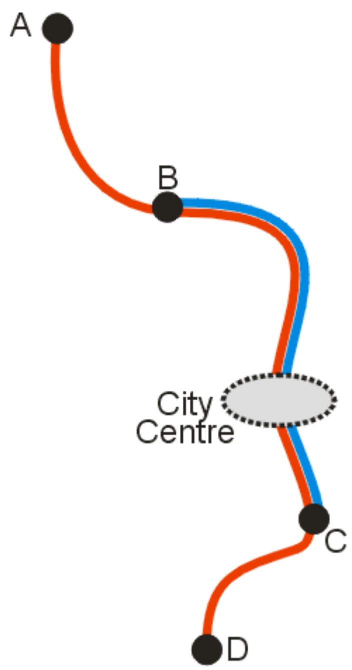


Figure 2.7: Diagrammatic example of route mirroring between two operators

2.5.5 New Types of Public Transport Map

Whilst it cannot be denied that a network map is essential in providing users with a general overview of the PT services on offer across a whole town or city, the map use studies reviewed suggest that people are unable to use these maps to their full potential. As part of a review into how the future contemporary research agenda in geographic visualisation can be applied to PT applications (Fairbairn, 2005), two of the specific challenges under this general agenda were "to develop new representation methods" and "to consider representations in the light of task requirements" (p.516). Therefore, in addition to network maps, it would be beneficial to look at new forms of representing this information in a way that would be more relevant to the current journey planning task, relating back to the idea of having different maps at different locations and stages throughout a PT journey (Balcombe and Vance, 1998; Caiafa and Tyler, 2002).

This requires us to take a network map and break it down into its component parts, namely into individual areas, individual services or, at the smallest level, individual stops. This section of the review will look at these needs in turn but it must be noted that to produce a large number of unique maps in small or even single copies requires automated production techniques in order to make such maps economically viable. A combination of computerised cartography, digital datasets and user-defined functionality in GIS now allows us to focus on developing systems to generate maps for these individual components automatically. We will return to this idea later in Section 7.5.2.

Individual Area Maps

Morrison (1996b) suggests that maps showing only those services passing through individual areas within a city would be a useful addition to the corresponding network map. It is suggested that

> Residents will be interested in all the services within a limited area around their homes including the local shopping areas, schools, leisure facilities etc. Beyond that area, they will only wish to know the routes of services that extend from their local neighbourhood to other parts of the city
>
> (1996b, p.37)

This concept was initially introduced to Morrison as a result of work conducted by the Passenger Needs Department of Strathclyde Transport. Their prototype zone maps were drawn by hand and were inspired by London Transport's district maps, but Morrison argues that these names for such maps are misleading. Instead he gives them the rather interesting name of the 'Octopus' bus map, which can be concatenated to give the 'Octobus' map. This name is based upon the visual nature of these maps whereby the routes radiate out from a central zone, in a similar way to how the tentacles radiate out from an Octopus' body. Octobus maps are not simply fragments of a network map, but are specifically designed maps to show the routes operating to/from a specific area.

At the time of Morrison's paper, few examples of the Octobus map concept were in existence, primarily due to the difficult nature of manually producing them. Morrison (1996b) describes a computer program specifically written to assist with the automated production of Octobus maps. The main benefit of computerised mapping was that it allowed maps to be distorted with much greater ease than was possible using manual methods, and to emphasise the pattern of services in the central zone in greater detail, Morrison proposed the use of a central undistorted zone which has a constant scale, and then the scale of the map reduces as the distance from this central zone increases. A derivative of the Octobus concept has found its way into mainstream PT mapping, in the form of TfL's SpiderMaps (Figure 2.8).

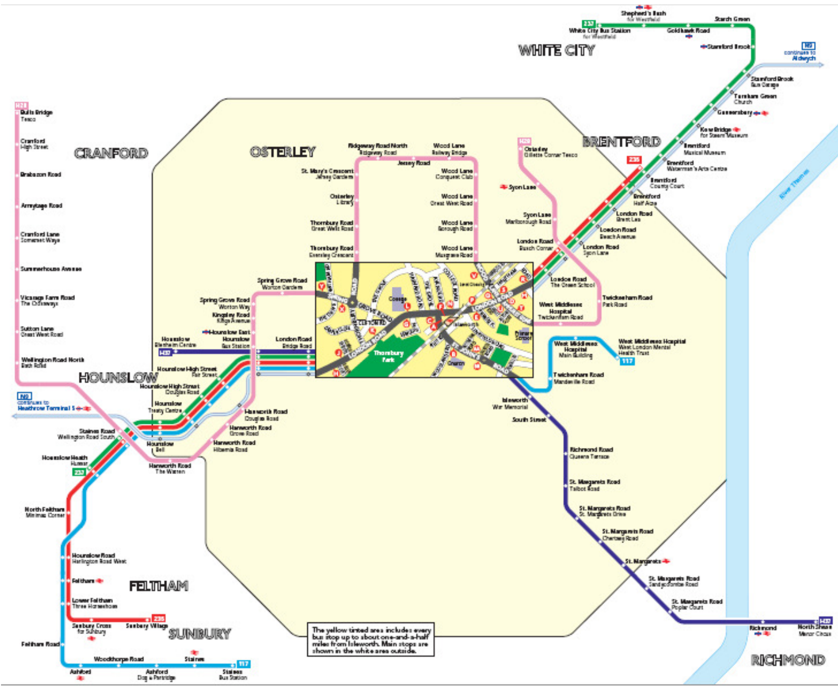


Figure 2.8: Example of a SpiderMap for the Isleworth area, West London (© TfL)

A SpiderMap is formed of two parts. There is a geographically true central inset map which acts as the body of the Spider and shows the location of all bus stops in the immediate vicinity, the layout of the main streets, prominent landmarks, railway and underground stations where appropriate. Radiating out from this central area are the Spider's legs, but unlike on an Octobus map, these are represented schematically. The general scale of the map decreases as the distance from the central inset increases, as per the Octobus concept, and all bus stops within 1.5 miles of the central area are shown on the SpiderMap and only the key bus stops are shown beyond this limit. Again, the relative success of the London Underground map is cited as one of the main reasons for the development of the SpiderMap concept:

> The main reason for the development of bus spider maps was that London Buses wanted to simplify the way they showed bus routes in London, along the lines of the way that the Tube [Underground] map simplifies underground journeys. Obviously the bus network is a lot more complicated than the Underground network, but our cartographic agencies soon found that by splitting the bus network into various local "hubs" they could use different coloured lines to simply show the bus routes running in each area.

(Harriage, 2006, *pers. comm.*)

Clearly this is the view taken by TfL and their cartographic contractor, but it is important to understand whether such a radical design of map, moving away from what many would consider to be a normal design, is met with approval by those who actually will use the map, i.e. the passengers.

Market research conducted over a period of time (TfL, 1999, 2000, 2003) into the ongoing developments of the SpiderMap concept has shown that people do welcome such a novel means of representation, as long as the traditional, more familiar means of providing information are maintained:

- The new style "spider map" was strongly endorsed. Without exception it proved a more effective tool in journey planning than the traditional local area map. It also received higher ratings for clarity, ease of use and design and it inspired greater confidence in making journeys by bus.
- Although displaying the spider map in conjunction with the local area map has little effect on the success with which journeys are planned, people seem reluctant to abandon conventional maps and information sources completely.

(TfL, 1999)

Respondents felt that the "level of information currently on the map is the minimum acceptable. More destination information and geographical features such as landmarks and major street names are felt necessary" (TfL, 1999) but where a large number of routes are to be shown on the map (especially in Central London) there is already a lot of information for the user to digest and further research has shown that "it is clear that there are drawbacks in adding information to an increasingly busy and complex map, and any further changes made should be with a view to simplifying rather than adding information" (TfL, 2000).

The positioning of the user's location on the map was also found to be important, which supports Morrison's earlier work on providing an Octobus map centred on the specific area:

- Most positive reactions were found at Cavendish Road, where the vicinity map [a small geographic map showing the immediate area about the bus stop] was centred on the bus stop. Bus users at this stop were mostly familiar with the area and had few problems in tracing a route on the vicinity map.
- Bus users at Benhill Wood Road, where the vicinity map was not centred on the bus stop, found this task more difficult.
- 'You are here' stickers go some way towards compensating those whose bus stop is not at the centre of the vicinity map, although people find it more convenient if their bus stop is at or near the centre of the map.
- People at out-of-hub bus stops had few problems in finding their stop on the spider maps, again aided by 'You are here' stickers. Indeed, bus users at out-of-hub stops found it easier to locate their stop than those at in-hub stops, where there is a higher density of information on the maps.

(TfL, 2003)

The results of both Morrison's (1996b) earlier work and the more recent work conducted by TfL provide positive evidence for the wider adoption of individual area maps.

Individual Service Maps

Little research has been conducted into maps which only show the actual route of a single service. Morrison (1996c) comments on how these individual service maps might be useful to someone who finds the network map confusing to use, but also identifies three potential sources of confusion when using these maps (ibid., p.252):

- Which direction does the bus travel on the diagram? Do the maps read up or down; left or right?
- Where is the user's current location on the map? Does the map depict the whole route or just the forward portion?
- If there is more than one individual service map displayed, the user needs to consult each map in turn to identify which service(s) will take them to their destination and which service is possibly the optimum one [something which would be difficult to achieve using linear diagrams].

Morrison (1996a) identifies that these maps are suitable for use "in association with the timetable [a booklet or at-stop display] for that service, or at a bus stop served by only one service, or on display within a vehicle operating that service" (p.103). Whilst displaying these individual service maps inside a vehicle would be useful for the passenger as it allows them to monitor the progress along their journey, this practice is also somewhat operationally restrictive as, in a similar fashion to individual route liveries on the outside of vehicles, these vehicles should only really be used on that specific route.

There are two main representations for individual service maps. The first are simple straight line diagrams which are usually found at bus stops along with the service's timetable. Morrison (1996a) comments on how this method of representation has some interesting names on the continent, namely 'thermometer diagrams' (*schéma thermomètre*) in French, 'string of pearls' (*Perlschnur*) in German and a 'stripe' (*strisce*) in Italian. Although basic in their design, straight line diagrams do have some adaptability as they can either show the whole route, or can be designed just to show the forward portion of the route from a particular stop (although this needs to be made clear to the user, as shown by the examples discussed by Morrison, 1996c). Different line styles can be used to show limited service sections (such as peak hours only), route variations (such as evening and weekends), or hail-and-ride sections, so these simple maps could potentially provide quite useful information if designed appropriately.

The other method of representation is a more geographically-true means of representation, whereby the actual route of the service is shown by the map. The author has only viewed such maps within timetable booklets for an individual service, and Morrison (1996c, p.261) presents an example from Paris which shows four individual service maps side-by-side. As Morrison comments, "these are excellent maps individually, but difficult to integrate with each other" (1996c, p.254), a perfect illustration of how these maps appear to simplify the information yet can almost be more confusing that the corresponding network map.

As part of his map use tests, White (2005) investigated how people used straight line, individual service maps to plan a journey from a particular stop. Three individual service maps were presented to the respondents but the actual size of the maps, in particular the font size used, were perhaps larger than what could easily be accommodated at a bus stop alongside all the other timetable information.

Unsurprisingly, the vast majority of respondents were able to use these maps correctly, 100% getting the first question ('which bus goes to…?') right and 95.2% getting the second question ('how long does it take to get to…?') right. The simplicity of these maps does appear to be appealing to users, 38% stating that these straight line maps would be their preferred map to be displayed at bus stops and one-third of all respondents stating they would like to see these maps appear at 'as many stops as possible'.

Despite their apparent simplicity, individual service maps are limited in their functionality and have a disadvantage where there are numerous services calling at an individual stop, as using the individual service maps is likely to be just as difficult as using the respective network map. Clearly, there is some scope to take a number of individual service maps and combine them so as to show all this information in its most relevant form i.e. only showing the forward portions of all calling services from an individual bus stop – the Stop-Specific Bus Map.

Individual Stop Maps – The Stop-Specific Bus Map

As described in the introduction, a Stop-Specific Bus Map (SSBM) only shows the forward-sections of *all* routes of *all* services that call at an *individual* bus stop on a *single* map or diagram. So far, very little has been written about the SSBM concept and any definitive research into these maps is still to be conducted. The first SSBM examples were generated automatically by Morrison and Lissett in 1985-1987 as part of a Science and Engineering Research Council contract and past examples of SSBMs have also been recorded by Morrison (1996c) in Paris, Edinburgh (both examples were hand drawn) and Tilburg, in the Netherlands (Morrison, *pers. comm.*).

Today in the UK, examples of SSBMs do exist (Figures 2.9 to 2.12), but all are of a highly diagrammatic design which maintains the topology (connectivity) of the various routes but distorts the spatial relations between the routes. Although the adoption of these maps should be welcomed, it is believed that the schematic design is possibly not the optimum design to use for such form of mapping information. This view is supported by Allen and Golledge (2007, p.89) who state that "maps used for public transportation… frequently present route information in largely linear [schematic] formats, with little consideration to the geometric accuracies of such depictions".

It is possible that other areas in the UK may have adopted a SSBM design, but the author is only personally aware of these examples. Each SSBM design has a number of design issues, which do not conform to the specification outlined by Morrison (undated), and these are now discussed in greater detail.

Figure 2.9: London Stop-Specific Bus Map (© TfL, taken by the author)

The SSBM in Figure 2.9 was taken in London, but examples of this map have only been viewed by the author at bus stops within the Central London area, so their existence is not as common as the SpiderMap concept. The London SSBM shown was displayed in a bus shelter alongside a SpiderMap and a geographic street map of the local area, but the author has also viewed these SSBMs in the limited space provided by display panels at bus stops (which only have a pole with flag and no shelter), demonstrating the possibilities of designing mapping information within small spaces, although some stops have multiple SSBMs, each displaying a subset of the calling routes grouped by the general direction of travel.

London SSBMs are in Morrison's 'French' style, each route being represented by its own line so it is easy to identify where each service goes, and is further assisted by having each terminus point clearly labelled on the map alongside the service number. The positioning of the termini points in Figure 2.9 is adequate in terms of their approximate spatial relations, as Marylebone is roughly north-east of Paddington and Queen's Park is to the north of Paddington, but again the schematic nature of the maps does not truly represent their spatial relations.

However, this design of SSBM has some issues. First, it is highly schematic with no attempt made at representing the actual path followed by the routes of each service and so users are unable to work out the relative distances between the routes – it is not clear to an unfamiliar user if they could board a bus for Paddington, then alight at Paddington and walk across to Marylebone, or whether the distance between the two would make attempting this journey prohibitive. Only key stops are shown on the map, perhaps constrained by space limitations, and whilst some are familiar landmarks and stations (e.g. 'Marble Arch', 'Marylebone Station') others are of a more local nature and are likely to be known only by those with previous knowledge and experience (e.g. 'Shirland Road, The Chippenham').

London SSBMs also show the origin point of the calling services to which it is not actually possible to travel from the current stop. This feature is potentially confusing and of little use to the user, unless they are meeting someone off a bus and know which direction it came from and/or the origin of the service, or perhaps if they need to know the destination of the return journey of the service on which they have just travelled. Although the user's current location is clearly indicated on the SSBM, which could reduce the potential confusion created by showing the previous sections, the inclusion of this previous route information has to be questioned.

The London SSBM is designed to be read downwards, similar to timetables, whereas most maps are best read from the bottom up. Research into 'You Are Here' (YAH) maps, of which SSBMs are a specific type, by Levine (1982) found that YAH maps worked best when the forward 'direction' of the map was reading up the map face, defined by Levine as the 'forward-up equivalence': "The orientation of a vertical map is psychologically equivalent to that of a horizontal map produced by a simple laydown (90^{o} forward rotation) transformation… in other words, there is a psychological equivalence between forward and up" (p.231). This is supported by Liben (2009, p.312) who states that "mental rotation skills are particularly relevant when the map cannot be physically turned" adding further weight to the case for having forward direction of travel reading up on the map, minimising the need for some initial cognitive reorientation of the map to align with direction of travel. However, this SSBM is orientated so that buses run north-south on the map when in reality they run approximately south-north, going against Levine's 'forward-up equivalence' rule.

Overall, the London SSBM design would probably be useful to someone who knows the location of their intended destination well enough but is not sure which service(s) will take them there and a quick glance at the SSBM should provide them with the information they require. For an unfamiliar user, this SSBM will probably be of little use unless the specifically want to travel to a location indicated on the map or have an A-to-Z map on their person and are able to perform a quick mental interpolation of their destination between the stops given on the map.

Figure 2.10 shows an example of the SSBMs produced by SYPTE that can be found in the South Yorkshire area (Sheffield City Centre). Examples of this map have been viewed by the author at major city centre bus stop totems - specific information panels located next to the respective bus stop, displaying the SSBM and accompanying timetables accordingly. The Sheffield SSBM is part of a wider programme of bus improvements in the SYPTE area, including "…a high quality of infrastructure and information provision, and new information signs being tried out in the city centre [which] emulate London's 'spider maps' [SSBMs]... the high quality of South Yorkshire's conventional [not real-time] information… extends to 92% of the area's 8,000 bus stops" (Morris, 2009/10, p.16).

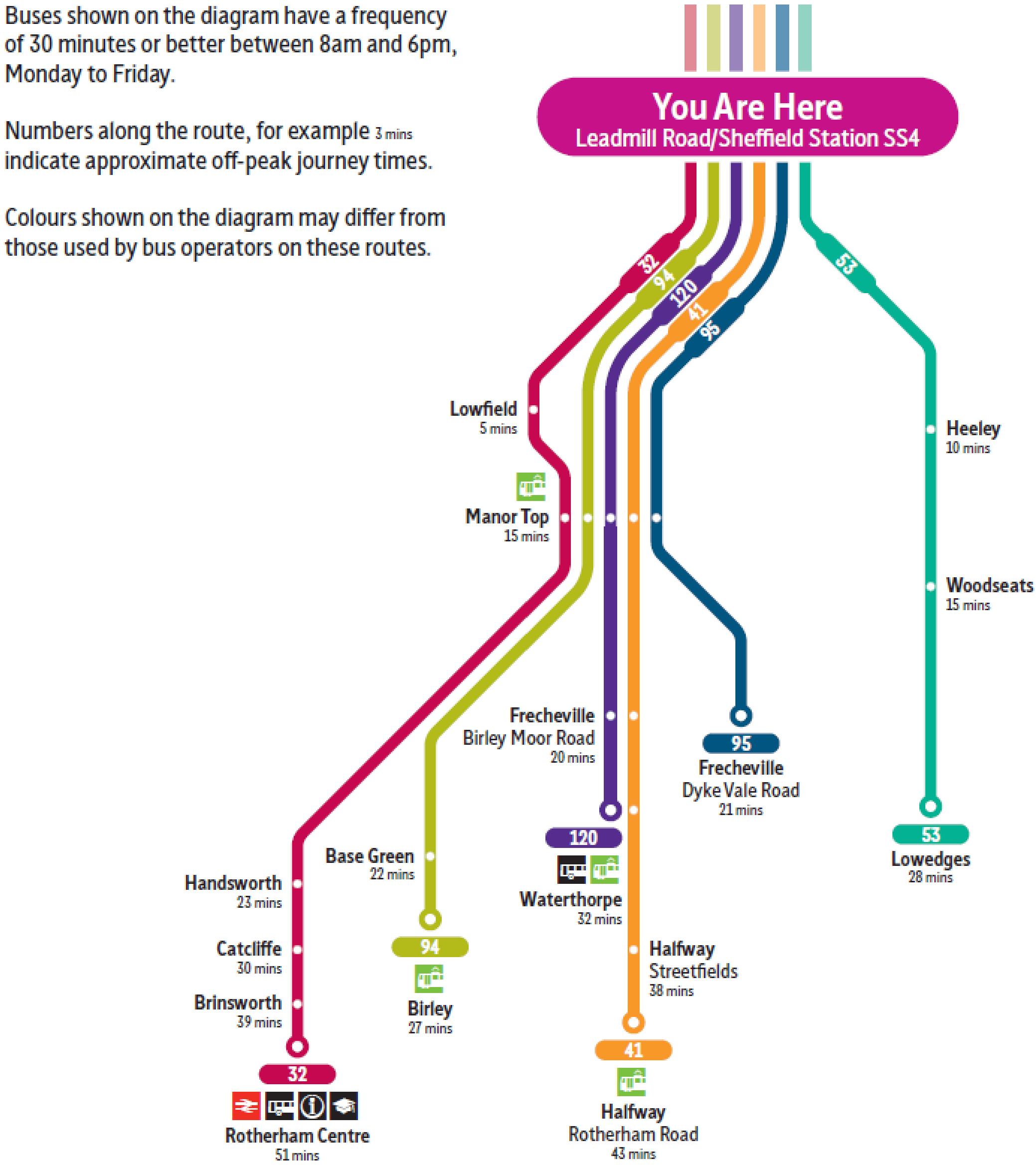


Figure 2.10: Sheffield Stop-Specific Bus Map (© SYPTE)

Therefore, it is unsurprising that Sheffield's SSBMs are very similar to those found in London - they read downwards and use Morrison's 'French' style so it is easy to identify where each individual service goes. As with the London SSBMs, the ease of following each route is further assisted by the service number being clearly labelled alongside each terminus point and, on the Sheffield SSBMs, at the start of each route, at the top of the map. There are some differences on the Sheffield SSBM; the first being that there is a degree of representation, albeit schematically, about where buses diverge from sections of common route. Unlike London, only services with frequencies of 30 minutes or better are shown, whereas London versions show all services. The locations shown on the Sheffield example appear to be key localities ('Handsworth', 'Woodseats' etc.) as well as key transport interchanges which are likely to be more familiar or easily identifiable to the traveller than some of the bus stops on the London version. The disadvantage of this, however, is that it is not evident on the Sheffield SSBM as to which roads are served within each of the localities shown. Finally, the Sheffield maps do not show the origin point of each service, a feature on the London SSBMs which could potentially cause some confusion. Nevertheless, the Sheffield SSBMs are, however, still subject to the aforementioned limitations of the London SSBM.

Figure 2.11 shows a SSBM displayed at Ninewells Hospital in Dundee. These maps were introduced as part of a wider bus improvement scheme, the Dundee 'SmartBus' project (Hacker, 2004) which was designed to bring confidence into PT using both 'hard' and 'soft' measures, including improvements to both the infrastructure and the information provided.

Previous work by Morrison (2000a) identified the provision of bus information in Dundee as one of the poorest in the UK, and also in Europe, and "it was recognised that the standard of static information provided to the public needed improvements" (Hacker, 2004, p.11). A new schematic network bus map was designed, following the style of FirstGroup's Overground concept, whilst SSBMs were designed for each bus stop in the City Centre and at Ninewells Hospital Interchange, although to date the author has not viewed a SSBM at any of Dundee's City Centre bus stops.

Figure 2.11: Dundee Stop-Specific Bus Map (taken by the author)

Compared to the London and Sheffield SSBMs, Dundee's version is still schematic but is more closely related to the actual geography of the area so users may be able to identify certain journeys where they can board a different service to the one they had planned to use, alight at a different stop and take a short walk to complete their journey. The Dundee SSBM is designed to read upwards, in the traditional map convention and the user's location is clearly marked, but the SSBM in Figure 2.11 is actually orientated so that east is at the top.

One useful feature on this SSBM is the addition of the suburb names (Lochee, Dryburgh, Blackness etc.) which do not dominate the map face but are beneficial in assisting the user in identifying which service(s) they can take to (or close to) their destination. If a user is familiar with the geography of the area and the spatial relations of the suburbs, the inclusion of these names will also allow the user to mentally orientate themselves in relation to the actual orientation of the SSBM, hopefully allowing them to recognise that north is not actually at the top.

The number of stops listed is much greater than on the London SSBM which further assists users in planning their journey, although this is only achieved in by not showing the entire route of each service. The map appears to cut-off routes after the City Centre, instead relying upon labels in the margin which list the eventual termini of the routes plus a number of intermediate locations (e.g. 'towards Kirkton/Fintry/Whitfield/Douglas/ Broughty Ferry' for services 9 and 11) although timetables are provided alongside these maps to provide additional route information. Hacker (2004) presents another example of a SSBM for a stop in Dundee City Centre which appears to show all routes in their entirety, so perhaps the amount of information shown on each SSBM in Dundee depends on the actual geographic extent of the forward portions of all the calling services.

The Dundee SSBM design is closely related to a true 'French' style of map, but it also uses service number labels throughout, as per the 'Classic' style. In Figure 2.11, four of the calling services (9, 10, 11 and 12) are represented by three individual lines, each in an identical dark blue colour. Common termini may be the reason for these lines having the same colour as they all eventually terminate in Broughty Ferry, although the 10X service (the orange line) also appears to terminate here. It is also not overly clear why services 10 and 12 (the dark blue line running to the top-right of the map) are grouped together whilst services 9 and 11 (the dark blue lines running to the top-left of the map) are shown individually. The only reason that the author can suggest for this is that the length of common routes between services 10 and 12 is much greater than that between services 9 and 11. However, the Dundee SSBM does provide a lot more detail than the London and Sheffield SSBMs, especially with respect to the actual routes taken by each service. Its main disadvantage is that the entire length of each route is not shown, but perhaps the majority of passengers travel from Ninewells Hospital to Dundee City Centre and so it was felt that there was little need to show route information beyond this point.

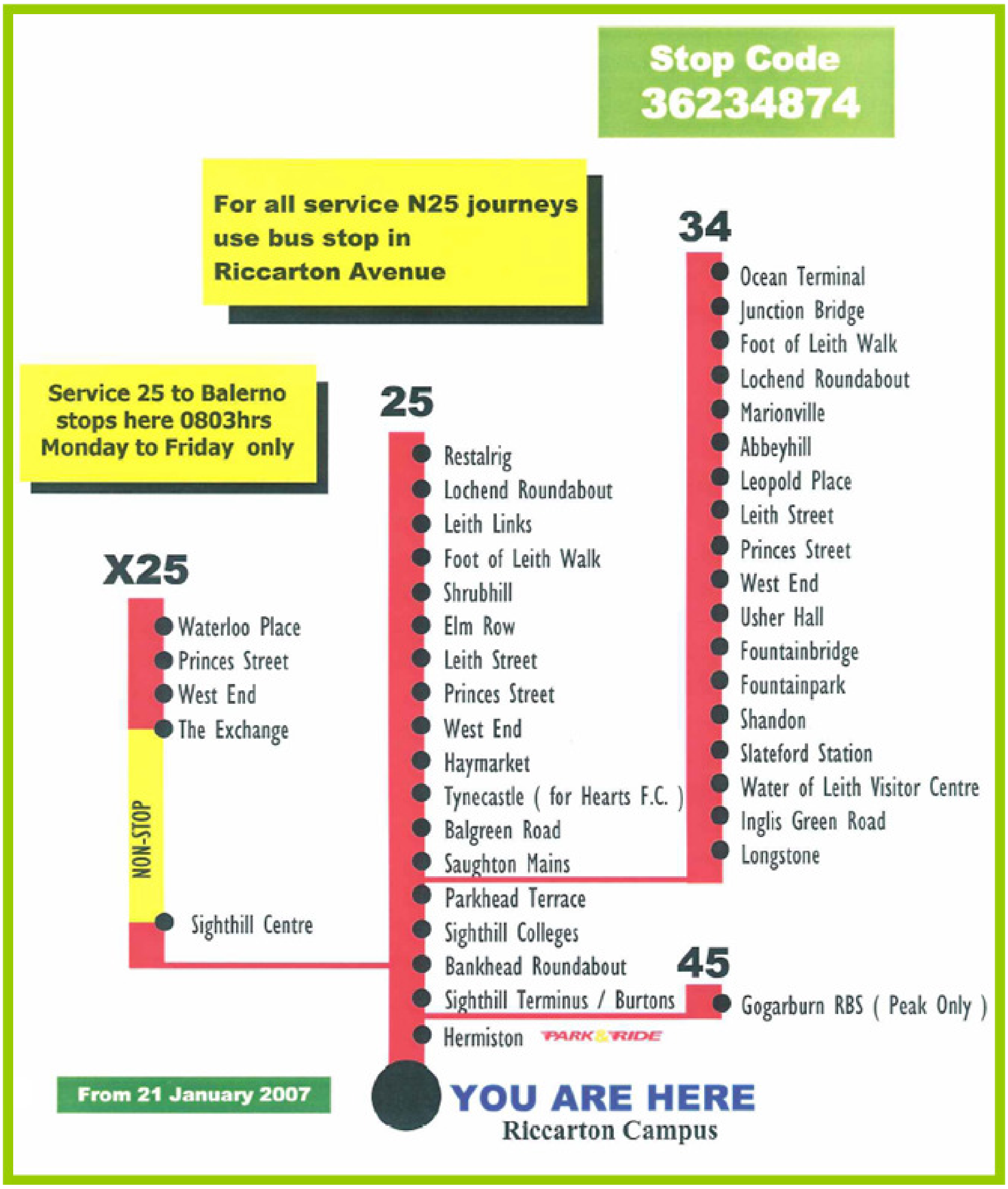


Figure 2.12: Edinburgh Stop-Specific Bus Map (© Lothian Buses)

Edinburgh is often quoted as an area which has excellent PTI provision, and this is particularly due to the efforts of Lothian Buses, one of the few remaining municipal bus companies in the UK, who are owned by Edinburgh City Council (91%) and East West and Midlothian councils. Lothian Buses provide users with an A3-size 'French' style network map which is very useful whilst in-transit, and in the past have also produced a very detailed (and thus very large in size) 'Classic' style network map, based upon a street plan of Edinburgh. Lothian Buses have also recently introduced the Bus Tracker system to their network which provides real-time departure information to the majority of bus stops in the street, and for all stops via an online virtual bus stop interface. Therefore, it is unsurprising that a bus operator with such a forward thinking attitude to the provision of PTI produces and displays SSBMs at the majority of stops across their network.

Unfortunately, whilst the 'French' style network map is very well designed, Lothian's SSBMs are of a highly schematic 'Classic' design and, in a similar way to the London SSBMs, do not attempt to represent the spatial relations of the services. In fact, it could be said that Edinburgh's SSBMs are actually worse than London's SSBMs. In London, services running along common sections are shown but on SSBMs in Edinburgh, services initially follow a common section and then branch off at the relevant point from this section, but not always on the correct side and in the correct direction from the common section. After the services branch off, they all appear to follow separate routes to their respective termini but if two or more services return to follow a common section later on in their routes, this feature does not appear to be shown on every SSBM.

Looking at Figure 2.12, users could be forgiven for thinking that every service had its own route from Parkhead Terrace onwards. Reading along the list of key stops for each route reveals that services 25 and 34 share another common section of route between Edinburgh's West End and Leith Street and could actually be said to extend to Elm Row/Leopold Place, as these stops are close to each other and together are marketed as an interchange (but the user is not to know this without prior knowledge). These services then also meet again further along their routes at the foot of Leith Walk so they provide two options for travelling to these particular destinations. However, the SSBM does not represent the routes in this way so users essentially have to consult each individual list of stops in a similar fashion as if they were presented with a number of individual route maps.

Another problem of the Lothian SSBMs is that at some stops, users are presented with a single map showing the routes of all of their services, and where there are a large number of calling services the corresponding SSBM can be quite complex and overwhelming at first sight. At other stops, users are presented with a number of individual SSBMs, each showing a subset of the calling services. Whilst this breaks down the information into more manageable pieces, it means the user has to consult each SSBM in turn, in order to determine which service(s) will take them towards their destination. This process can be made simpler by grouping routes according to their general direction (or by common termini as in the Dundee SSBM) and showing these groups on individual SSBMs, but it appears that this approach has not always been used in Edinburgh.

Despite the above problems, the Edinburgh SSBM does follow some of the main SSBM conventions as it is orientated to read upwards and the user's current location is clearly marked at the foot of the map. The routes of all services are shown in their entirety and the amount of stop information provided on each SSBM is much more detailed than the information that appears on either the London or Dundee SSBMs. One key feature of the Edinburgh SSBMs is that instead of referring to local streets and landmarks, which are only really known to those who live in the area or to those with previous knowledge, they tend to show locations that are well-known (such as Princes Street, Tynecastle Stadium or Leith Walk), suburbs that are clearly defined (such as Saughton Mains and Shandon) or are easy to locate on a street plan, including main roads (such as Balgreen Road and Inglis Green Road) and major road junctions (such as Lochend Roundabout).

The Edinburgh SSBM would be useful to both familiar and unfamiliar users, primarily because of the choice and naming of the stops shown on each map. Armed with a suitable street map, even the unfamiliar user should be able to work out an approximate location for their desired destination in relation to the range of stops shown on an Edinburgh SSBM. The major disadvantage of this form of SSBM is in the way the routes are treated as individual entities which, once away from the initial common section, appear to never converge with the other routes. This feature appears to be a remnant of when these SSBMs were primarily used to show fare zones, and in some instances individual services would follow different routes to a common destination, each service therefore requiring a different fare to be paid (A. Morrison, 2010, *pers. comm.*) Perhaps this subtle design element has been retained to keep the design relatively simple and quick to reproduce the PTI in light of any alterations to the network.

2.6 Conclusions to the Literature Review

This review of the existing literature has revealed some interesting findings. There is clearly a need to provide PTI to passengers as it allows them to make informed choices about how they travel, and without passengers, PT operators would be making losses instead of profits. There are also the wider socio-economic issues of congestion and social exclusion to consider, and it has been shown that PT can play a vital role in alleviating both of these problems. PTI can have a positive impact on peoples' general impressions of PT, as people want a service that is legible and that they feel confident when using, and information provided at the right time, in the right way, can actually achieve this goal. There therefore needs to be more emphasis put upon the provision of **mapping** information.

There has been a handful of studies which have investigated exactly how people use PTI, and from these it was apparent that the traditional forms of PTI have some disadvantages. With respect to mapping information, users were often presented with too much information for their current needs and so they were unable to find the optimum solution for their travel queries. There was a clear gap in the market for the provision of information that was designed to be used at a specific point in the journey, including the concept of the Stop-Specific Bus Map.

Existing SSBM designs are schematic in their nature, and Avelar and Hurni (2006) argue that the key advantage of using schematic representation for bus maps is that they are generally easier to use, which can be linked to the fact they "closely mimic the way in which we store information about our physical environment as cognitive maps" (Mooney and Winstanley, 2001, p.14). However, both Bartram (1980) and Morrison (1996a) do not advocate the use of schematic maps for depicting bus network, as "… Euclidean spatial relations between stops and between stops and final destinations cannot be determined" (Allen and Golledge 2007, p.89) and so "the more one deviates away from spatially accurate representations of the world, the less one can rely on the spatial deduction made" (Mooney and Winstanley, 2001, p.14). It is therefore believed that a more geographically-true design could be of greater benefit to users, as it would correspond to their mental map of the local area and surrounding environmental anchors, accurately depicting the spatial relations between the different bus routes and their intended destination. This research will take the findings of this review and attempt to answer this need for such a map design.

3.1 In this Chapter

This Chapter describes the first half of the research methodology, drawing upon the methodologies and findings of previous map use tests to develop a procedure for selecting typical British towns and a variety of bus stops for which SSBMs will be designed and subsequently tested.

3.2 Suitable Methodologies for Cartographic Research and Testing

The discussion in the Literature Review about how people actually use PTI gave no definitive guidance as to how PTI use tests should be conducted. The previous studies into PTI use adopted a variety of methodologies, used a range of sample demographics, with tests being conducted either in laboratory conditions or undertaken in the real world PT system, so it is unsurprising that the results are quite varied. As there is no single consistent method that PTI research should follow, the methodologies used for selecting the test locations for this study will be guided by previous research, as well as a logical assessment of the possible options.

Despite there being a vast number of previous map use tests, when it comes to the testing and evaluation of how people use maps, there does not appear to be any definitive guidance in the cartographic literature as to exactly *what* tests should be used and *how* they should be conducted. The International Cartographic Association (ICA) commission on ‘Use and User Issues’ was established in 2005 with a view to developing “a forum to work together on use and user issues in cartography and geo-information processing and dissemination” (ICA, 2005). More recently, a formal ICA research agenda into Use and Usability Issues has been established (Virrantaus, Fairbairn and Kraak, 2009) including a specific section on the usability of maps and other geographic information.

There are many issues and debates surrounding cartographic use and user studies which need to be considered. Robinson (1977) identifies five main approaches to cartographic research, two ‘indirect’ and three ‘direct’, which are briefly summarised below:

1. Empirical (indirect) – essentially a 'trial and error' approach, greatly relying upon personal opinions of the cartographer.
2. Adaptation of Studies Made in Other Fields (indirect) – borrowing ideas and methodologies from other areas as diverse as graphic design through to psychology and adapting them to cartography.
3. Census of User Reactions (direct) – employing questionnaire or interviews in order to ascertain which map design is best out of a range of similar designs.
4. Task-Orientated (direct) – actual user testing of maps for a specific task, usually associated with search operations or quantity estimation.
5. Psychophysical (direct) – experimental research into users' reactions when presented with different visual stimuli.

In choosing which approach to adopt, it is important to initially identify the tasks for which the final map would actually be used. It can be said that for every individual map there is a *specific* purpose for which it is intended to be used, which in turn requires a *specific* method of testing and evaluation, in order for any results obtained from the tests to be meaningful:

> The rigorous evaluation of maps must be based upon map reading tasks that are *appropriate* to the map reading objective. Only by showing the links between purpose, map design and map reading will it ultimately be possible to establish standards of map design that are more than conventional and aesthetic

(My emphasis, Board, 1978, p.1)

3.2.1 Laboratory versus Real World Testing in Cartographic Research

In addition to Board's statement on conducting user tests with appropriate tasks, it is also important to consider the physical conditions in which the tests are to be conducted. Laboratory conditions are often used for map use studies as they allow a number of external environmental conditions to be monitored and tightly controlled, to allow the effects of different situations to be recorded in a scientific manner. However, laboratory conditions cannot account for the uncontrollable external factors which will affect the user's performance, such as the weather, variable lighting conditions, interruptions and other distractions.

The discussion on cognitive mapping in journey planning (Section 2.4.1) has shown that there is a clear need to consider the influences of the external surrounding environmental conditions when planning how to test SSBMs. However, traditional scientific custom would suggest that a controlled test should be conducted in a laboratory. Therefore, one key issue that has to be resolved early on is which environment is most appropriate for testing the SSBMs as both laboratory and real world testing have their advantages and disadvantages.

Laboratory testing has traditionally been associated with research in the physical and life sciences where tight, measured control over the influence of external variables is critical (Falk and Heckman, 2009) whilst maintaining an element of realism is not deemed to be as important, or even required at all. In the general area of social sciences, it appears that laboratory testing is still viewed by many as an approach which lacks the vital element of realism, producing results which are not necessarily transferrable into real world behaviours. Robson (1993) identifies that the main disadvantage of laboratory tests is that they lack 'experimental realism' (it is hard to replicate real world conditions in the laboratory) and 'mundane realism' (experiences in the laboratory are rarely, if ever, found in the real world). This suggestion is borne out by a study by van Elzakker, Delikostidis and van Oosteron (2008) who concluded that "usability cannot be properly checked by means of controlled laboratory experiments alone. In the laboratory, a big part of the contextual information cannot be investigated and real users' behaviour and activities may not be sufficiently understood" (p.141).

Nevertheless, it would be wrong to wholly dismiss the potential for laboratory testing. Falk and Heckman (2009) have argued that more consideration should be given to laboratory testing in the social science domains, stating that previous concerns and objections over the realism and 'generalizability' provided by laboratories are not as evident as previously thought. Rigorous testing of certain cartographic attributes will require controlled laboratory conditions, particularly where a scientific aspect is concerned or measurements using calibrated instruments (such as eye tracking) are needed. One example of this is Gill's study (1986) into the perception of line thickness and colouring, where standard lighting conditions were paramount to ensure all colours were viewed under identical conditions.

However, it is now thought that cartographers should not wholly be constrained by the limitations of science, as identified by Perkins (2008) who concludes that a "scientific approach to mapping is certainly important, but it is only one of many ways of increasing our understanding of how and why maps are used" (p.158). There has been an ongoing debate surrounding the environment in which maps should be tested, but unlike the social sciences where more laboratory testing appears to be on the research agenda (Falk and Heckman, 2009), the cartographic agenda is generating a large amount of evidence and arguments for more testing in the real world. Board (1978) provided the initial steps in the debate for map use testing in the real world, arguing that "it is only by asking the right questions and by testing hypotheses derived from the ways in which map readers normally use maps that these conclusions can have any real validity" (p.10). Blades and Spencer (1987) added to this debate through their review of map use in navigational tasks, where they found that many adults have difficulties with using maps for navigational purposes and proposed future research should undertake "direct tests of different map designs in the environment to find out how map design can affect individuals' use of maps" (p.73).

Furthermore, in a review of qualitative methods for research into map making and map-use, Suchan and Brewer (2000) put forward the notion that cartography was no longer an isolated domain and cartographers should be conversing and converging with other academic practices, stating that these new collaborations would transfer "…cartographic research from the controlled lab environment to real users in place (*sic*)" (p.146) where cartographers are "…structuring research in natural and complex settings, in addition to the artificial settings of controlled [laboratory] experiments" (ibid, pp.152-153).

This lack of natural testing was also identified by Sluter Jr. (2001, p.36) who proposed that "appropriate user testing should be integrated fully within each and every research project". Sluter Jr.'s view is supported by Dodge, Perkins and Kitchin (2009, p.231), who state that "studying mapping needs to progress outside controlled laboratory environments and to seek deeper ethnographic understanding of mapping in the 'wild', so to speak". This notion is incorporated in the aforementioned ICA Research Agenda which advocates the greater adoption of real world cartographic testing: "map design should always be user orientated (user-centred design) and be based upon good knowledge about the elements of usability… use of maps and geospatial data in particular situations is necessary to assess the impact of contemporary displays" (Virrantaus, Fairbairn and Kraak, 2009, p.67)

It must be noted that a real world approach would not be without its disadvantages and restrictions as Robson (1993, p.84) notes that "move outside the laboratory door and such tight and comprehensive control [of external variables and test conditions] becomes impossible" (p.84), so in terms of testing the SSBMs versus existing PTI, it may prove difficult to compare the different forms of information on a totally even basis. However, Robson goes on to state that "if you can find a feasible and ethical means of doing this [testing in the real world] when planning a field experiment, then you should seriously consider carrying out a true experiment" (p.86).

The approach to studying how people use PT maps will naturally come under Robinson's (1977) definition of Task-Orientated research which can be carried out either "by testing subjects with various sorts of exercises, recording and analysing the results… [or] by interviewing subjects while they are performing the tasks" (p.167). The main problem with any Task-Orientated approach is that they are "difficult and complicated undertakings" (ibid.) as it is hard to attain conditions that could be considered as completely normal, especially for the respondents, who will always be aware that they are under some form of test conditions, no matter how informal the actual setting may be. This is especially true with regard to conducting on-street tests and interviews, as would befit the testing of the SSBMs, as shown by White (2005).

Many of the previous studies into how people use various forms of PTI for journey planning and execution were conducted in situations which do not truly represent the actual environment in which the PTI is intended to be used. Only the studies by Bronzaft, Dobrow and O'Hanlon (1976) and Hall (1983) were conducted in the real world environment, by asking respondents to plan and undertake real journeys through the actual PT system. Some of the previous studies in this area (Hardin, Tucker and Callejas, 2001; Cain, 2004) were undertaken in shopping centres or town halls, which are still outwith strict scientific laboratory conditions, whilst the remaining PTI studies were conducted in laboratory or classroom environments, which it is believed are not wholly appropriate for producing results comparable to those obtained from real world situations.

3.2.2 Real World Testing: Aspects of the Stop-Specific Bus Map Concept

However, there are aspects of SSBMs and how people use PTI when undertaking journeys that require real world testing. First, SSBMs are designed for one specific bus stop and do not serve any useful purpose at any other location. To provide some evidence on the utility of the SSBM concept, they should be compared to existing PTI provided to the traveller. As there is great variation in the provision of PTI across the UK, it would be a challenging task to replicate indoors this variation of PTI provision.

As many journey destinations are not clearly marked points on the map and other PTI, it was essential that some degree of local knowledge was incorporated into the testing. For one of the four journeys, the destination was not clearly marked on the map and so a correct response could only be made by someone with existing knowledge of the local geography. Testing at the bus stop would allow the sample of respondents to include a typical proportion of people with different amounts of local knowledge of that specific area and the bus services available in each area. Testing in a laboratory would require a greater amount of resource to recruit a similar sample, and respondents may have to be persuaded to travel to the location of the laboratory, away from the individual bus stop.

There are a number of spatial issues to be resolved, which are only of concern to the user when at the actual bus stop. A traveller needs to initially orientate themselves within the PT system, relating the SSBM (and other PTI) to the routes followed by PT services and the environmental anchors (key landmarks) which are visible from the surroundings of the bus stop, then position all this information upon their existing mental map of the local geography of the area, which will vary between individuals. It would be difficult, and perhaps unrepresentative, to ask respondents to undertake these tasks, by mentally replicating their surroundings and orienting themselves at a given bus stop, when they were actually in a laboratory.

This issue of user orientation is also important when testing the SSBM design, as they are meant to be designed and displayed in such a way that they are orientated so that the forward direction of travel of the services calling at the bus stop reads up the map face. Testing in environments other than the specific bus stop at which the SSBM is meant to be used would remove this orientation issue, and therefore not directly replicate how the SSBMs would be used in the real world.

From these points raised above, the decision to test the SSBMs in their real world environments was made. Whilst the laboratory could provide a perfectly valid environment for testing, allowing a greater degree of control over external variables, it was noted that conducting at-stop tests would allow for different respondents to be consulted, each individual having varying levels of local geographic knowledge stored in their cognitive map, reflecting how the existing PTI is used. The unique function of the SSBM was such that their true purpose would be better measured by applying them in the environment in which they were intended to be used, therefore real world testing of the SSBMs at their respective bus stops was chosen.

3.2.3 Using Real World Public Transport Data versus Fictional Data

Another practical issue that relates to the above argument is whether the test data to be used should represent an actual real world situation, or if data for a fictional area should be used. This question does not appear to have been widely considered in general cartographic research. The debate essentially hinges on whether users' previous knowledge and familiarity with an area is a required factor in the overall tests, and if varying levels of previous knowledge could possibly influence the final results.

This issue of user familiarity is particularly relevant when it comes to considering the wider sphere of cognitive psychology and its relation to map design research, as discussed in Section 2.4.1. When compiling the test maps, a definite decision has to be made as to whether real world data should be directly used, adapted in some way or not used at all. For PT users, it has been shown that previous knowledge of the general geography of an area is highly beneficial as they are then able to use PTI to overlay the spatial path followed by the route of a service onto their existing mental map of the area. If fictional data were used, then user familiarity would no longer apply as no-one can have previous knowledge of an area which does not exist. All the previous PTI studies discussed in the Literature Review used real world PTI and no reviewed study gave any consideration to using fictional data.

A major part of this research is to investigate whether SSBMs can be successfully designed and developed for existing bus stops from an existing specification (Morrison, undated) for the semi-automated production of SSBMs. By using real data from actual PT systems, the features of different networks can be used to test the features of the specification in its entirety, including features that may be unique to an area and not directly accounted for in the specification. Also, the time and resources required to produce fictional test data is another issue that needs to be considered. This will naturally depend upon the actual aims of the research and the need for fictional data could be accommodated by adapting existing data, as shown by Gill (1986) and Morrison and Forrest (1995). However, for this study, the task of generating the fictional test data will require a significant amount of time to collate and process the required route data, and then produce the final SSBMs. The production of the equivalent timetable and other Network Mapping information would require additional time and resources that are not available to this study.

Finally, one benefit of using fictional data in map design research is that the content of the data can be strictly controlled and the maps can be compiled in such a way as to incorporate specific design details and other information that can then be directly measured during the tests, especially in a controlled laboratory environment. However, this would have to be applied in such a way that the investigator could not be accused of biased results through deliberately inventing a network of streets and routes which would favour SSBMs over the other forms of information with which it was to be compared. This debate adds further weight towards testing the SSBMs in real world environments using real world data, to avoid any accusation of bias towards the SSBM concept and to provide appropriate test conditions.

3.3 Reasons for Testing in Different Towns

One criticism of the previous PTI studies is that the majority of the user tests were only undertaken in one location. This may be due to limited resources but by only testing the PTI for a single location, there is little consideration given to the existing PT arrangements in different areas (such as the number of bus services or the network topology), the variation in users' experience with using different modes of PT and thus the different forms of PTI to which people might be exposed.

One possible option for deciding on where to test the SSBMs would be using existing PTI provision to develop a sampling framework to identify areas with PTI that could be considered typical of the UK, providing a good baseline against which SSBMs could be measured. However in Britain, it is well documented that the general impact of deregulation has resulted in great variation of the general structure of PT systems between areas, and within each individual area there is also great variation between the PT operators and Local Authorities in terms of the amount and quality of PTI they provide (Cartledge, 1984; Cahm, 1990; Greenwood, 1993; Morrison, 2007; Scrimgeour and

Forrest, 2008) and this disparate level of PTI provision is now regarded as one of the main negative effects of deregulation in the UK (White, 1995). Today, there is no single PT map design which could be considered as standard across the UK, and at-stop timetable provision is highly variable both within towns and between towns.

Another prohibitive factor to this approach is that attempting to try and identify what form of PTI (mapping and timetables) is provided across the UK would be a time-consuming and potentially expensive task, far beyond the resources of this study. Although online sources would help identify the mapping information available online for each UK town and city, there is no guarantee that this information would be generally available in hardcopy form in the respective towns. Also, SSBMs would have to be tested against at-stop timetable information, which is not available online and journey planner timetable output is not an equivalent form of PTI. Therefore this approach, whilst potentially desirable (as it would be using PTI to form the rationale behind the selection of test locations), would simply not be feasible under the constraints of this study.

As noted in section 2.7.2, "…[transport map] circumstances depend widely upon the local geography and the variety of services to be portrayed" (Anon, 1985, p.639) and so testing the SSBM concept across different towns was deemed to be essential. Instead of using existing PTI provision as a means of identifying where to test the SSBMs, it was decided to use demographic and PT service characteristics to establish a sampling framework, as these were easily accessible measures for the whole of the UK, through online sources such as the National Census and various PT websites. The basis of this approach was guided by Balcombe and Vance, who conducted their PTI tests in four different British towns "to incorporate a wide range of demographic characteristics, bus service patterns and bus information arrangements" (1998, p.4).

As the amount of time and financial resources available to this research were somewhat limited, it was decided to conduct tests in Glasgow and Edinburgh, as these were easily accessible with large, complex bus networks, plus two other towns outside Scotland. It must be acknowledged that the direct selection of Glasgow and Edinburgh may introduce some bias into the results, therefore it was important that the additional two towns were to be selected in such a way that the final four locations together exemplify four different kinds of town from the point of view of bus stop information, bus service patterns and other demographic attributes, as per the Balcombe and Vance approach.

3.4 Selection Criteria for the Test Towns

The final two test towns were to be selected using a set of criteria derived from the findings of Morrison's previous work into the potential factors influencing the provision of PT spatial information throughout Western Europe. Morrison had previously studied the factors which may influence the merit of bus information during the period 1992-2000 through visits and interviews with transport officials, in 57 cities across 16 European countries, including eight cities in Britain. A general explanation of the work, and preliminary results, are provided by Morrison (2000a, 2000b), but the results relevant to this study appear in a later working paper (Morrison, 2005).

The analysis conducted in 2005 regressed the merit of the bus information in each of the 57 towns against numerous variables which it was thought might influence it, and eight of these variables were identified as sufficiently independent of each other for multiple regression. Details of these eight variables are tabulated below, in order of the strength of their simple correlation with the score for bus information.

Table 3.1 - Variables Having an Influence on the Spatial Scores for Bus Information across 57 European Towns (Morrison, 2005)

Name of variable	**Definition of variable. This relates to the agglomeration unless stated otherwise.**	**Simple correlation coefficient with merit of bus information**	**Significance (see note below).**
PTA	Lies within a Public Transport Authority =1, otherwise =0	0.53	***
TENDER	Uses general competitive tendering for buses =1, otherwise= 0	0.42	**
Rail%	Percentage of passenger journeys on rail-based modes	0.36	**
GDPph	GDP (Gross Domestic Product), in purchasing power units, per inhabitant, for large region in which town lies.	0.31	*
LogAgPop	Logarithm, base 10, of population of agglomeration	0.27	*
Tourism	Logarithm, base 10, of bed places in hotels and similar establishments per 1000 inhabitants, for small region in which town lies	-0.19	-
DEREG	Has deregulated buses =1, otherwise =0	-0.15	-
CAPITAL	Is a national capital =1, otherwise =0	0.01	-

Note. The stars in the column headed 'significance' are related to p-values as follows.

<0.001	***	Extremely significant
0.001 to 0.01	**	Highly significant
0.01 to 0.05	*	Significant

Although the criteria in Table 3.1 are based upon results from a Europe-wide study, there have been no studies of this nature from a solely British perspective and so a truly British set of criteria could not be established. However Britain is part of Europe, and British cities were included in Morrison's studies, so it was felt that the findings would still be applicable to this research. Of the variables identified by Morrison, the last three were found to have no significant influence, one (TENDER) took the same value (0) for all the towns involved in the present division into strata, and the data required for two others (GDPph and Rail%) would have been unduly laborious to assemble for the present study. This left two variables which could be used: PTA (r = +0.53, p = 0.000) and LogAgPop (r = +0.27, p = 0.046). When these two variables are combined as predictors in a multiple regression their combined effect is +0.50 which is 'extremely significant'.

Based upon the appropriate influencing factors, the set of criteria to be used in the overall selection process are discussed in the following sections.

3.4.1 Population of Between 75,000 and 300,000 People (in the 2001 Census)

The population figure was defined as that given for '2001 Population: All people' in table KS01 'Usual resident population' from the Census 2001 data, available through the National Statistics Online service. As Glasgow and Edinburgh are amongst the largest population centres in the UK (Glasgow City, 629,501; Edinburgh City, 430,082), it was important to limit the population range here in order to select towns that had a smaller population than Glasgow and Edinburgh.

The original population range was to be between 100,000 and 300,000 but on inspection of the potential sites within this range, it was found that reducing the lower limit to 75,000 would allow smaller towns such as Lincoln, Crewe and Bedford to be included and thus increase the range of the candidates for sampling. Below this limit, it was felt that towns would not be of sufficient size to warrant a network with enough bus routes to be of significant complexity to require SSBMs. An upper limit of 300,000 would ensure even the larger towns within the sample would still be substantially smaller than Glasgow and Edinburgh.

The figure used was the population of the highest level of output area given, as there are some locations which are defined as an 'Urban Area' with a population greater than that of the main town of the same name within the agglomeration. Morrison (2005) identifies that the logarithm of the agglomeration population has a significant influence on bus information scores, and a higher correlation with bus information scores than either the town population or the logarithm of the town population. As bus services serve the entire Urban Area and beyond, it is important to ensure that this is reflected in the locations used in the sampling frame.

For example, the Doncaster Urban Area (Figure 3.1) has a population of 127,851, consisting of:

- Doncaster (67,977)
- Bentley (33,968)
- Kirk Sandall (13,276)
- Armthorpe (12,630)

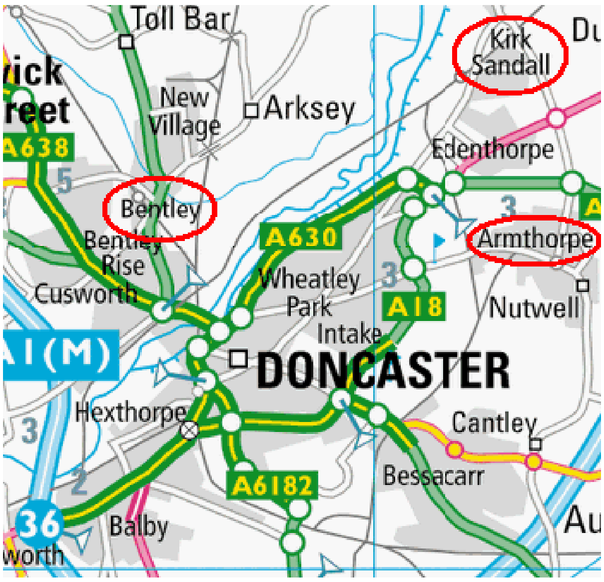


Figure 3.1: Doncaster Urban Area showing the component towns

3.4.2 The Location must be Outwith a PTE/ITA Area

PTEs/ITAs cover the largest urban areas in Britain and Morrison's analysis (2005) indicates the presence of a PTE/ITA has an extremely significant influence on bus information scores. Towns within these areas have a score of between four and eight percentage points higher than those not in a PTE/ITA area (Morrison, 2000a).

PTEs/ITAs often have larger PT budgets than other LAs, including financial resources specifically for the provision of PTI. As Glasgow is within the jurisdiction of Strathclyde Partnership for Transport (SPT), any potential influences on PTI provision of a PTE/ITA will be included in the overall testing.

3.4.3 Distance from London

The distance from a Capital City (or other major urban area) was not one of Morrison's original influencing factors, but interviews conducted with relevant LA transport officials in the eight British towns in Morrison's survey revealed a 'proximity to London' factor, whereby those located within 100-125 miles of London had aspirations to adopt similar PTI in their town to that found in the Capital (A. Morrison, *pers. comm.*). Given London's unique status within the UK with respect to its population and variety of PTI provision, it was decided to use this 'proximity to London' as an additional criterion.

The extent of the transport networks throughout the South East of England means that it is possible for people to live a significant distance from London yet still visit or even commute there and back easily within a day. Whilst travelling in London, it is likely that they will encounter the variety of PTI that is available, thus influencing their knowledge and expectations about what PTI would be available in all areas, perhaps even subconsciously. Therefore, it was desirable to incorporate this potential 'London effect' into the selection process, whereby people living close to, but not actually in, London would possibly have preconceptions about PTI.

It was decided that one location should be within a 100 mile radius of Central London as this was estimated to be the limit of the 'London effect', but would also be outwith the M25 boundary, as this is the general area covered by Transport for London (TfL). The second location would be outwith the 100 mile radius of Central London and not within the jurisdiction of a PTE/ITA. Upon inspection of the geographical location of potential candidate towns, this 100 mile limit also ensured that the distribution of the candidate towns between the two sampling strata was relatively equal.

3.4.4 Appropriate Local Public Transport Services

This is a study primarily on providing new forms of spatial PTI for *bus* travellers. It was important to ensure that towns had a bus network of suitable size which would allow a set of bus stops to be identified which had sufficient variety in the numbers of calling services, directionality, and city/suburban locations to allow the intended plan for the stratified random sampling of bus stops to be carried out.

Morrison (2000a) identified that rail-based systems generally have better spatial PTI than bus systems so it was also important to ensure that test subjects were not influenced by the presence of a rail-based system. Although the PT system in the area is to be primarily bus based, it is likely that there will be at least one railway station, but it is essential that the town has no rail services that could be defined as a suburban network, competing with bus services for intra-town journeys. All PTE/ITA areas in Britain have a substantial rail presence (heavy, light or both), so would be ruled out by the previous PTE/ITA criterion.

As it could not be assumed that towns without a local rail system have an adequate bus network, the candidate towns would be screened (in order they were selected) to assess whether the PT services on offer in each town were primarily bus based, and there was an adequate number of services across the network. It must be stressed that this was not part of the initial sampling process, as it would be difficult to define the necessary strata to represent the variation in local rail services.

3.4.5 Towns Should be Freestanding

One final criterion which had to be considered was that final towns should be freestanding settlements. Although the population criterion considered the population of individual towns and Urban Areas, it was important to avoid any towns which were in close proximity to other towns of similar size and population. It is likely that local bus services would operate in and between both towns, thus serving a larger population. Ensuring towns were freestanding would also enable the full set of bus services operating within each town to be easily identified, which would assist with randomly sampling the bus stops in each area (see section 3.7) and the subsequent designing of the SSBMs.

3.4.6 Implications of the Sampling and Screening Procedure

By using these sampling criteria to identify two medium sized British towns in addition to Glasgow and Edinburgh, it was felt that a wide range of different demographics and bus network attributes would be tested, producing results that were representative of the general travelling population and typical bus networks, whilst remaining as unbiased as was possible through the introduction of these additional criteria. It is acknowledged that this process is more involved that a simple one-step sampling process, however, it was felt that the addition of these criteria would assist in a rational, justifiable selection of typical British towns and cities. By adopting this procedure, this would help with the evaluation of the SSBM concept across as many different demographic and transport attributes as possible, whilst being achievable within the confines of this study's resources and remit.

Post-sample screening of randomly sampled records is perhaps not a wholly desirable process to incorporate, and future sampling processes could be strengthened by further stratification before random sampling occurs. Nevertheless, for this study it was felt that post-sample screening was the simplest solution to allow the final two criteria (appropriate PT services and freestanding town) to be incorporated into the final results.

3.5 The Sampling Procedure

Once the selection criteria had been determined, the next task was to generate the sampling frame and divide into two strata, one for towns within 100 miles of Central London, the other for the remaining towns. The first criterion to be addressed was population. The sampling frame was derived by selecting all towns within table KS01 in the 2001 Census which had a total population of between 75,000 and 300,000 (Table A.1 in Appendix A).

Once this sampling frame had been generated, the next criterion to be incorporated was the distance from London, to account for the assumed 'London effect' on PTI provision and user perceptions. This was achieved through a simple GIS query, using a shapefile of all the remaining candidate towns from the population criterion and a buffer of 100 miles around London. This process assigned the towns into the two sampling strata, one for those locations less than 100 miles from London, the other for those locations more than 100 miles from London (Tables A.2 and A.3 in Appendix A).

To account for the influence of a PTE/ITA, each stratum was screened to remove all towns within a PTE/ITA boundary, and for the less than 100 miles from London stratum, all towns within the M25 boundary. Finally, any overlaps between Urban Areas and corresponding towns (e.g. Doncaster Urban Area and Doncaster, as shown in Figure 3.1) were removed by deleting the individual town, leaving two final sample strata with unique records belonging to either an individual town or an Urban Area agglomeration. The records were then arranged alphabetically and assigned a sequential two-digit number starting at 00, incrementing by 1 (Tables A.4 and A.5 in Appendix A). A random number table was used to generate two sequences of two-digit numbers, which were used to sample four unique records from each stratum.

After the random sampling, each town was screened using the 'suitable PT services' and 'freestanding settlement' criteria. If the first town did not satisfy this screening process, the second was assessed and so on until a suitable candidate was identified. If it was found that all four selected towns were deemed to be unsuitable, then the random sampling procedure was repeated but with the original sampling strata adjusted accordingly by removing the towns drawn previously to ensure they would not be selected again.

The sampling and screening processes were adopted to reduce the potential for any accusation that the final results were biased, through the direct, purposeful selection of towns which would naturally suit the SSBM concept. Post-sample screening was unavoidable in order to include some of the criteria, but it is recognised that the inclusion of this additional process is not always desirable. Nevertheless, the criteria adopted for the sampling (but not the post-sample screening) are based upon the extensive work of Morrison (2000a, 2000b, 2005) and from this, the final two towns to be used for the testing were Cambridge and York. A full description of all the towns selected, and the reasons for rejecting the other towns, can be found in Appendix B.

3.6 Selecting the Test Stops

Once Cambridge and York had been selected as the final two towns along with Glasgow and Edinburgh, the next task was to randomly sample a number of bus stops within each of the four towns for which a SSBM would be designed and tested. What appears to be a 'simple' bus stop can actually have many different attributes, and it could be argued that there will be some stops at which the SSBM concept would be more applicable.

Therefore, as with the selection of the test towns, it was important to employ a stratified sampling process to ensure that the chosen stops encompassed a wide range of attributes whilst also minimising any potential for biased results in favour of the SSBMs.

3.6.1 Number of Calling Services

Perhaps the most important factor that will determine how useful a SSBM could be is the actual number of services which call at a specific stop. SSBMs can, in theory, be applied to any bus stop regardless of the number of calling services, although in practice this is usually no more than eight to ten individual services (but there are exceptions, particularly in the centre of larger cities)

There are stops with just a single calling service, which are usually found in suburban areas, and at these stops the information provided by timetables or on Network Maps might suffice. One example of where a SSBM may not be wholly useful is at stops approaching the terminus of a solitary service. Given the close proximity of such stops to the terminus, it is likely that most passengers will alight here rather than board the service and there is little information about the forward-portion of the route that can actually be displayed, although the author has viewed SSBMs at such stops in Edinburgh.

At the other extreme, in city centres many services often converge on a single stop (possibly within a group of 'individual bus stops' - explained in greater detail below) and the author is aware of individual bus stops which have upwards of 15 calling services. Here the amount of information provided by complete timetable information can be overwhelming, as users will potentially have to study every individual timetable to identify which service(s) they could board to travel to their desired destination. This then raises the question about how easy it is to identify the *optimum* service for a given journey. As there are a large number of services on offer, this greatly increases the chance that more than one service will fulfil the traveller's journey requirements, yet previous research (Bronzaft, Dobrow and O'Hanlon, 1976; Hall, 1983) suggests that once a traveller identifies a route that will satisfy their intended journey, it is likely that they will use it regardless of whether there might be a more efficient alternative. Once they are *en route* to their destination, it is rare that they seek a better alternative for fear of deviating from a route which they have stored in their cognitive map and thus feel confident, to a certain degree, in following (Golledge and Gärling, 2004).

Where there is a large number of calling services at a stop, there is a significant amount of route information and increased opportunities for future interactions between different services further along their respective routes. Given the volume of information that the traveller has to process when travelling from these stops, Network Maps could become increasingly difficult to use efficiently. At these stops, one might expect that a SSBM would be an ideal form of PTI to display.

Therefore, to fully explore the potential of SSBMs, it will be necessary to test them at a variety of stops with different numbers of calling services. Morrison (1996a) has identified that the maximum number of individual colours that should be used to unambiguously represent the routes on a single bus map is nine. For stops with up to five calling services, it would be possible to represent each route with an individual line colour, although where two or more services follow a common section for the majority of the forward-portions of their routes, it might be sensible to group these services and represent them accordingly.

Between six and nine calling services, a similar situation may occur but it is unlikely that every individual service will have a wholly unique route and thus warrant an individual line to be shown on the SSBM. For these maps, it is likely that grouping of services will naturally occur, reducing the number of individual lines on the SSBM and improving the overall clarity of the map. For those stops with ten or more calling services, Morrison's findings mean that some grouping of routes is unavoidable. This is especially true for high-frequency bus corridors where numerous services operate along all, or part, of the corridor before branching off to serve their respective destinations. This grouping of services could also benefit the passenger if it is done in such a way that all services to a particular area or destination are grouped together.

Therefore, one criterion to be included in the final random sampling procedure will be based upon the number of calling services, to incorporate Morrison's grouping theory:

- Between one and five calling services;
- Between six and nine calling services;
- Ten or more calling services.

For sampling purposes, it was also important to consider what constituted a single bus stop. When numerous services operate along a single road they are often assigned to depart from different bus stops, often determined by their general direction of travel relative to the particular stop (e.g. one stop for services to the north of the city, another for those to the east). Morrison (undated) categorises this arrangement into three levels of bus stop, whereby any number of 'individual bus stops' in close proximity can be defined as one 'bus stop', and aggregations of 'bus stops' are defined as a 'cluster'. There are different SSBM design permutations that could be adopted when dealing with individual bus stops within bus stops within a cluster. For the purposes of this research, each individual bus stop will be dealt with as a single entity, be it part of a bus stop, a cluster or otherwise.

In addition to treating bus stops on an individual basis, where there is a small number (say less than five) of services calling at the stop, it may be possible to include additional information on the SSBM about interchange stops and potential onward journeys using services that do not operate from the current stop. This extra information would be of great benefit to a passenger who initially identifies that they cannot reach their desired destination directly from this stop but with the addition of interchange information, they would not have to search at other stops for the necessary information. However, as the number of services calling at the stop increases, the number of potential interchange points for onward journeys also increases (with the risk of duplicating journeys that can be made without interchange) and the amount of vacant space for displaying extra information on the map decreases. Determining exactly which interchange services should be shown is a complex task and so for the purposes of this research, it was decided that the SSBMs will remain true to their original definition and not show onward connections with other non-calling services.

3.6.2 Network and Bus Stop Characteristics

Simpson (1994, pp.157-158) identifies four main bus route patterns. An examination of a range of typical Network Maps reveals that the majority of services operate either from a central location (often a dedicated bus station) within the town or city centre, to and from the suburbs (known as radial services), or begin in one suburb, travel through the city centre and then continue on to terminate in another suburb (known as cross-city or transverse services). These services tend to run along bus corridors (sections of road with numerous bus routes which, when combined, provide passengers with a high service frequency) when travelling into and away from the city centre, branch off from this bus corridor at separate locations within the suburbs and then follow an individual route to their final destination(s).

The majority of passenger flows are between the suburbs and the city centre, so commercial operations tend to focus on providing such services. However, if only radial and transverse services were provided, passengers who wanted to travel between different suburbs might have to initially go into the city centre to change to another service which would take them out to their final destination. Therefore, in addition to radial and transverse services, peripheral services are provided that do not serve the urban centre but instead operate on routes that run directly between suburbs. Whilst these peripheral services are usually fewer in number, they provide useful connections between individual suburbs and also between radial and transverse services on different bus corridors.

In some instances peripheral services actually form a complete loop around the urban area (known as an orbital or circular service). Where circular services are provided whose routes are of a significant length, there are often two individual services, with one running in a clockwise direction and the other running in an anti-clockwise direction, for example, First Glasgow's services 89 and 90 which are marketed as the 'Inner Circle' (anti-clockwise) and 'Outer Circle' (clockwise) respectively. Smaller circular services, such as local town centre services or those which connect a handful of suburbs with a local shopping centre, sometimes operate in one direction only, and can include portions which traverse a single road link in both directions, 'figure of eight' configurations, 'hail and ride' sections and some even serve different destinations depending on the departure time of each journey.

With such a range of potential bus route patterns and characteristics, it is possible for an individual bus stop to be served by a variety of radial, transverse, peripheral and circular services. Consequently, many bus stops cannot be characterised by a single route pattern. This means that route pattern is not a suitable criterion for stratifying the set of bus stops in a town. Instead it will be more practical to use the general directionality of the onward sections of bus routes (inbound or outbound), plus the actual location of the stop within the overall urban area (either city centre or suburban.) Stops located in suburban areas normally have a small number of calling services and are either served by inbound services (those travelling from the suburbs to the city centre), or by outbound services (those travelling to the suburbs from the city centre). This is not a completely exclusive set, however, as there are also stops which are served solely by peripheral or circular services.

Each stop will have a different combination of route patterns, which in turn will generate a different design of SSBM. In city centres, numerous services tend to converge on bus stop clusters and are typically assigned to individual bus stops within each cluster based upon their general direction of travel after departing from the stop. Here, services either operate towards a central bus station, and are essentially still on their inbound journey, or continue through the city centre and onto another suburb, so move from the inbound leg of a journey to the outbound leg.

It would therefore not be an easy task to identify a set of bus stops which represents every individual case, ensuring that the SSBM concept is tested in a robust manner whilst keeping the testing of the SSBMs at a manageable level. Bus stop location can be simply divided into two categories, city centre and suburban. Direction of travel, on the other hand, has more potential categories. In addition to those easily defined as inbound or outbound, which probably suffice for city centre areas, there could be peripheral only bus stops in suburban areas, in addition to the inbound and outbound categories. Incorporating all possibilities could lead to an inconveniently large total number of strata, which may eventually exceed the desired number of bus stops in the sample for each town. To avoid this, directions of travel were confined to inbound and outbound, thus all bus stops can be easily allocated to one of two directions of travel, and to one of two locations.

3.7 Final Selection Framework

To demonstrate the versatility of the SSBM concept, it was important to identify a variety of stops which allowed all possible combinations of bus stop attributes to be shown on a series of SSBMs. To achieve this, a framework was designed which ensured that the set of sampled stops encompassed all of the bus stop attributes (as discussed in the previous sections) but were not biased by only including stops which were more suited to having a SSBM on display. The sampling process focussed on randomly choosing a number of individual bus stops in each town based upon the above criteria.

A variety of data sources was required in order to select the test stops. In order to determine how many services call at each stop, route information had to be collated and captured in the GIS for every service that operated within each area, regardless of the operator, commercial or otherwise. This would allow the number of services operating along each road link to be calculated which would then be spatially assigned to each bus stop. Bus stop location (suburban or city centre) and general directionality were fixed attributes, and thus required no data processing.

3.7.1 Base Digital Dataset Issues

The primary information requirement was a detailed digital dataset depicting the national road network upon which the individual route data could be captured. The University of Glasgow subscribes to the Digimap service provided by EDINA, which allows access to a number of Ordnance Survey (OS) digital datasets:

Table 3.2: OS Digital Datasets provided by the Digimap Service

Dataset Name	Scale	Description
Strategi	1:250 000	"Road atlas" style mapping at a scale of 1:250 000, showing major settlements, roads, railways, water features and land use
Meridian 2	1:50 000	Comprehensive road network, railway lines, urban areas, boundaries, water features, woodland and place names, with a nominal scale of 1:50 000.
Land.Line-Plus	1:1250 (in Urban Areas)	Shows the accurately surveyed positions of the natural and man-made features of the topography including outlines and divisions of buildings, land parcel boundaries, road kerbs, rivers and water features and feature names

At the time of compilation, plans to replace the Land.Line-Plus (LLP) dataset with the seamless MasterMap dataset had been announced, but MasterMap was only available to a trial number of subscribing institutions and was not then available to Glasgow. In selecting a base dataset, a decision had to be made regarding the spatial 'resolution' and content of the road network. If bus routes only followed main roads, then the Strategi dataset might have been suitable but bus routes operate into suburban areas and the limited data on side streets in the Strategi dataset meant that it was quickly discarded.

Although the Meridian 2 dataset is marketed as being a 'comprehensive road network' and thus the most appropriate candidate, it was important not to discount the LLP data without inspection. Having worked with both datasets in the past, it was felt that both would be suitable for the purpose, but the data management issues associated with each dataset had to be considered. A compromise was required between the overall spatial resolution of the dataset and the time required to download, process and store the necessary data tiles for each of the test areas. As the coverage of a single Meridian 2 tile equalled that of four LLP tiles, it was clear that using Meridian 2 would have a substantial advantage in terms of reducing the time required to download and process the data, and would also require less memory in which to store the data. Upon inspection of the content of Meridian 2, it was found that the road network was indeed 'comprehensive' and of sufficient detail to allow bus routes to be captured in their entirety.

One further issue in favour of using Meridian 2 was that LLP was being replaced by MasterMap and so the current LLP content was not being maintained nor updated, which led to concerns about how up-to-date the LLP road network might be. Therefore, the decision was made to use the Meridian 2 dataset for the base data, and the necessary tiles covering each of the test towns was subsequently downloaded from Digimap, then processed by extracting the transport network layers and merging each layer into a single shapefile encompassing each area. Each road link was then assigned a new unique identifier to allow for the network of routes to be referenced to each link at a later stage.

3.7.2 Bus Stop Data

In the UK, the DfT and Thales maintain the NaPTAN (**Na**tional **P**ublic **T**ransport **A**ccess **N**ode) database which provides a unique reference point and identifier for every PT access node in the country – all National Rail stations, light rail and subway stations, bus and coach stops, airports entrances, ferry terminals and docks, tram stops and taxi ranks. Along with these unique identifiers, the data also contains a variety of attribute information about the access node, including its type (bus stop, railway station entrance etc.), official name, common name and, key to this project, the node's Eastings and Northings in the OSGB36 reference frame.

The data within the NaPTAN database is primarily used in computerised and online journey planners utilising XML and UML programming languages, but it is also available to download as .csv files on an area-by-area basis. A personal user licence was obtained from Thales which then allowed the latest version of the NaPTAN data to be downloaded for each of the four test locations which would be used as the raw data in the random sampling of bus stops for each area. Each of the .csv files were converted to an (x,y) point shapefile in ArcCatalog for an initial visual exploration in ArcMap. On inspection of the level of attribute detail of the NaPTAN data and its spatial accuracy in relation to the Meridian 2 transport networks, it was clear that the NaPTAN data would be suitable for use. There was a slight spatial mismatch between a minority of bus stops and the road network data, as some stops appeared on the incorrect side of the road, or alongside a different street altogether (Figure 3.2).

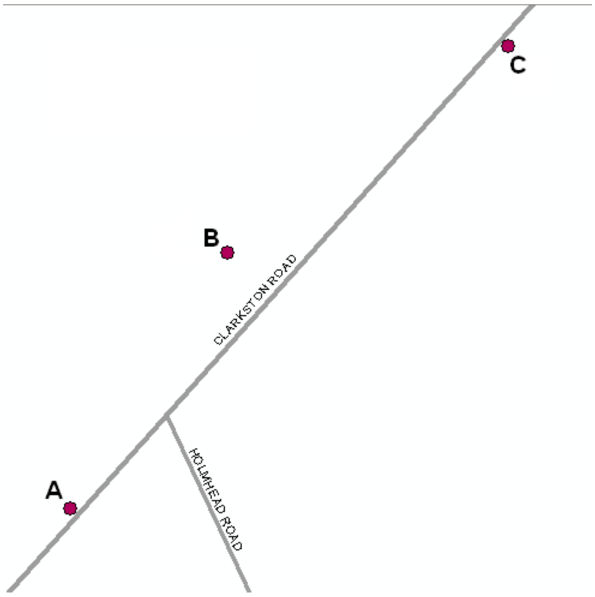


Figure 3.2: Example of spatial mismatch between OS Meridian 2 dataset (road links) and NaPTAN dataset (bus stops).

- Stop A is actually on the wrong side of the road;
- Stop B is on the correct side of the road, but the distance between it and the road is excessive;
- Stop C is placed correctly.

This problem was further complicated by the addition of side streets, back lanes and other minor thoroughfares, but overall the vast majority of bus stops did appear in the correct spatial location and so it was decided to proceed with the data. All of the NaPTAN shapefiles were cleaned by removing all non-bus stop entries (railway station entrances, taxi ranks, ferry terminals etc.) to produce the initial populations of bus stops for each area.

3.7.3 Compiling the Route Data

Although compiling route data about all services within an area would appear to be a time consuming task, it would actually serve two purposes. Not only would this data allow the number of services passing-by each stop to be calculated, but it would then be possible to use the data in the compilation and design of the SSBMs. Initial consideration was given to directly approaching the relevant bus companies and LAs in each test town to ask if they had digital datasets for all bus services across their network or area. However, this idea was promptly abandoned for a number of reasons.

First, it was not known whether such GIS-ready digital datasets existed or if they were actually the property of the PT companies or LAs. Given the existence of NaPTAN and TransXchange data formats used for online journey planning purposes throughout the UK, it was assumed that GIS-ready data could probably be derived from these datasets using suitable programming syntax (Hall, 2008). If such GIS-ready data did exist, there was still no guarantee that access would be permitted due to commercial sensitivity (for example, planned revisions to existing routes or completely new services) or how complete it would be in terms of the services provided by the smaller operators.

If such data did exist and it was made available to this study, the next question would be if it was spatially compatible with the OS Meridian 2 digital dataset obtained from Digimap. Depending on how the route data might have been captured, and from what base dataset it was derived, there could potentially be numerous hours of additional editing and georeferencing required to transform and spatially align the datasets. It seemed more appropriate to use publicly available service information (Network Maps, timetables and journey planners) to identify the individual services and their routes, and then manually capture each route in the GIS. This would ensure total compatibility between the various datasets and would not run the risk of any delay to the overall research, due to relying on third parties to supply data. Finally, by using publicly available information and creating an entirely independent database of bus services using base data accessed via Digimap, this would also remove the need to address the issues of commercial sensitivity and copyright.

Although the larger PT operators tended to provide a wealth of service information, both in printed form and via their websites, there was still the desire to develop an impartial database and so it was also important to identify the services that were operated by the smaller operators, the majority of whom do not produce up-to-date literature or have a web presence. Some information about the services provided by these smaller operators was available from the relevant LA websites, as these generally provide a more 'impartial' source of PTI. However, during the search for PTI a website called 'Carl Berry' (http://www.carlberry.co.uk/) was discovered which provides lists of all PT services in any area, from the smallest settlement to the major conurbations. Although the data from 'Carl Berry' came with many disclaimers regarding the currency of the data, and therefore had to be treated with a degree of caution, it proved very useful as an initial reference listing all services and acted as a portal to other information sources, which were often more up-to-date.

Where possible, a road-by-road list was obtained for each individual service, which was then cross-referenced with the latest version of the local Network Map. All links within the road layer shapefile were labelled with their respective names (contained within the attribute table) allowing each service to be captured in the GIS by following the road-by-road list, selecting the required road links and exporting the selection to a new shapefile.

Where a service followed slightly different routes depending on the direction of travel, all one-way links were incorporated into the final selection of road links.

If the road-by-road list was not available, it was also possible to trace the route of each service by downloading its complete timetable (showing all stops) from the associated Traveline journey planner and then repeating the selection process outlined above. However this method also required the NaPTAN bus stop point shapefiles to be added and labelled, then the route was captured by following the Network Map and the list of bus stops - essentially 'joining the dots' but using the road links as pre-defined lines.

Overall, this method of capturing the route of each individual service was somewhat time-consuming, especially over longer routes or where the route information obtained was not clear. Despite the time required, it was felt that the eventual datasets would be in the desired format and would have further uses in the designing of the SSBMs, so it was worth putting in the effort.

3.7.4 Determining the Number of Services at Each Bus Stop

After the complete route of every service had been captured in the GIS, the next stage was to calculate the number of services that ran along each road link. Once this calculation had been successfully achieved, the information could then be associated with each individual bus stop to allow for the necessary sampling strata of bus stops to be populated.

After trying a number of different approaches, it was found that there was no suitable way of achieving the required outcome through the standard GIS functions and so an alternative method was required. As discussed, each individual road link in the base dataset had been allocated a unique ID which would now be utilised in the calculation process. By selecting route information from the base dataset and creating a new shapefile for each of the individual routes, this ensured that the attribute table of the new shapefile contained the same unique ID of each link which made up the entire route. These could then be matched to identify which routes operated along each road link in the base dataset.

The attribute tables of the road base data shapefile plus all the individual route shapefiles were exported into a Microsoft Access database which ensured that the raw data within the attribute tables was not unintentionally edited. A series of relational queries were established within Access which matched the unique ID from each individual route shapefile to the overall base dataset unique IDs, allocating a ‘1’ if there was a match, and a ‘0’ if there wasn’t:

`IF (ROAD_ID = XXX_ID, 1, 0)` *where XXX = the individual route shapefile*

This process was repeated for all of the individual service shapefiles, eventually producing a large binary output table which essentially identified which services operated along each road link. Once the binary table was complete it was exported into Excel and a summation along each row allowed for the number of services along each link to be established. A simplified example to illustrate the overall process can be found in Figures 3.3 and 3.4, and Table 3.3.

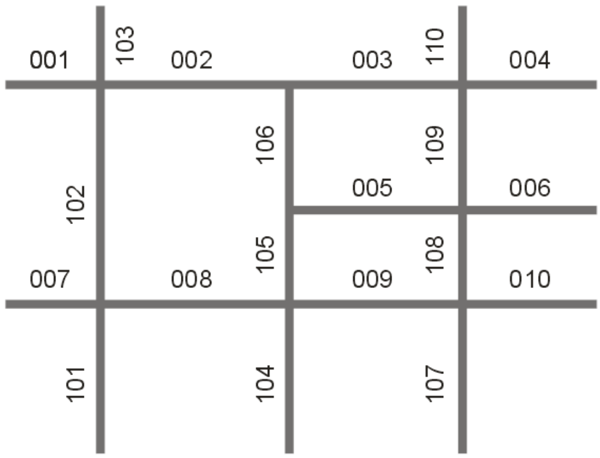


Figure 3.3: Base network of road links, each assigned with a unique identifier

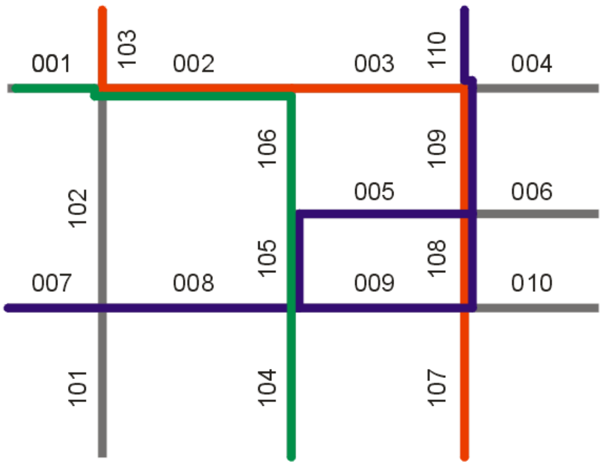


Figure 3.4: Example network of individual bus routes captured by selecting the required links which constitute each route. This transfers the unique identifiers to each individual route.

Table 3.3: Output Table of Identifier Matching Query for the Example Network

Link_ID	Service_1	Service_2	Service_3	Total_Services
001	0	0	1	1
002	1	0	1	2
003	1	0	0	1
004	0	0	0	0
005	0	1	0	1
006	0	0	0	0
007	0	1	0	1
008	0	1	0	1
009	0	1	0	1
010	0	0	0	0
101	0	0	0	0
102	0	0	0	0
103	1	0	0	1
104	0	0	1	1
105	0	1	1	2
106	0	0	1	1
107	1	0	0	1
108	1	1	0	2
109	1	1	0	2
110	0	1	0	1

Once the summation was complete, this column was exported back into the attribute table for the road base data shapefile in the GIS. The final step in this process was to allocate the number of services along each road link to the individual bus stops, which was achieved by implementing a spatial proximity join between the bus stop shapefile and the revised road shapefile, assigning each bus stop to its nearest road link. This transferred the number of services from the road attribute table to the bus stop attribute table, and a visual inspection of the results showed that the final outcome of the overall procedure was successful.

One small issue arising from this process occurred when the spatial layout of the shapefiles did not agree. Incorporating datasets from different organisations (i.e. OS Meridian 2 road centreline information and NaPTAN bus stop information) highlighted a few instances where the two did not coincide and so a handful of bus stops appeared on the wrong side of a junction or even on the wrong side of a road (Figure 3.2). Upon applying the spatial join procedure, a very small number of bus stops were allocated to the incorrect road, with some bus stops being assigned to a road with no operational bus services when in fact they should have been assigned to a main road with numerous operational bus services (Figure 3.5). However, as only a minority of stops were affected, it was decided that this would not have a detrimental impact on the final sampling procedure.

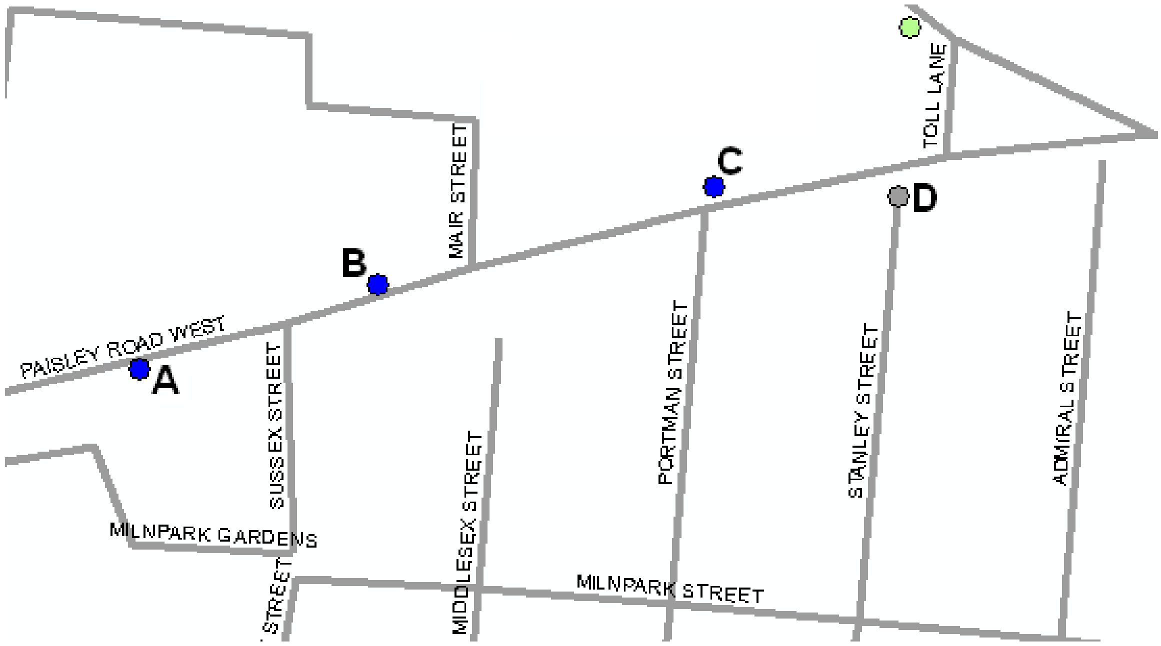


Figure 3.5: Example of Incorrect Allocation of the Number of Calling Services due to Spatial Mismatch between Datasets.

In Figure 3.5, Paisley Road West is a main bus corridor between Glasgow and Paisley, and stops A, B and C have correctly been allocated the number of calling services (13), whereas stop D has been allocated 0 calling services because it is closer to Stanley Street, a cul-de-sac with no bus services running along it.

3.7.5 Generating the Final Sample of Bus Stops

Once the number of calling services had been determined for each bus stop, it was then possible to allocate the bus stops into their respective sampling stratum based upon Morrison's grouping theory, as discussed earlier:

- Stops with between one and five calling services;
- Stops with between six and nine calling services;
- Stops with ten or more calling services.

Once the bus stops had been allocated to each sampling stratum, the records within each stratum were assigned a sequential three digit number, the first record being at '000'. A random number table was then used to sample bus stops to populate the following bus stop sampling frameworks:

Table 3.4: Bus Stop Sample Framework (Glasgow and Edinburgh)

Location of Bus Stop	Calling Services	General Directionality	Number of Stops
City Centre	One to Five	Either	2
City Centre	Six to Nine	Either	2
City Centre	Ten or More	Either	2
Suburban	One to Five	Inbound	1
Suburban	One to Five	Outbound	1
Suburban	Six to Nine	Inbound	1
Suburban	Six to Nine	Outbound	1
Suburban	Ten or More	Inbound	1
Suburban	Ten or More	Outbound	1

Table 3.5: Bus Stop Sample Framework (Cambridge and York)

Location of Bus Stop	Calling Services	General Directionality	Number of Stops
City Centre	One to Five	Outbound	1
City Centre	Six to Nine	Inbound	1
City Centre	Ten or More	Outbound	1
Suburban	One to Five	Inbound	1
Suburban	Six to Nine	Outbound	1
Suburban	Ten or More	Inbound	1

Given the time limitations for testing in Cambridge and York, it was decided to be not as strict with the directionality criterion as in Edinburgh and Glasgow. The topology of the bus networks in Cambridge and York were such that it was not as easy to define an inbound bus stop within the City Centre. Therefore, it was more practical to have two outbound bus stops and one inbound bus stop within the City Centre, and reverse the numbers for the suburban bus stops.

Having completed the random sampling of bus stops for each of the test towns, the designing and testing of the SSBMs could commence. This is described in the next Chapter, outlining the overall design flowline and the pilot user tests, followed by the revisions to both the SSBM design and testing procedures which were adopted for the final user tests.

4.1 In this Chapter

This Chapter describes the various procedures used in the initial design of the SSBMs. A description is provided for each stage in the flowline used to *manually* design SSBMs for three stops in Glasgow as part of the pilot study. The design flowline is guided by a specification written by Morrison (undated).

4.2 Existing Design Guidelines for Public Transport Maps

> Nearly any reasonably executed map can be read with some degree of success but cartographers should not settle for that. As designers of functional products one of our chief goals should be to make them work as *efficiently* as possible, a task which requires that extra bit of effort, care, and concern for the user
>
> (Delucia, 1979, p.179)

Delucia's statement highlights one of the main challenges of cartographic design: designing a map that is functional yet aesthetically pleasing is by no means a simple task. Taking an attitude of 'that will do' is simply not enough. However, the problems raised by this challenge are exacerbated when designing a new type of map, as there is little guidance from which the cartographer can draw inspiration and identify potential solutions. There is often nowhere to turn to find some assistance or reassurance other than traditional cartographic theories, which may not be wholly applicable to the new design. Therefore, a trial and error approach to finding a suitable design is often the only available way forward.

There have been some attempts to produce design guidelines for geographically true PT maps (Ellson and Tebb, 1978b, 1981a; DfT, 1996; Higgins and Koppa, 1999; Denmark, 2000; Foreman and Tucker, 2003; Cain, 2008), whilst Avelar and Hurni (2006) and Avelar (2008) have investigated the design issues surrounding *schematic* PT maps which, as argued by Morrison (1996a), are not usually suited for the representation of bus networks. With respect to SSBMs, the examples shown in Chapter 2 (Figures 2.9 to 2.12) suggest that there are a number of different approaches that could be adopted when designing SSBMs, but all have different outcomes, advantages and disadvantages.

Fortunately, Morrison (undated) has developed a specification (referred to hereafter as 'the specification') outlining a software system for the automatic generation of SSBMs. The earliest version of the specification was composed by Morrison during a research contract with the (then) Science and Engineering Research Council in 1985-87 which aimed to produce software which would generate automated PT maps. Some working software resulted, written by the research assistant (Duncan Lissett), but it was of limited functionality.

Various additions were then made to the specification, and two abbreviated versions were prepared when the specification was submitted for publication in the International Journal of GIS in 1999 and in the Cartographic Journal in 2005. In both cases, the specification was split into two papers totalling about 19000 words with 20 figures. On both occasions the editors of each journal decided that it was not appropriate to publish a software specification as a journal article or articles, and so the specification remains under Morrison's IPR. (A. Morrison, 2010, *pers. comm.*) The version made available to this study is officially undated, but is contained in a computer file created in 2005, consisting of 16195 words over 24 pages, along with 21 colour diagrams.

The specification goes into a great amount of detail regarding the various stages required for *automatically* generating SSBMs, and this study will not implement the specification in full or in the original order intended, but will instead use the existing specification to guide the manual production of the SSBMs. There are some sections in the specification which are too computationally complex to be easily applied manually, whilst other sections will require some adaptation for this study. Other ideas and recommendations for the design of the SSBMs will be drawn from the above PTI design guidelines, and will be applied where appropriate.

4.3 Design Flowline for the Manual Design of Stop-Specific Bus Maps

The following sections outline the different stages and decision processes undertaken during the designing of the SSBMs. It must be reiterated here that this study is not attempting to undertake a detailed design exercise but to test the general SSBM concept, and as the specification is deliberately quite open in its nature, the procedure adopted for this study is merely one interpretation of the more detailed requirements discussed by the specification.

4.3.1 Define Map Dimensions and Background Attributes

One of the first stages outlined in the specification was to define the dimensions of both the paper to be used and the amount of space dedicated on the paper for the SSBM, should other information (timetables, fares etc.) be required. As the only feature to be designed and printed for this study was the SSBMs, it was decided to keep the process simple by working to an A4-sized (21.0 × 29.7 cm) design which would reduce any potential printing problems that could occur when using non-standard paper sizes. However, it must be noted that this amount of space may not be available within bus stop display cases, especially those with only a flagpole and single display case, so future SSBMs may require redesigns to account for the reduction in available space.

An A4 map layout was created with a title frame of 19.5 × 3.0 cm and a map frame of 19.5 × 24.75 cm. Morrison (1996a) discusses the various possibilities for selecting a suitable background colour; the specification default was a light grey. However, as a grey background would essentially rule out using greys for linear features such as the service groups and other features which are often associated with grey (such as roads and railways), it was decided to use a very light colour instead, as recommended by Higgins and Koppa (1999), Denmark (2000), and Scrimgeour and Forrest (2008). The eventual background colour selected for the map was a very pale yellow (CMYK: 0/0/7/0) as this gave the subtle impression of a background whilst not causing any colour conflict except with white and yellow, which could be solved by employing a dark casing around any lines of these colours.

4.3.2 Define Extent of Data to be Exported

While the data was displayed in the Layout View of ArcMap 9.2, the scale of the map was altered and the view of the data repositioned until the location of the bus stop and the forward-portions of all calling services were contained within the data frame (Figure 4.1) After this initial overview was established, the specification required a decision to be made regarding the overall extent of these forward-portions. Depending on the number of calling services and the geographic extent of their forward-portions, there is the potential for longer distance services to extend far beyond the general service area of the majority of services (e.g. the dark blue route in Figure 4.1) which, if left unattended, could grossly distort the map and thus reduce the overall legibility.

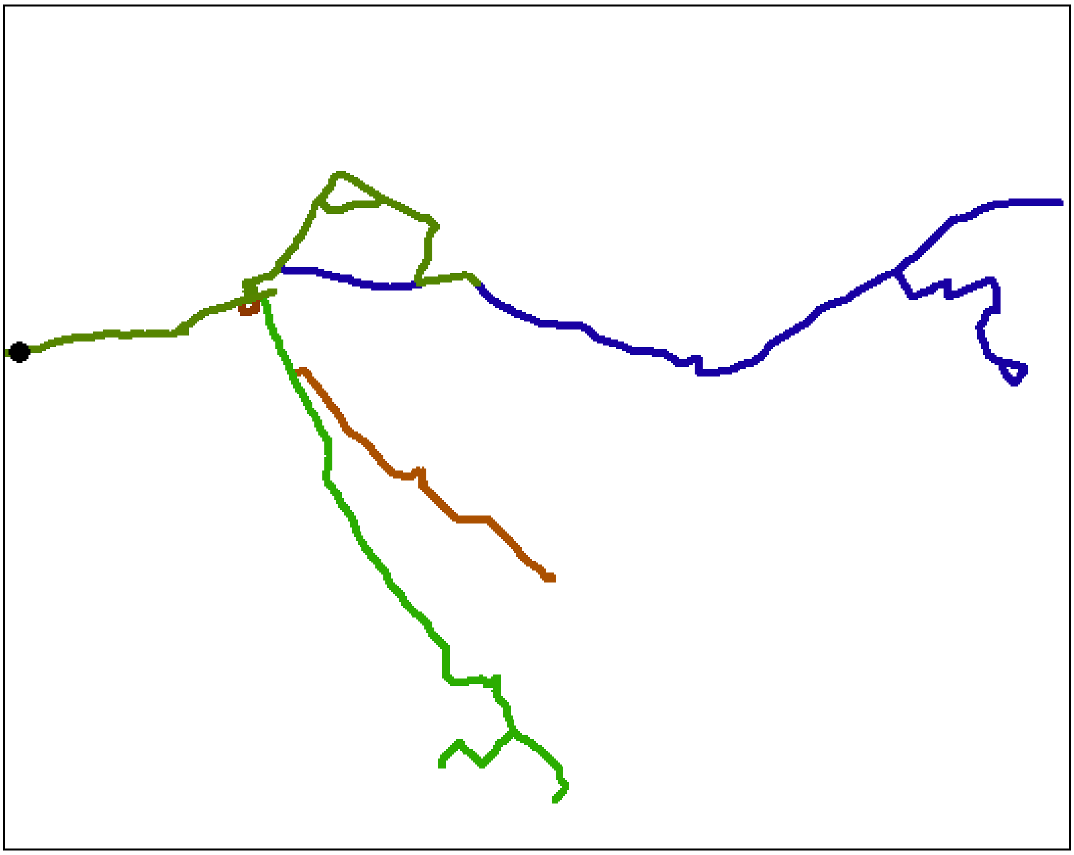


Figure 4.1: Initial extent of the forward-portions of calling services for a bus stop in Edinburgh. The black dot indicates the location of the stop for which the SSBM would eventually be designed. All roads, railways and rivers have been removed for clarity.

It would not be sensible to allow for the clarity of the majority of services to suffer because of peripheral sections of the minority of services which are essentially 'geospatial outliers'. One solution to this issue would be to adopt a scale factor that progressively reduces the scale as the distance from the bus stop increases, as applied to 'Octobus' maps (Morrison, 1996b), but this requires implementing mathematical procedures, rubber sheet distortions and a translation of co-ordinate systems, all of which are not possible in CorelDraw 9, and still may not produce a satisfactory result depending on the overall scale distortion factor required.

The alternative solution proposed in the specification was more achievable in the manual production of SSBMs. This solution required any sections of route which extend far beyond the general service area to be highlighted, and then truncated at an appropriate point, adding a note in the margin to indicate the eventual terminus point and, where possible, a number of intermediate points (Figure 4.2).

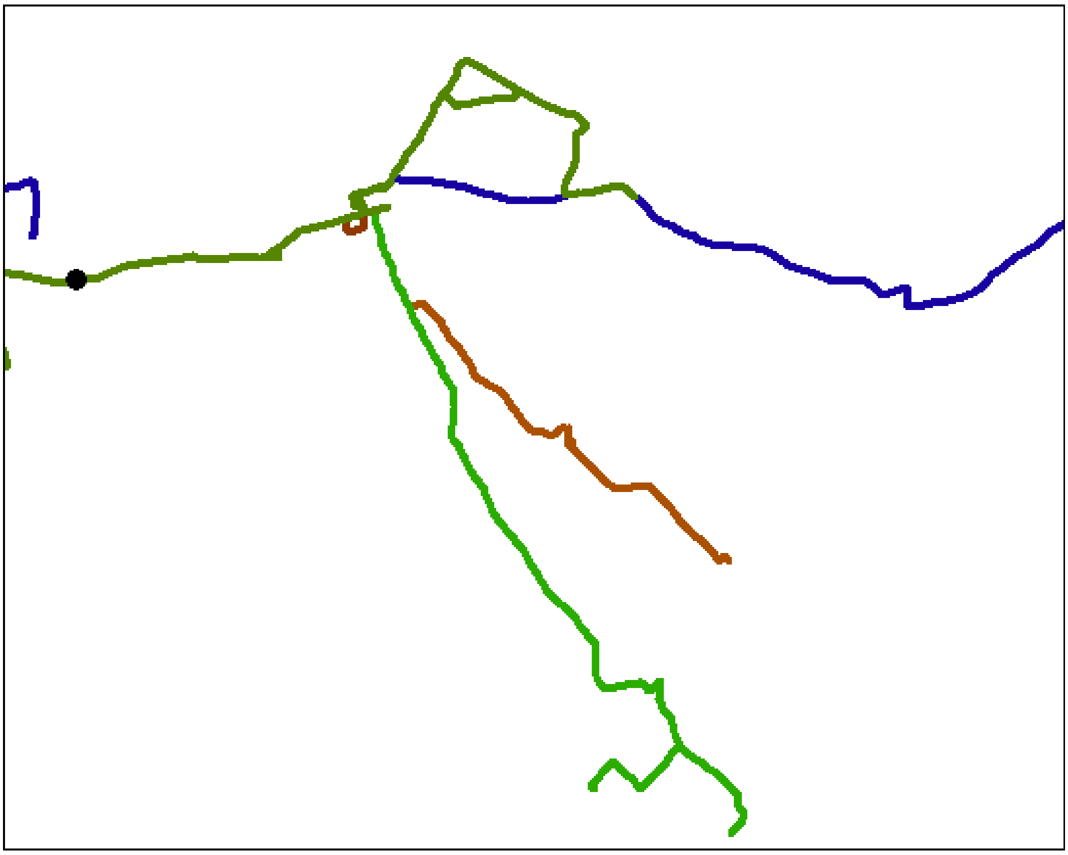


Figure 4.2: Revised extent of forward-portions of calling services, removing outlying sections of routes. Again, roads, railways and rivers have been removed for clarity.

This truncation procedure was implemented by visually inspecting the geographic extent of the forward-portions of all calling services and then rescaling and repositioning the map within the data frame to cut-off the outlying sections of a few routes until a suitable display was achieved. This allowed for the majority of the forward-portions of all calling services to be clearly represented on the map without a great loss of overall detail.

4.3.3 Alignment of Data in Map Frame

The data was imported, aligned and rotated to fit within the map frame so that the general directionality of the services ran up the map, following the 'forward-up equivalence' of Levine (1982). If a rotation was required, the degree of rotation was noted to allow for the correct orientation of a North arrow in due course.

4.3.4 Define Service Groups

One of the key aspects of the SSBM concept is the use of groups of services to simplify the amount of information presented to the user, so the initial task that must be completed is the assignment of each service to a particular group. The specification outlines a detailed algorithm for assigning individual services to groups based upon their 'similarity' scores which are derived from the proportion of common route with other services, times of operation, the operating company and general direction of operation. The overall grouping procedure is similar to a cluster analysis but it was felt that it was perhaps too mathematically complex to be applied on a manual basis, especially where there were upwards of 15 services to be compared against each other for some SSBMs.

As there were only a limited number of SSBMs to be produced in this study, the grouping procedure was achieved by sketching out the approximate route of each service, noting the eventual terminus and sections of common route. From this, it was possible to develop a list of potential service groups primarily based upon the proportions of common route, but also by considering the general directionality and eventual terminus of each service. The specification states that the maximum number of groups on an individual SSBM is nine, although ideally between two and five groups should be used. When compiling the list of groups, an attempt was made to restrict the maximum number of service groups to five, six if necessary. Each service group was then inspected and some services were subsequently reassigned to a different group to prevent one group having a disproportionally large number of services assigned to it.

Where possible, services provided by different operators were assigned to separate groups, but one feature that affected this decision was where smaller operators 'mirrored' the routes of the larger, dominant operator in an area. If each operator's service was to be represented individually, there would be two parallel lines throughout, the only observed difference possibly being the terminus of each operator's individual service. However, one of the primary reasons for the grouping procedure is to keep the number of individual lines on a SSBM to a minimum, and so representing each operator's service in a mirroring situation would result in needless duplication. The specification accounts for this by introducing a factor of 0.90 to the 'similarity' scores of each individual route where there are different operators, so when there is more than one operator, the proportion of overlapping route needs to be a little greater than if there was just a single operator.

If the overlap was 100% (as found in route mirroring) then the services of each operator would fall in the same group, so it was decided that where appropriate, services of different operators which followed identical routes would be grouped together, and distinguished by a suitable prefix to the service number labels. Services provided by different operators were also grouped together as it was decided that a 'service 24' provided by company X would be easily distinguishable from company Y's 'service 158', and unless a passenger was in possession of a company-specific ticket or pass, the actual operator of a service was perhaps incidental to the passenger.

4.3.5 Create Parallel Lines for Adjacent Service Groups

One cartographic design complication identified in the specification is concerned with the production of multiple parallel lines, particularly along sinuous sections and where adjacent lines turn through angles between 90^o and 180^o. Few software packages appear to deal with this issue; the specification identifies that only a handful of packages actually accommodate multiple parallel lines, such as Bentley's Microstation, Caliper's TransCAD (Figure 4.3) and its predecessor GisPlus, but none appear to do so satisfactorily.

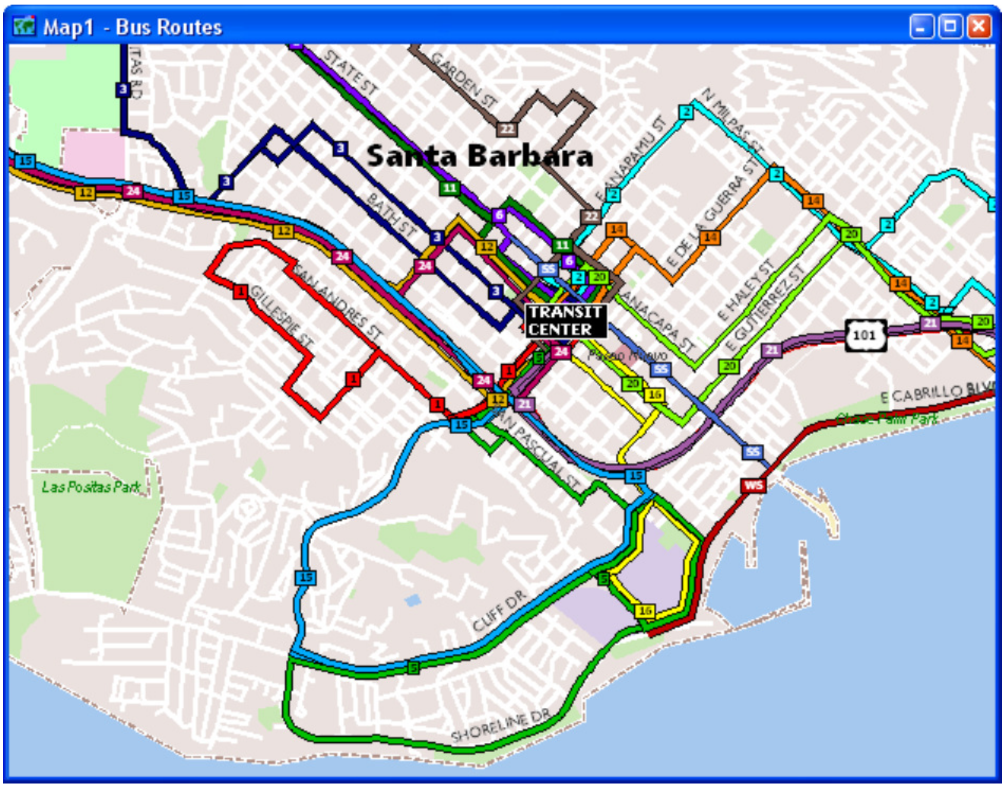


Figure 4.3: Screenshot of Multiple Parallel Lines in TransCAD 5.0 (© Caliper, 2008).

Note that in Figure 4.3, whilst the majority of adjacent parallel lines are placed accurately, there are some instances (particularly when services join or split from common sections of route) where parallel lines do not lie neatly next to each other, but instead overlap one another. It was found that the Contour tool in CorelDraw 9 could be applied to assist with the generation of very satisfactory multiple parallel lines, including along sections of common route with sharp bends and even complete loops (see generic examples in Figure 4.4). Although some post-Contour editing was required to assign different portions of the final parallel lines to the corresponding service group, this technique proved to be much more efficient than offsetting, once fully mastered. The full procedure is described in Appendix C.

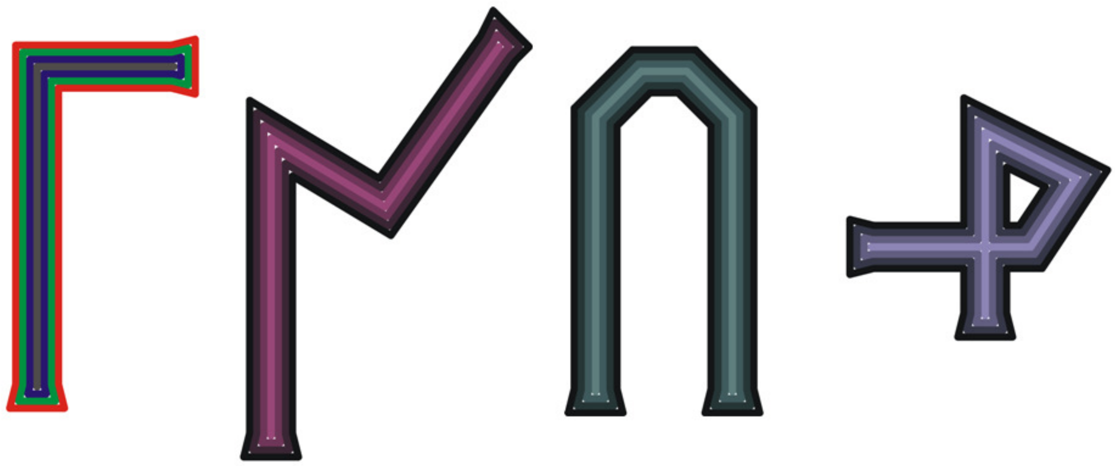


Figure 4.4: Examples of the Parallel Line Output from the Contour Function in CorelDraw 9.

The Contour tool required a line width to be specified in order to set the various parameters. The specification identifies the need to use a line width that allows colour to be employed so that individual groups are distinguishable from one another (minimum line width = 1mm), but without obscuring other details on the map. The widest part of all services shown on the SSBM is usually the ‘trunk’, corresponding to the section of route immediately after the stop in question, along which all service groups will normally operate. To avoid this trunk section appearing too wide on the map, thus visually dominating the final SSBM, the specification proposes a default maximum line width of 1.5mm. Therefore if five groups are required, the main trunk will have a maximum width of 7.5mm and should not appear too dominant on the map.

The default line width of 1.5mm was used in the paralleling process, but one additional feature identified in the specification was the use of a hierarchy of line widths to represent relative service frequencies in each service group. Whilst not fully implementing the recommendations of the specification, where there was a clear need to distinguish between frequent services and infrequent services (those which only operated once per day or even less frequently), a separate line width of 1.0mm was used for the infrequent services.

Once the paralleling process was completed, a large red arrow was positioned to cover the base of the trunk of service and was accompanied with the words ‘You Are Here’ (in Arial 10pt Bold, Red). The arrow served two functions: to indicate the user’s current position on the map, and to show that the general direction of travel was up the map.

4.3.6 Assign Colour for each Service Group

The use of colour is essential in PT mapping as “colour has been shown to be a valuable aid for locating and distinguishing items on display, particularly as the number of items increases” (Higgins and Koppa, 1999, p.22) but it must be applied carefully as “…the wrong choice or combinations of colours can make reading or understanding [maps] difficult, if not impossible” (Denmark, 2000, p.19). Therefore, the careful use of colour is essential for a successful SSBM and the specification identifies that nine is the maximum number of individual colours that can clearly be distinguished from each other when printed as thin lines (as often found on PT maps).

One key difference between PT maps (and associated information) and other cartographic output is the use of colour for branding and route identity (Higgins and Koppa, 1999; Denmark, 2000; Webster, 2008). In PT systems, individual services are sometimes assigned a specific colour which is then used throughout the system, especially on maps but also on corresponding timetables and on directional signage, which Scrimgeour and Forrest (2008) found to be important: “Colour co-ordination of individual and network maps (and vehicle livery if possible) should be encouraged to establish a route’s identity in the mind of the user” (p.126) and this colour scheme must be used throughout the system “… in a consistent way otherwise it will lose its effectiveness” (Denmark, 2000, p.20).

Colour is sometimes used in the actual name of a service (e.g. the 'Red Line') and First Group's 'Overground' networks usually designate each high-frequency service with a colour which then is used on the corresponding schematic network map and associated timetables (Helm, 2009). The problem here is that most bus networks have more than nine services. When attempting to assign each service with a unique colour, once the standard colours (red, blue, green etc.) have been exhausted there is a reliance on the more exotic colours (lime green, turquoise, beige etc.), some of which can be difficult to distinguish from the standard colours.

The specification identifies that where a colour is associated with a specific service, it should be considered in the overall decision process of assigning a colour to each service group. If there are not more than nine services on a SSBM, then each service can effectively become a group in its own right, and is therefore assigned the colour associated with that service (where such a colour association exists). However, if there are more than nine services then they have to be grouped as discussed above, but then the association of colour to each group becomes problematic.

Where a service group contains two or more individual services, each having its own associated colour, it is impossible to maintain a one-to-one association between every service and its respective colour. The specification recommends that in these situations, any associations should be ignored and this approach will be used where possible, selecting colours in such a way as to maximise the contrast between adjacent lines, as suggested by Higgins and Koppa (1999, p.24): "Colours used for route coding should be easily distinguishable from one another and should stand out against the background of the map." However, all previous PTI design guidelines (Higgins and Koppa, 1999; Denmark, 2000; Cain, 2008) state the importance of attempting to provide the consistency between the colours used across all PTI, so it was felt that the application of associative colours (i.e. using the colours assigned to each service on the respective PTI) was desirable, although as the specification identifies, this was not always feasible. Therefore, one additional solution to this problem which was also considered during the design of the SSBMs was assigning each group with the colour of the service that can be considered as the 'dominant' service of that particular group. The dominant service was defined as the service which had the greatest proportion of common route with all other services in the group, which was usually a service provided by the larger operator within an area.

When assigning colours, it transpired that the choice of colours for groups of routes sometimes varied for each SSBM as each stop has a different set of routes, or the same set of routes but overlapping in different proportions. The result of this allocation process was that there was some variation in the individual set of colours used on specific SSBMs, which may affect the relative readability of each map and therefore have an impact on the testing of these maps. To minimise any influence of the variety of colours used on each individual SSBM, the same palette of colours was used throughout the suite of SSBMs (i.e. every red line on the SSBMs would be represented by the same red colour and so on). The use of light, pastel colours was avoided unless absolutely necessary, such as when the associated colour required such a colour to be used, for example, First Group 'service 40' in Glasgow, which is assigned yellow on the Overground maps. In these circumstances, a dark casing can be applied to assist with maximising the contrast against the background and other lines on the SSBM.

4.3.7 Define the Road Network to be Shown

To provide useful location information to the user, it was important not only to show the road links followed by the route of each individual bus service, but also to represent those roads not served by the bus services, because such roads act as important landmarks (Scrimgeour and Forrest, 2008). The specification identifies three possible types of road on a SSBM:

1. Bus road – followed by at least one bus service on the current SSBM
2. Non-bus road – does not have any bus services
3. Non-bus road (current map) – a road which does have bus services, none of which operate from the particular stop in question.

For simplicity, it was decided to only consider a two-way distinction between the roads shown on the SSBMs. All 'bus roads' naturally had to be shown, but instead of having to distinguish between 'non-bus roads' and 'non-bus roads (current map)', all major roads exported onto the map were initially shown. Two separate layers were used: one for the Motorways, while the other combined the A-Roads and B-Roads into a single roads layer. These layers were subsequently edited to show all major thoroughfares which were in close proximity to the bus routes and some well-known roads that were not in close proximity to the bus routes (such as the A720 City of Edinburgh Bypass) were also maintained as geographical references and for orientation purposes. After the main road layers had been edited, any minor roads that acted as useful connecting links between different service groups were added to the A-Roads/B-Roads layer.

The default line width of 1.5mm was also used for representing the main roads. The Motorways were represented by a solid dark blue line (with accompanying road number labels to ensure they were not misinterpreted as a bus service group), whilst the A-Roads and B-Roads were represented by a cased white line, consisting of a 1.25mm white line on a 1.5mm 40% grey line.

4.3.8 Selecting Bus Stops and Other Point Features

Once all the bus services and major roads were in place, the next stage of the design process was to place point symbols to depict the terminus of each service, bus stops and other important locations *en route* which would assist users when tracing the route of each service on the map. As discussed in Chapter 1, the spatial distribution of bus stops in an area is such that attempting to represent every individual bus stop on a Network Map is often impossible to achieve successfully. Instead, Network Maps tend to show a combination of well-known localities, roads and landmarks, all of which have associated bus stops, to help users visualise the route taken by each service (Figure 4.5).

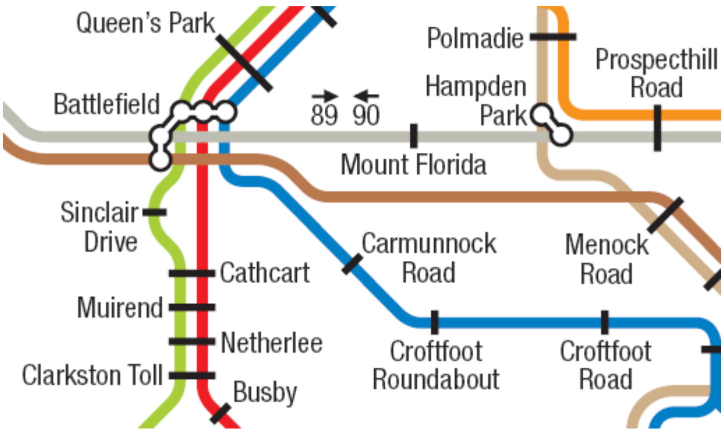


Figure 4.5: Extract from First Glasgow's 'Overground' Network Map, showing the variety of places shown, including localities (e.g. Cathcart), roads (e.g. Croftfoot Road) and landmarks (e.g. Hampden Park).

The problem of representing individual bus stops is further compounded by the fact that in most British cities, many bus stops do not have names that are a) clearly defined, b) familiar to the typical passenger and c) displayed prominently on the stop in a position which can assist those on-board to identify or confirm their current location, which is in stark comparison to the practices found in some mainland European cities (Morrison, undated).

The inclusion of termini was mandatory and took highest priority of all point features used to represent bus stops. For the remaining bus stops, the specification outlined a hierarchy of potential points which could be used to depict significant places along each route, which was used to assist the selection of key bus stops and landmarks. The specification gives priority to places which are well-known and easy to define, such as named road junctions and recognisable public buildings, eventually working down the list to unnamed bus stops. However, the Literature Review identified the practice of designating a number of well known bus stops along a route as 'timing points'. By only listing the departure times of each service from these timing points, the amount of information presented on a matrix timetable is more manageable for the user (Denmark, 2000). To allow the information presented on a SSBM to be easily related to the corresponding timetables, it was decided that the highest priority for placing *en route* point symbols would go to these timing point bus stops, followed by additional key places along each route, as defined in the specification.

Upon experimenting with using the different methods of representing bus stops, it was found that neither ticks nor bars (Figure 4.5) were completely suitable for geographically true SSBMs as the service group lines are not drawn at a standard set of angles, such as the 0^{o}, 45^{o} and 90^{o} lines typically found on most schematic maps. It was difficult to correctly orientate individual symbols so that each one appeared to be perpendicular to the lines of each service group. The non-standard angles of these lines also meant that when the perpendicular bars were drawn, the different angles required for each individual stop produced a SSBM that looked confused and untidy, and in some instances it was difficult to clearly label individual stops in close proximity to one another.

Therefore the alternative option that was adopted was the use of dots (Figure 4.6), and two solutions were considered. The first used individual dots (stop A in Figure 4.6) which were given the same diameter as the line width used for the service groups, which allowed them to be placed directly on top of each individual line so they did not overly disrupt the flow of the lines. The second solution was a development of the individual points, using a single 'lozenge' shape (stop B in Figure 4.6) for each stop, the length of which varied according to the number of service group lines at each particular stop.

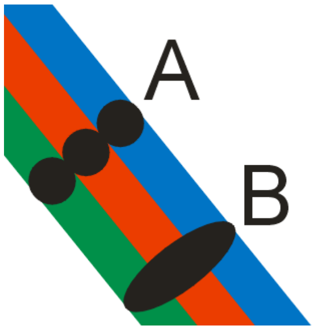


Figure 4.6: Different bus stop symbols used on the Stop-Specific Bus Maps: stop A utilises individual dots whilst stop B utilises a lozenge.

The advantage of the lozenge shape was that it reduced the amount of time required to position each individual circle in a straight line, and each lozenge could be rotated at an angle slightly off the perpendicular, to allow for clearer labelling of individual stops. One disadvantage of using the lozenges was that it suggested all services shown operating along a particular section of road would call at the each bus stop shown. There are some instances where services (e.g. limited-stop, express services) pass-by a stop, and in such circumstances the use of dots would perhaps be more appropriate, although this would also have implications for the assignment of services to each group. If such a distinction was necessary, this situation could be addressed by the use of two separate lozenges, with an accompanying textual note to confirm the calling services, if space permitted.

The specification requires the terminus of each service to be clearly indicated on the SSBM, as the name of the terminus is often the only textual information displayed on the vehicle. This allows the user to identify if a particular bus is travelling in the right direction and towards the correct terminus where the service branches to two or more terminating points. However, some bus stops are the terminus of one service and an intermediate point on others, so it was important that the symbol used to represent the termini was not too different from the symbol used to represent the intermediate bus stops (Figure 4.7).

Therefore, the standard bus stop symbol was adapted slightly by increasing the size of the symbol and adding a white fill which meant that the two symbols were compatible, allowing the terminus symbol to be placed adjacent to the standard bus stop symbol if required (Figure 4.7).

Figure 4.7: Extract of a SSBM showing the different symbols used for the termini and standard bus stops, and how the two are compatible.

After the termini had been placed, the final selection of the intermediate stops followed an iterative procedure. First, all the timing points were positioned on the map to identify any locations where the general density and frequency of these stops was either too dense or too sparse. If they were too dense, then alternate timing points were removed, or (where possible) two consecutive timing points were replaced by a single point representing a non-timing point stop located midway between the two original timing points, and the appropriate bus stop name assigned to this new point. If the timing points were too sparse, then the full timetable was consulted and the stop hierarchy outlined in the specification was implemented, positioning additional stops on the map which represented bus stops which could be associated with other significant landmarks.

The key to the overall process was obtaining a suitable balance between the aesthetic quality of the SSBM and the amount of information provided. It was important not to overload the SSBMs with too many bus stops as this could potentially increase the overall search time required, but providing little information would clearly not be of great help to the user.

4.3.9 Placement of Text Features

After the final set of stops had been positioned on the map, the corresponding text for the bus stop names and the road labels could be positioned on the map. However, before the text was added it was important to consider which font should be used, given the multitude of fonts available to cartographers today.

Whilst the specification does not specifically mention a particular font, other guidelines advocate the use of sans serif typefaces for titles and labels, as these are easier to read at a distance and by the visually impaired (Higgins and Koppa, 1999; Denmark, 2000). A range of sans serif typefaces exist, but to maintain a degree of simplicity and consistency it was decided to use just one typeface throughout the SSBMs. Arial was chosen as it is one of the most common typefaces in use and has a number of variations, including Arial Narrow, which would prove useful when space was at a premium.

Perhaps the most important attribute to consider here is the type size, as the use of small type sizes is one of the most common complaints relating to PTI design amongst PT users (Cain, 2008), but space on a map face is limited and this usually has an impact on the type size that can be used. It could be argued that as SSBMs are going to be viewed outdoors in poorer lighting conditions, possibly at an intermediate viewing distance, the use of a larger type size would actually be desirable. The majority of guidelines for printed PTI (including maps) recommend a minimum type size of 10 point, but Cain (2008) does concede that it is often not possible to fit 10 point lettering into the limited space available on PT maps, and proposes a minimum type size of 8 point for sans serif typefaces.

The specification also provides a list of suitable type sizes, ranging from 1.3mm to 1.8mm depending on the level of contrast between the text and the background on which it is to be printed. Where possible, the general rule of not going below the minimum 8 point type size was adhered to, but there were some situations where this simply was not practical or feasible and smaller point sizes were required but never below 6 point type size. Although this is not a desirable feature, especially in low light, for those with poor eyesight or inappropriate reading glasses, it can be argued that timetable information often adopts small type sizes in order to accommodate the desired amount of information in the necessary format, all within the confines of the bus stop display cases. The following font specification (Table 4.1) was developed for the various text features on the SSBMs, based upon the above guidelines whilst working within the limitations of an A4-sized map. In certain instances where map space was extremely limited (such as city centre locations) some slight adaptations had to be made to the existing specification, which again may have an impact upon the relative readability of the specific section of the SSBM in question. However, the focus of this study was to test the SSBM concept, and future work could investigate the impact of different font sizes on the legibility of individual SSBMs.

Table 4.1: Initial Text Specification for the Stop-Specific Bus Maps

Text Feature	Font Used (Colour = Black, unless stated)
Map Title	
Primary	Arial 24pt Bold
Secondary	Arial 18pt Normal
Bus Stop ID Number (ATCO)	Arial 14pt Normal
Service Termini (on SSBM)	
Service Numbers	Arial 8pt Bold, Various Colours
Names	Arial 8pt Bold
Sub-names (e.g. 'Bus Station')	Arial 6pt Bold
Service Termini (off SSBM, in Margins)	
Service Numbers	Arial 8pt Bold Italic, Various Colours
Names	Arial 8pt Italic
Intermediate Points	Arial 6pt Italic
Intermediate Bus Stops	
Names	Arial 7pt Normal
Sub-names (e.g. 'Shopping Centre')	Arial 6pt Normal
Road Names	Arial Narrow 6pt Italic
Service Numbers	Arial Narrow 6pt Italic
Additional Information	
'You Are Here'	Arial 10pt Bold, Red/Black Casing
Localities	Arial Narrow 9pt Bold Italic, White/80%Grey Casing
Panels – Heading	Arial Narrow 7pt Bold Underlined
Panels – Body Text	Arial Narrow 6pt Normal
Hospitals	Arial Narrow 6pt Bold Italic, Red
Landmarks (Golf Courses, Parks etc.)	Arial Narrow 6pt Bold Italic, Moon Green
Rivers	Arial Narrow 8pt Italic, Ghost Green
Other Labels	Arial 6pt Italic
Legend	
Headings	Arial 12pt Normal
Body Text	Arial 9pt Normal
Disclaimer/Warning	Arial 7pt Normal

Placement of the text on the map face followed the standard cartographic procedures, such as relative positioning, avoiding conflict between features and not printing text over lines unless absolutely unavoidable. The specification outlines different ways of positioning text features and these were generally adhered to unless space was at a premium. It was found that the manual selection and placement of text along a path (such as the road names and river labels) was the most cumbersome and time consuming task. If an automated system were to be developed, the placement of text along paths would be one area where the benefits of automation would be most appreciated!

4.3.10 Additional Information and Finishing Touches

Once all the text had been correctly positioned, the final stage of the cartographic editing was the addition of the legend features, other information such as the date of printing and a North Arrow, which was rotated if necessary, based upon the degree of rotation applied to the imported data. When all the final details were complete, the finished A4 map was printed and also exported to a .pdf file as these are standalone files, independent of any particular operating system, and would avoid any issues with external printing if required.

After the SSBMs for the pilot study had been designed and checked, the next stage of the study was to undertake some user tests to identify any problems with the initial SSBM designs, and to determine suitable solutions. The following Chapter discusses the design of the user questionnaire and procedure adopted for testing the SSBMs with respondents in the actual bus stop environment.

4.4 Examples of the Stop-Specific Bus Maps

The 36 SSBMs used in the field tests can be found on the following pages, showing the variety in cartographic output created by using the design flowline outlined above.

0500CCITY097

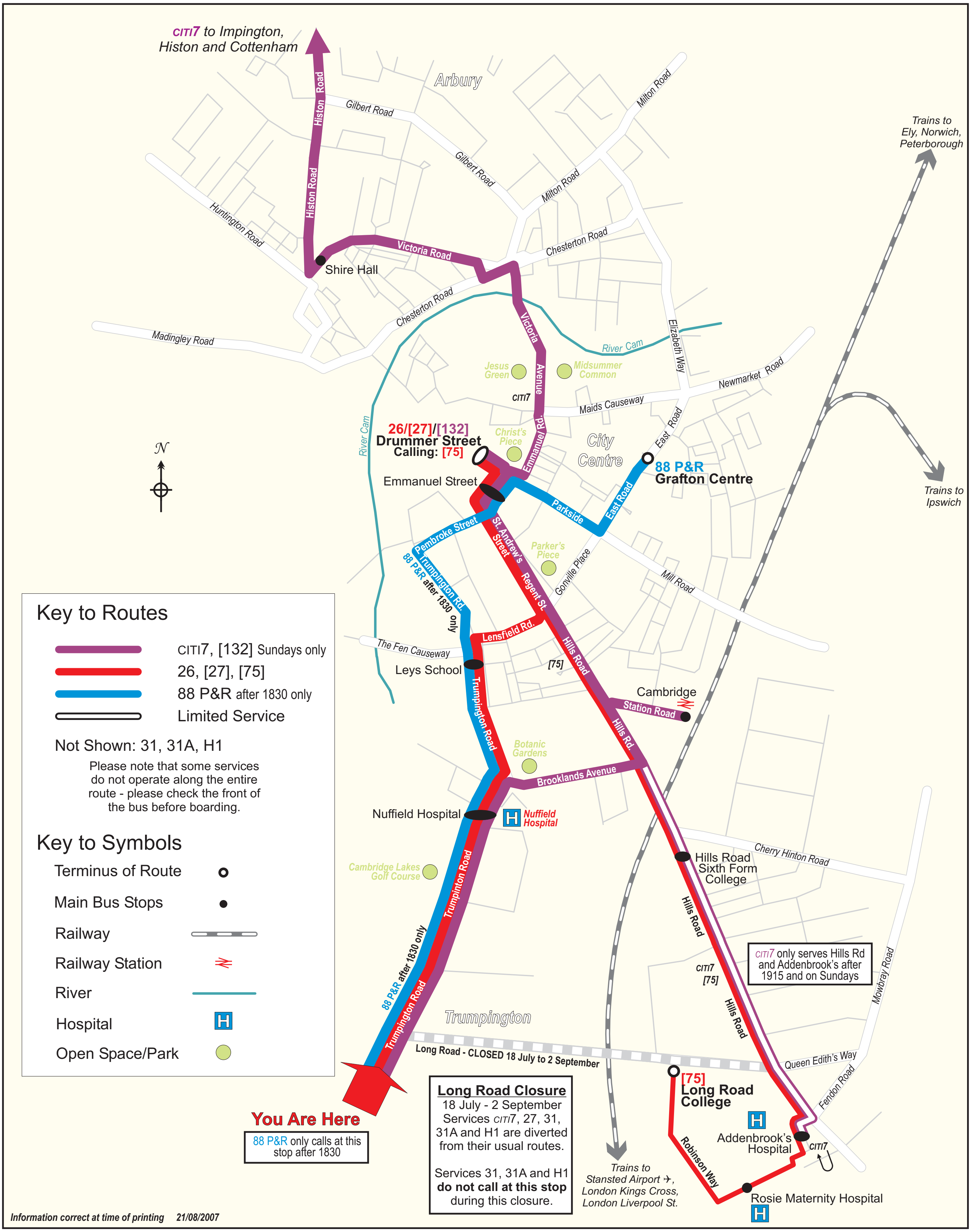
Buses from this Stop

Akeman Street, Histon Road, Chesterton

0500CCITY178

Buses from this Stop

Gazeley Road, High Street, Trumpington



0500CCITY283

Buses from this Stop

Queen's Meadow, Coldham Lane, Cherry Hinton

Key to Routes

16, 17

Please note that some services do not operate along the entire route - please check the front of the bus before boarding.

Key to Symbols

Terminus of Route

Main Bus Stops

Railway

River

Hospital

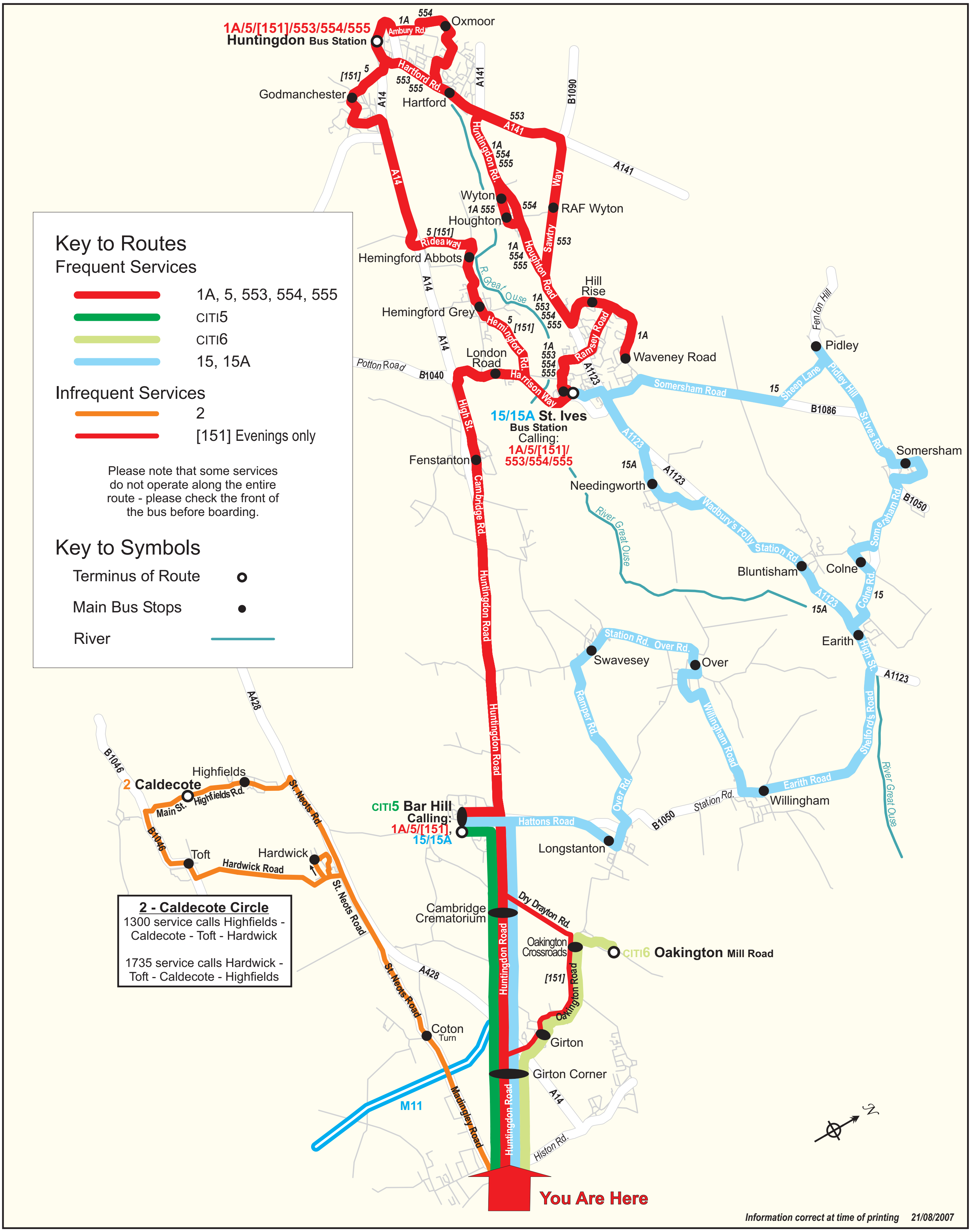
Open Space/Park

Information correct at time of printing 21/08/2007

0500CCITY401

Buses from this Stop

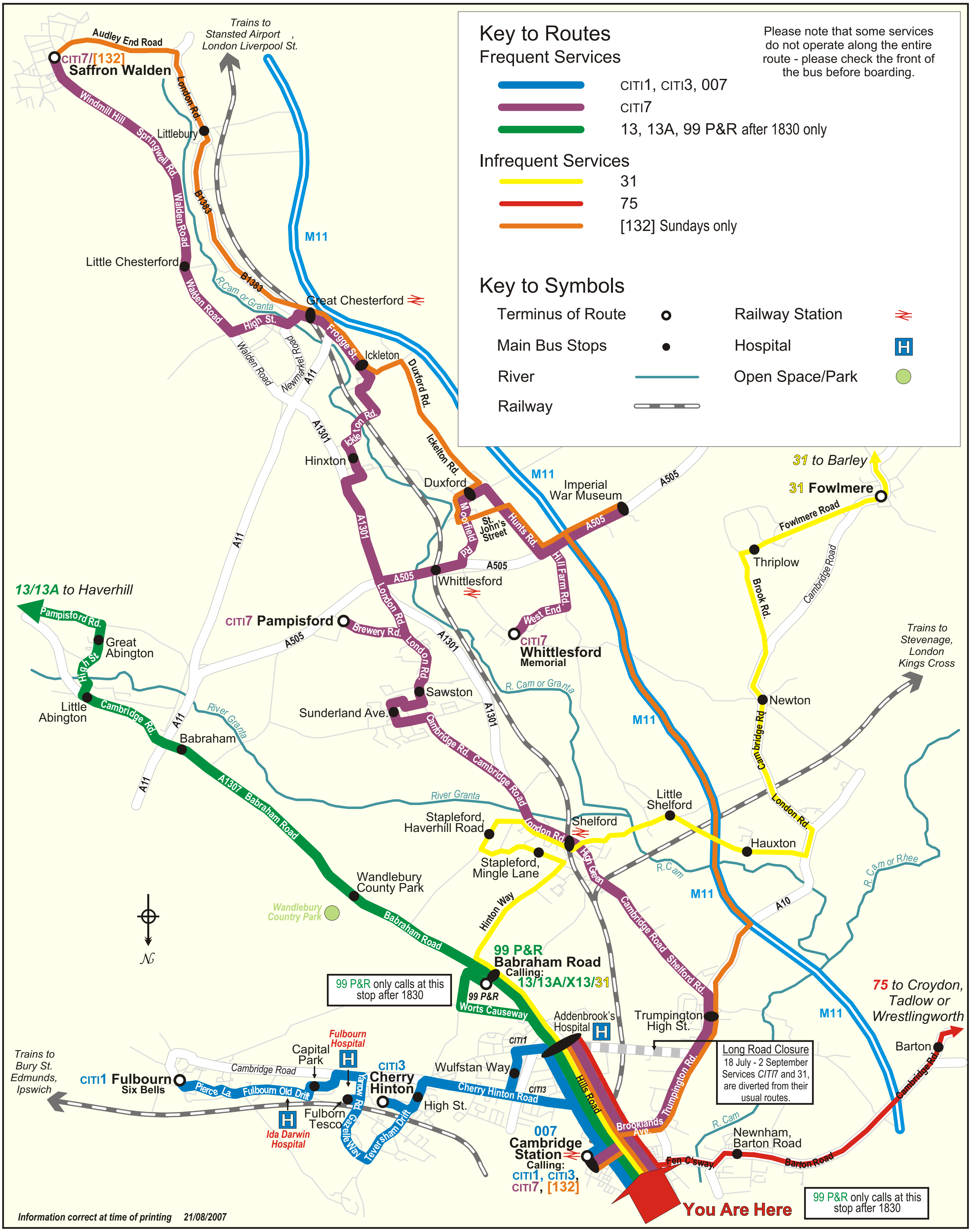
Castle Street, opp Shire Hall



0500CCITY245

Buses from this Stop

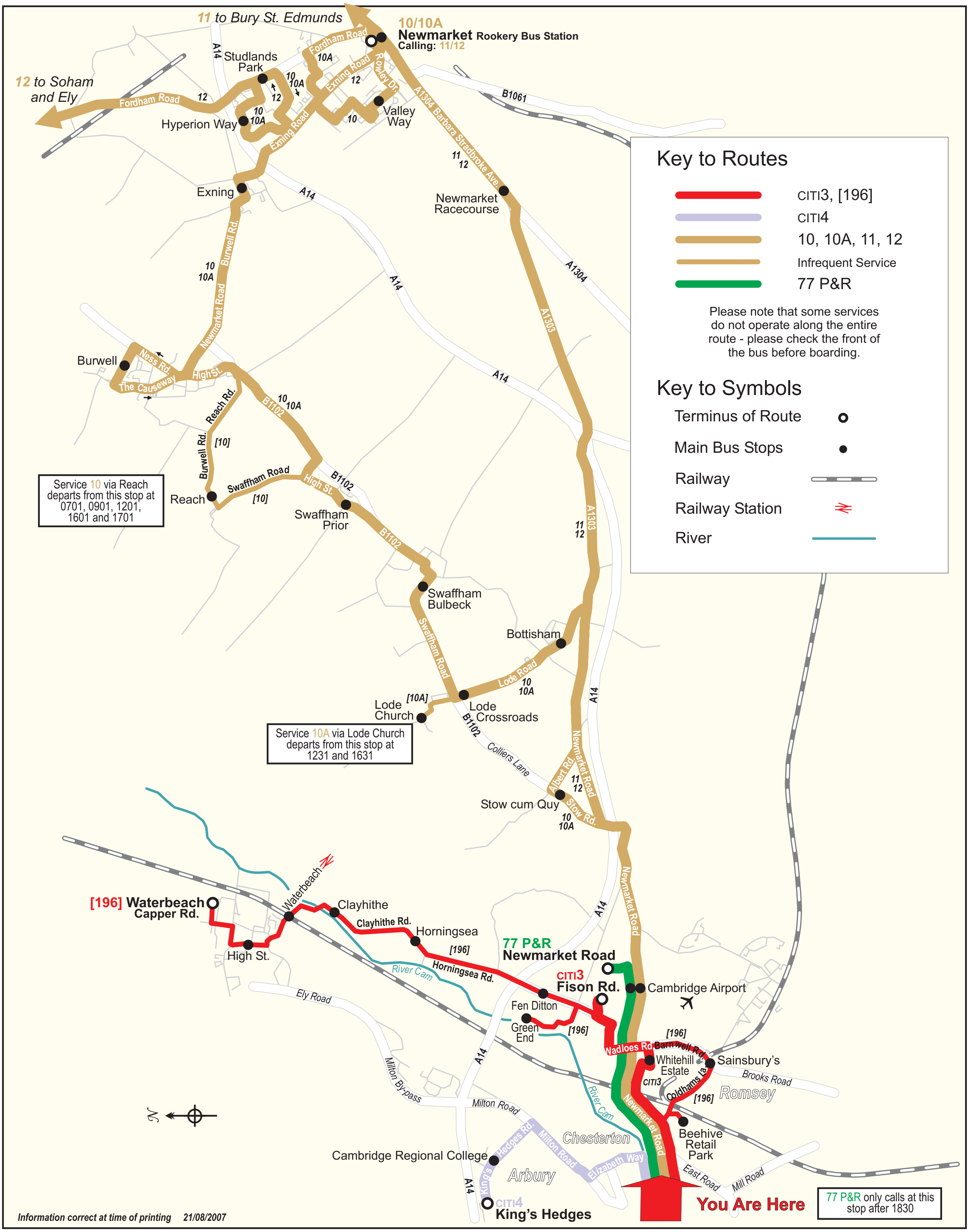
St. Paul's Road, Hills Road



0500CCITY104

Buses from this Stop

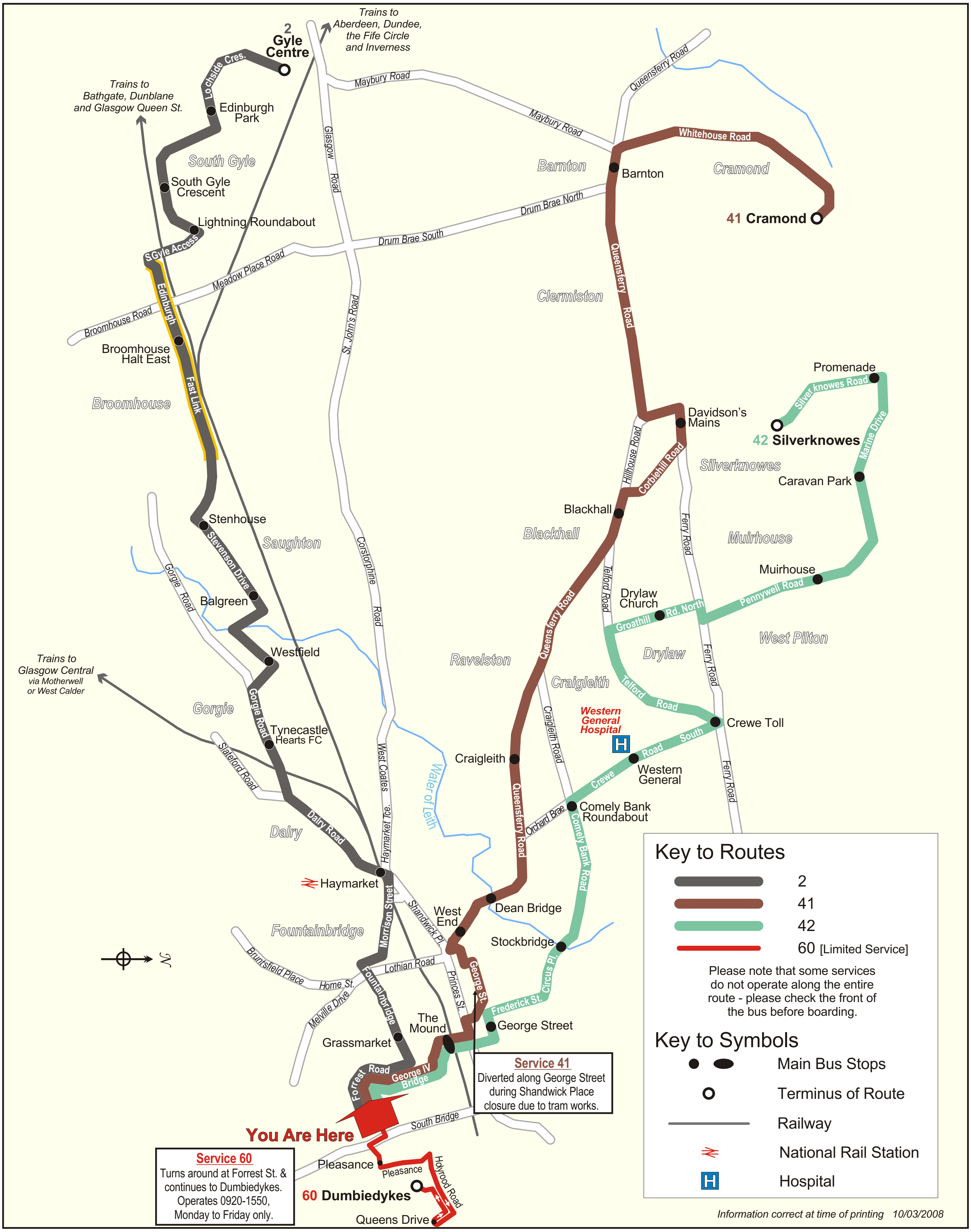
Victoria Avenue, Maids Causeway



6200243270

Buses from this Stop

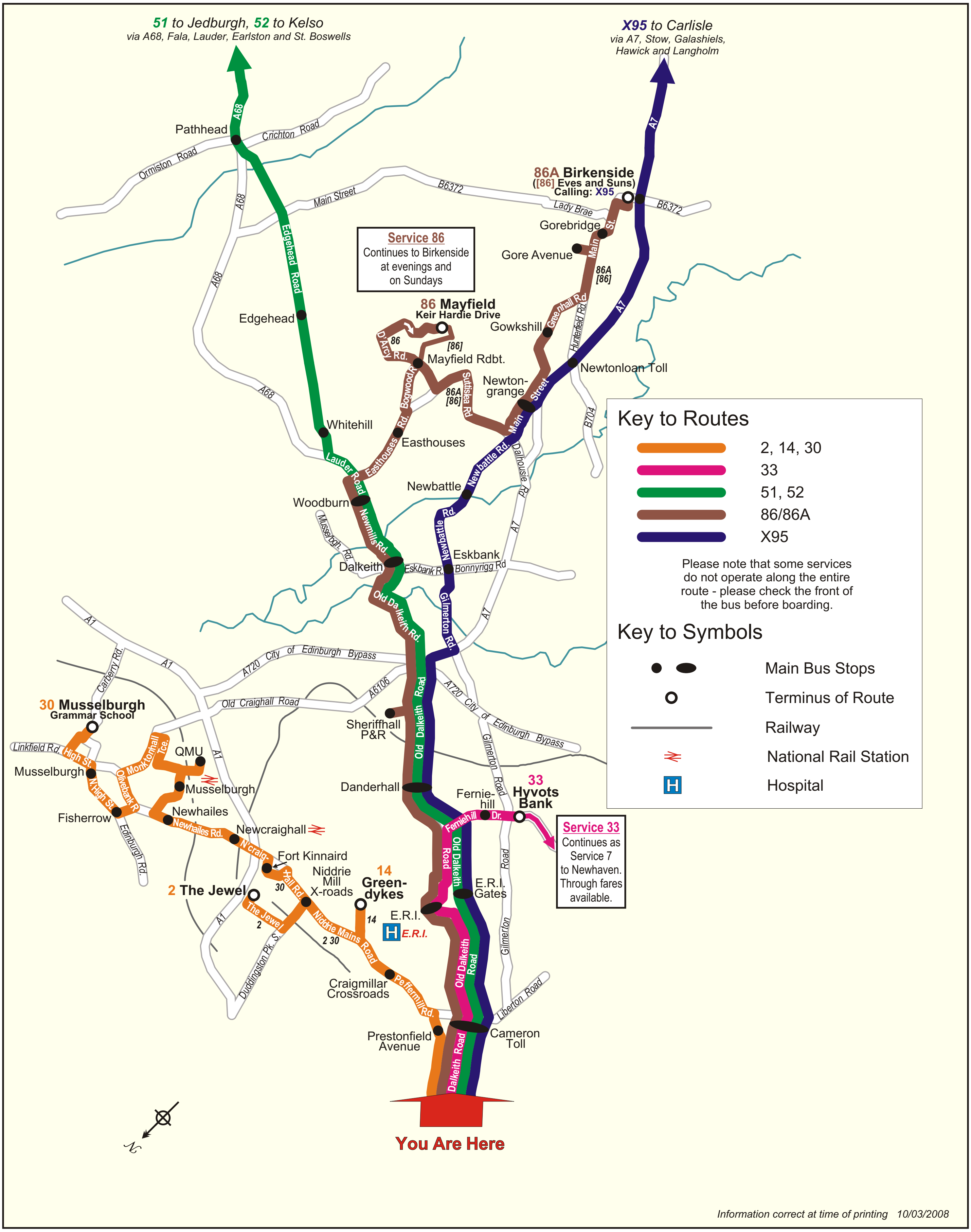
Lothian Street, Bristo Square (Edinburgh University)



6200208830

Buses from this Stop

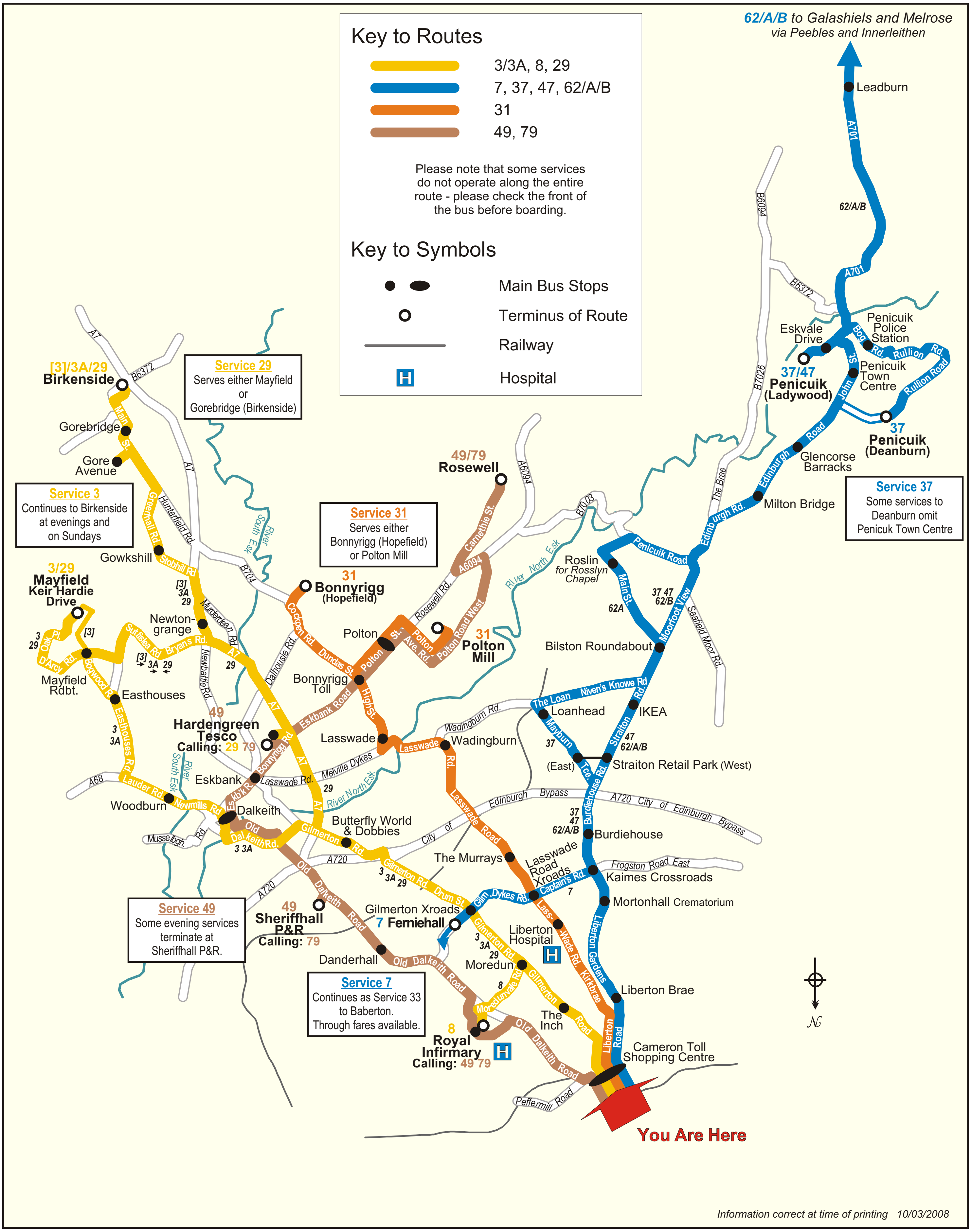
Newington, Dalkeith Road at Commonwealth Pool



6200208700

Buses from this Stop

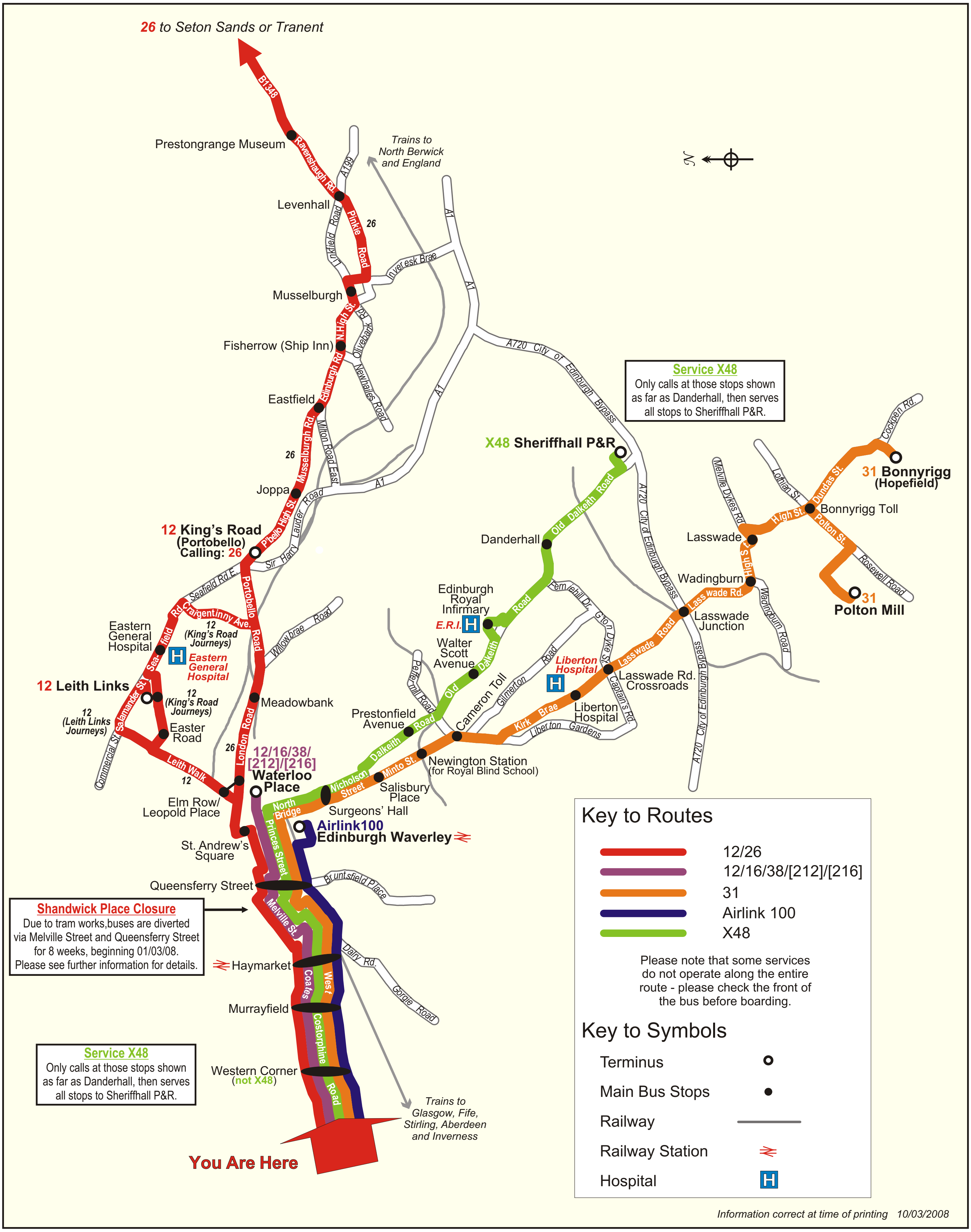
Craigmillar Park at East Suffolk Road



6200202800

Buses from this Stop

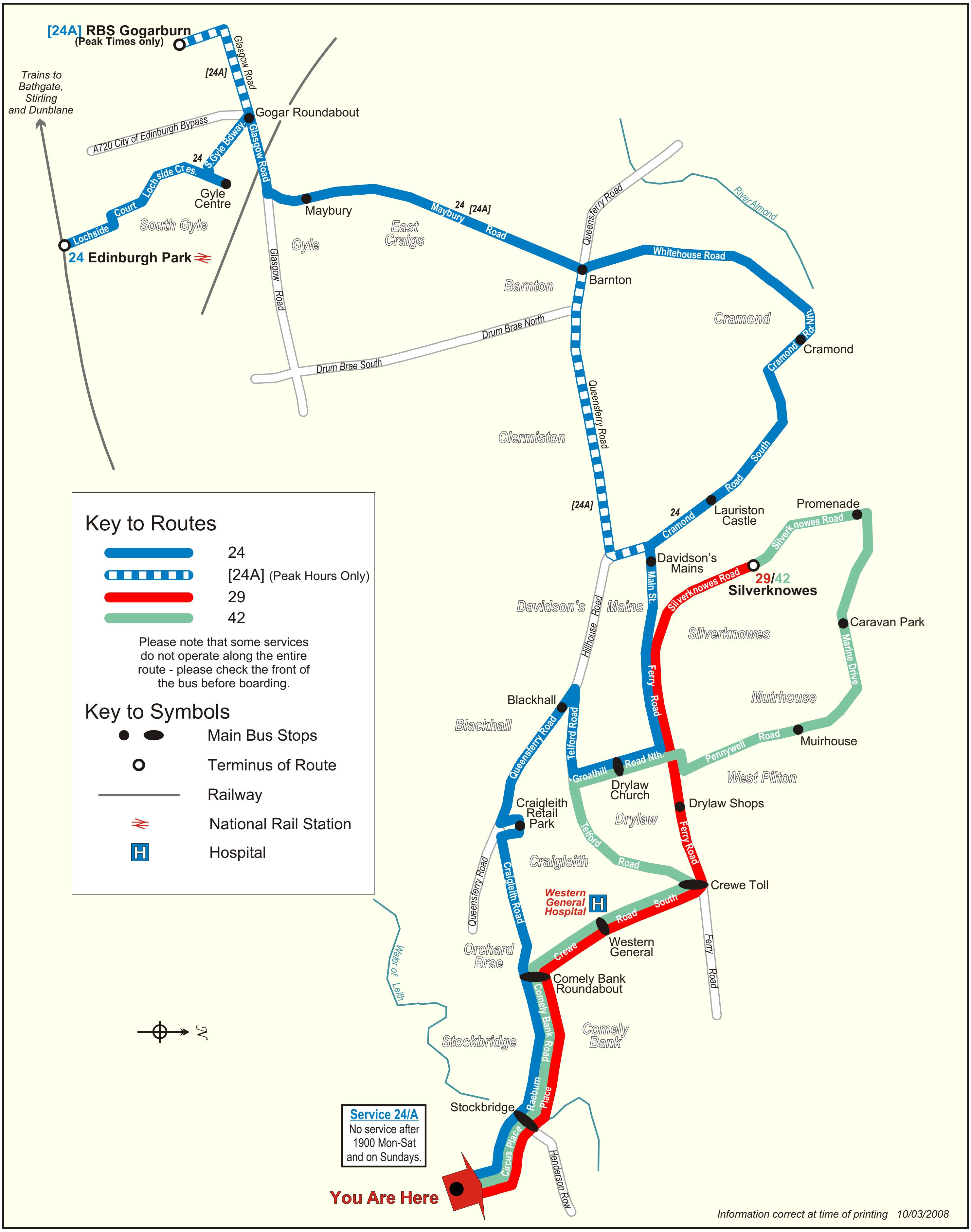
Edinburgh Zoo, Costorphine Road



6200244670

Buses from this Stop

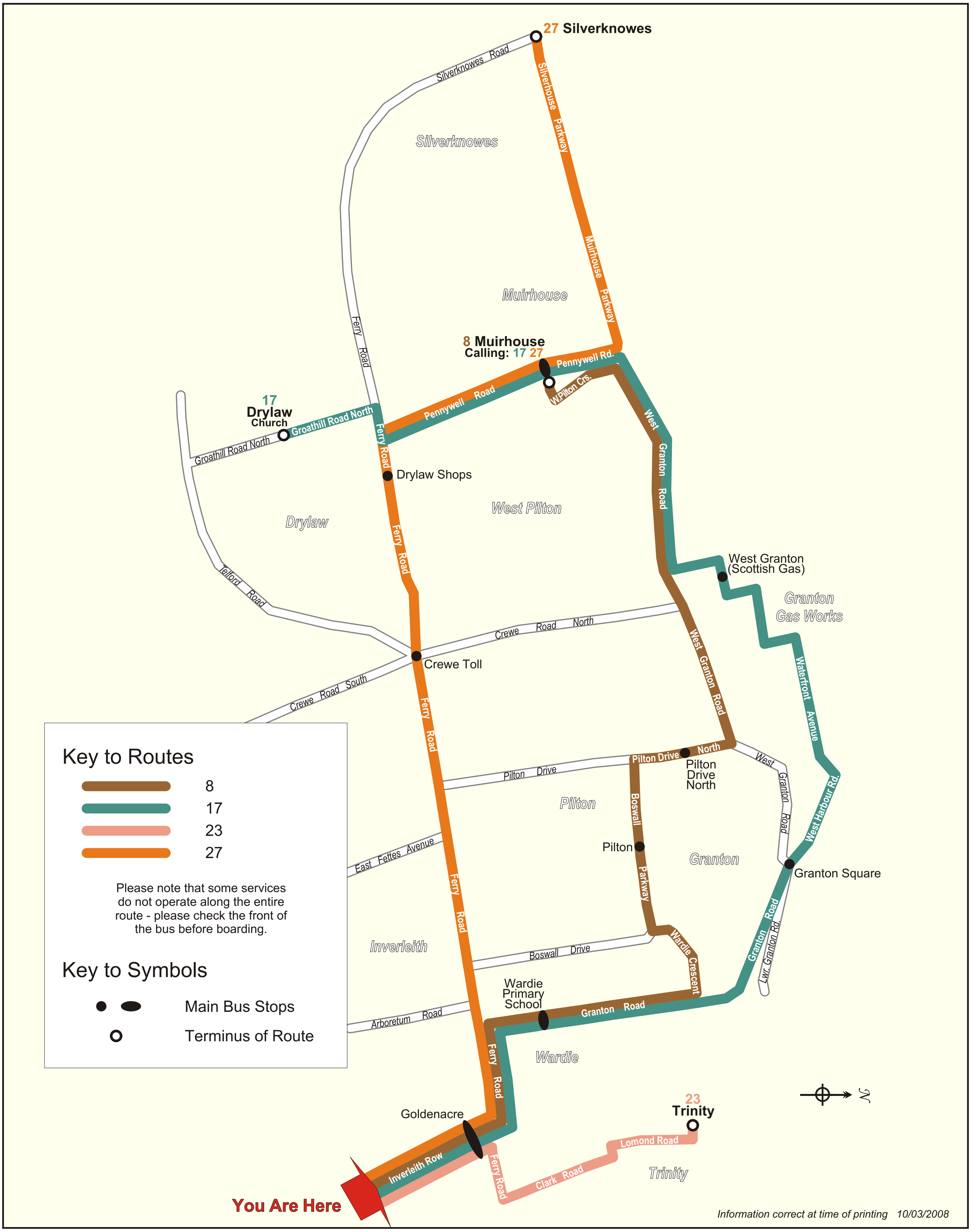
Frederick Street at Hill Street



6200244890

Buses from this Stop

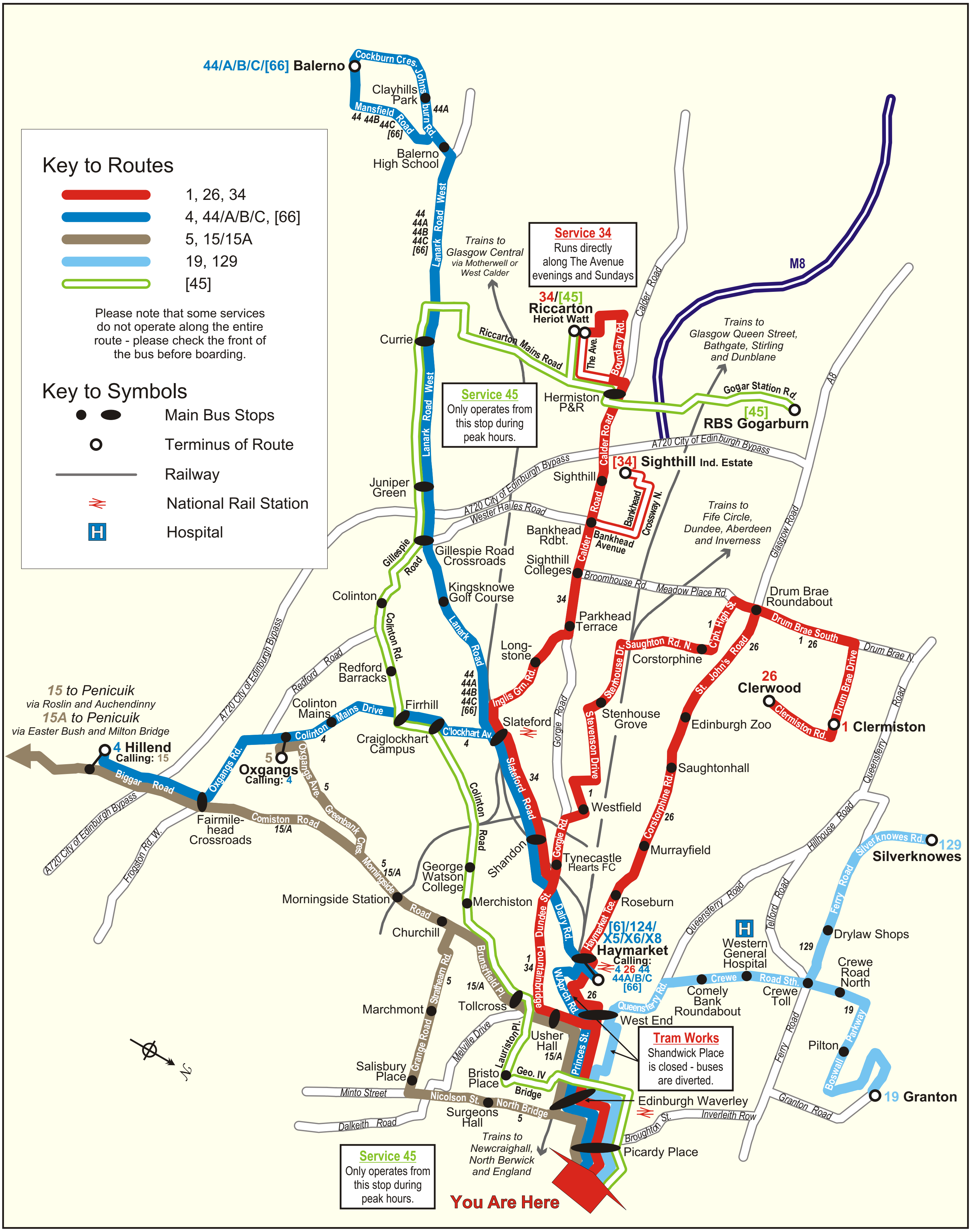
Inverleith Row opp. Warriston Drive



6200202910

Buses from this Stop

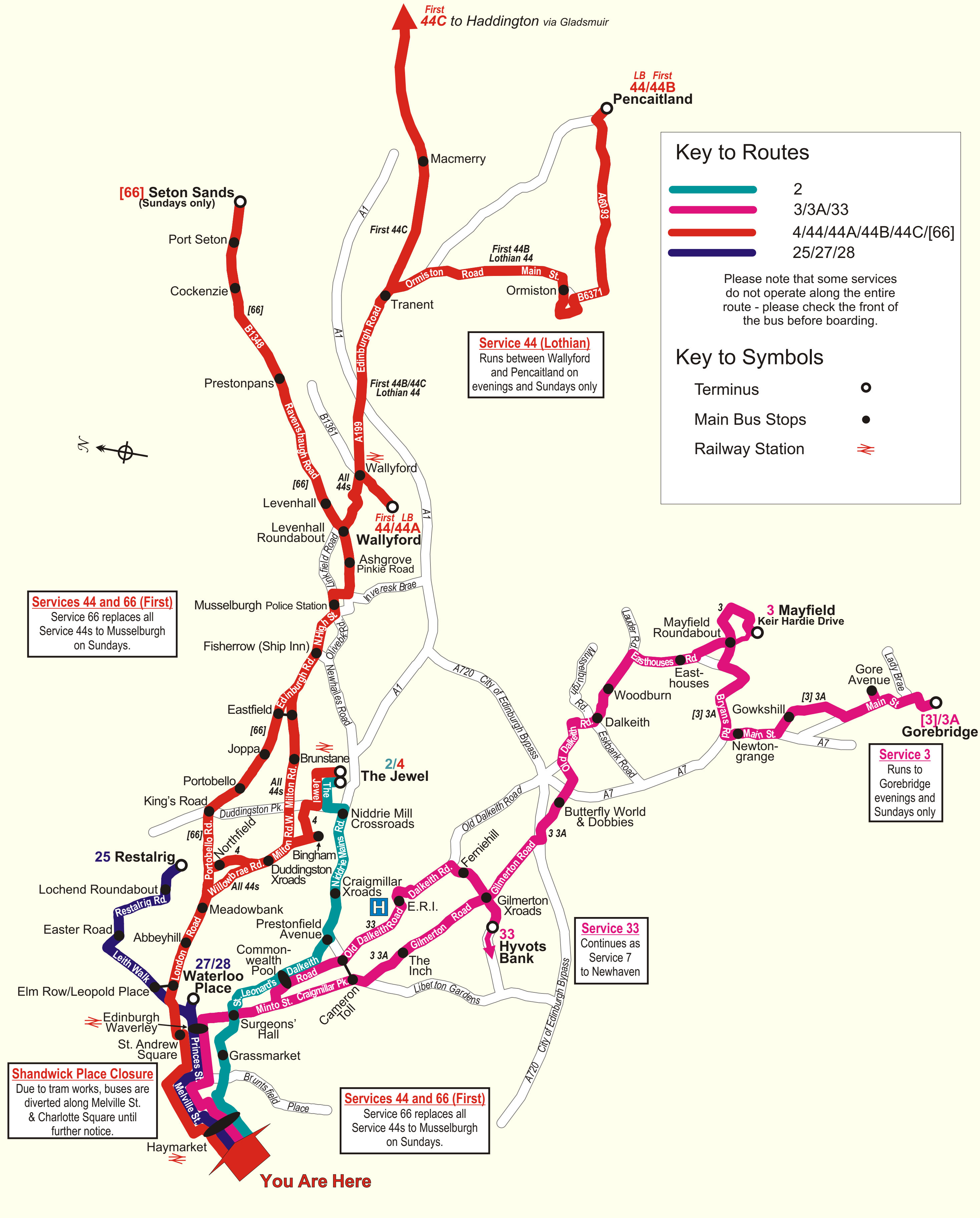
London Road at Leopold Place



6200201990

Buses from this Stop

Dalry Road, Murieston Crescent

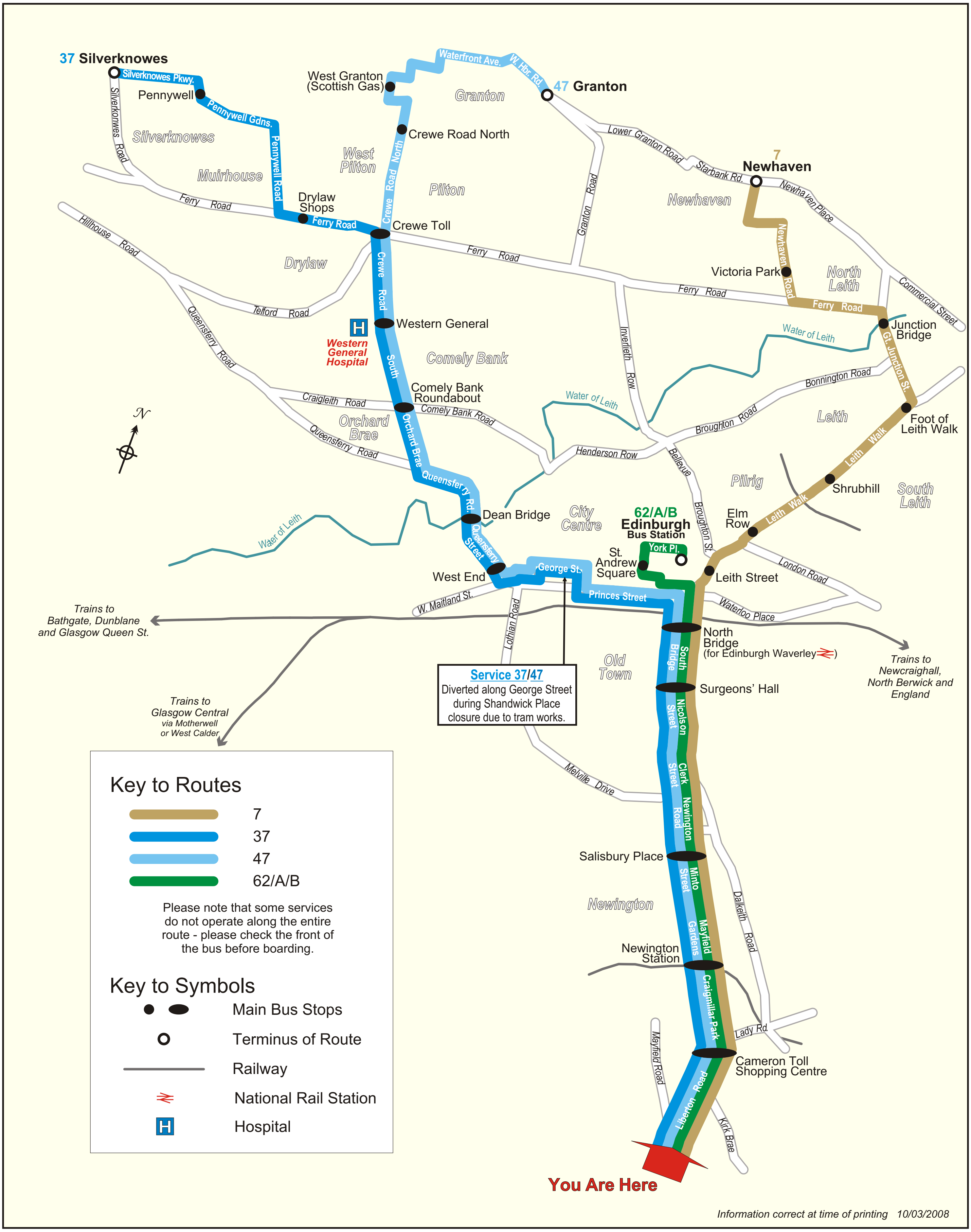


Information correct at time of printing 10/03/2008

6200239560

Buses from this Stop

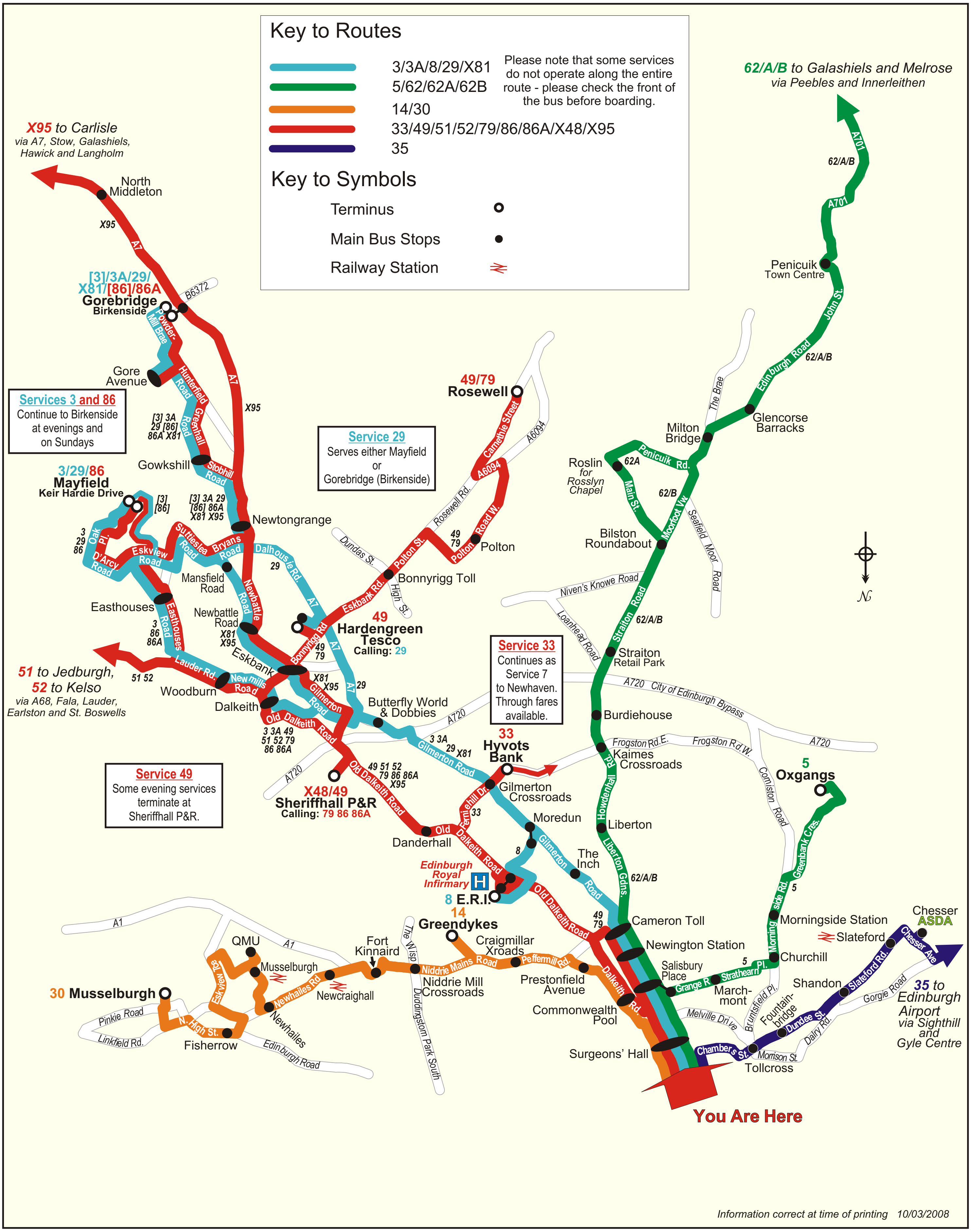
Liberton Brae opp. Orchardhead Road



6200208430

Buses from this Stop

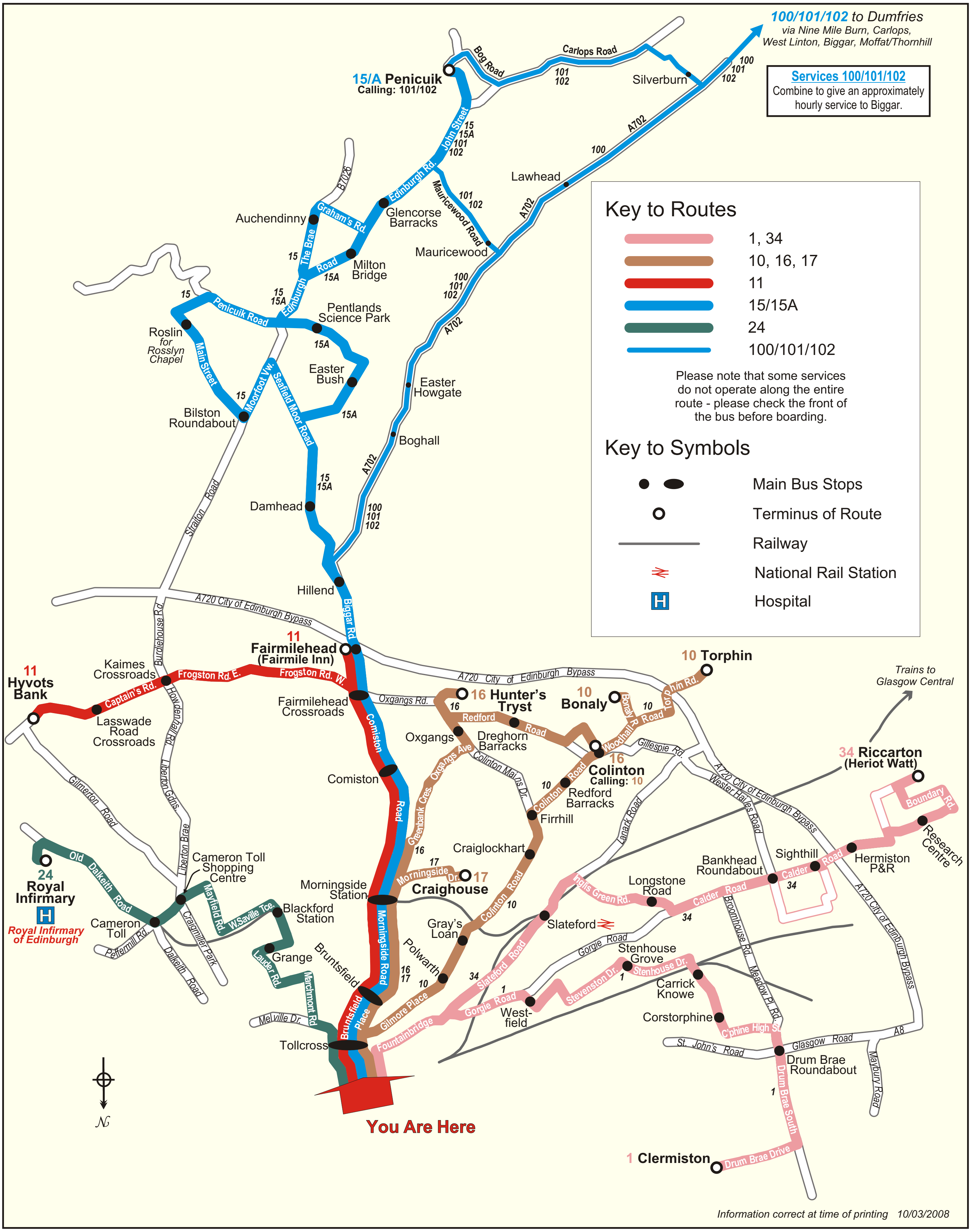
South Bridge, after High Street



6200243800

Buses from this Stop

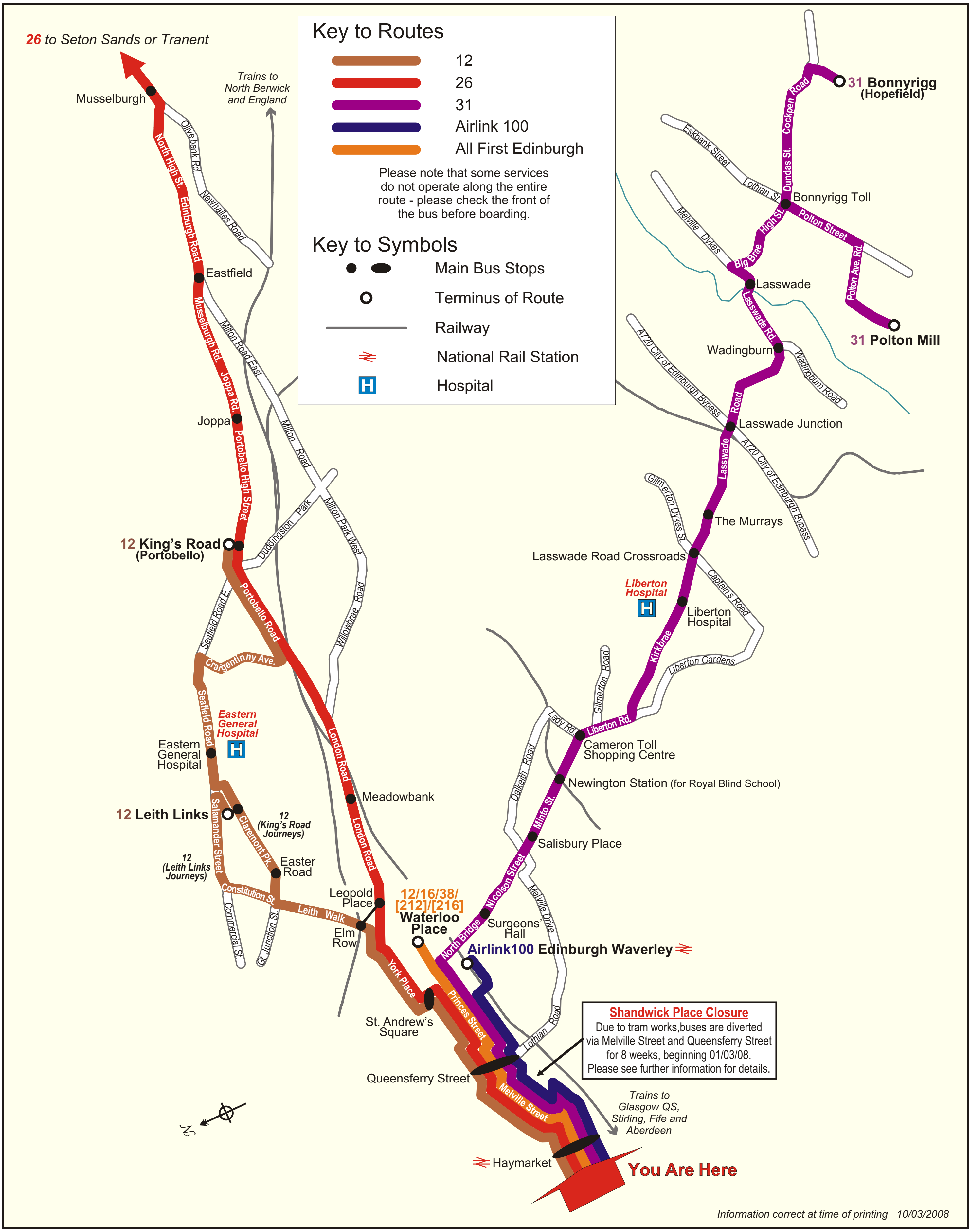
Lothian Road at Usher Hall



6200202910

Buses from this Stop

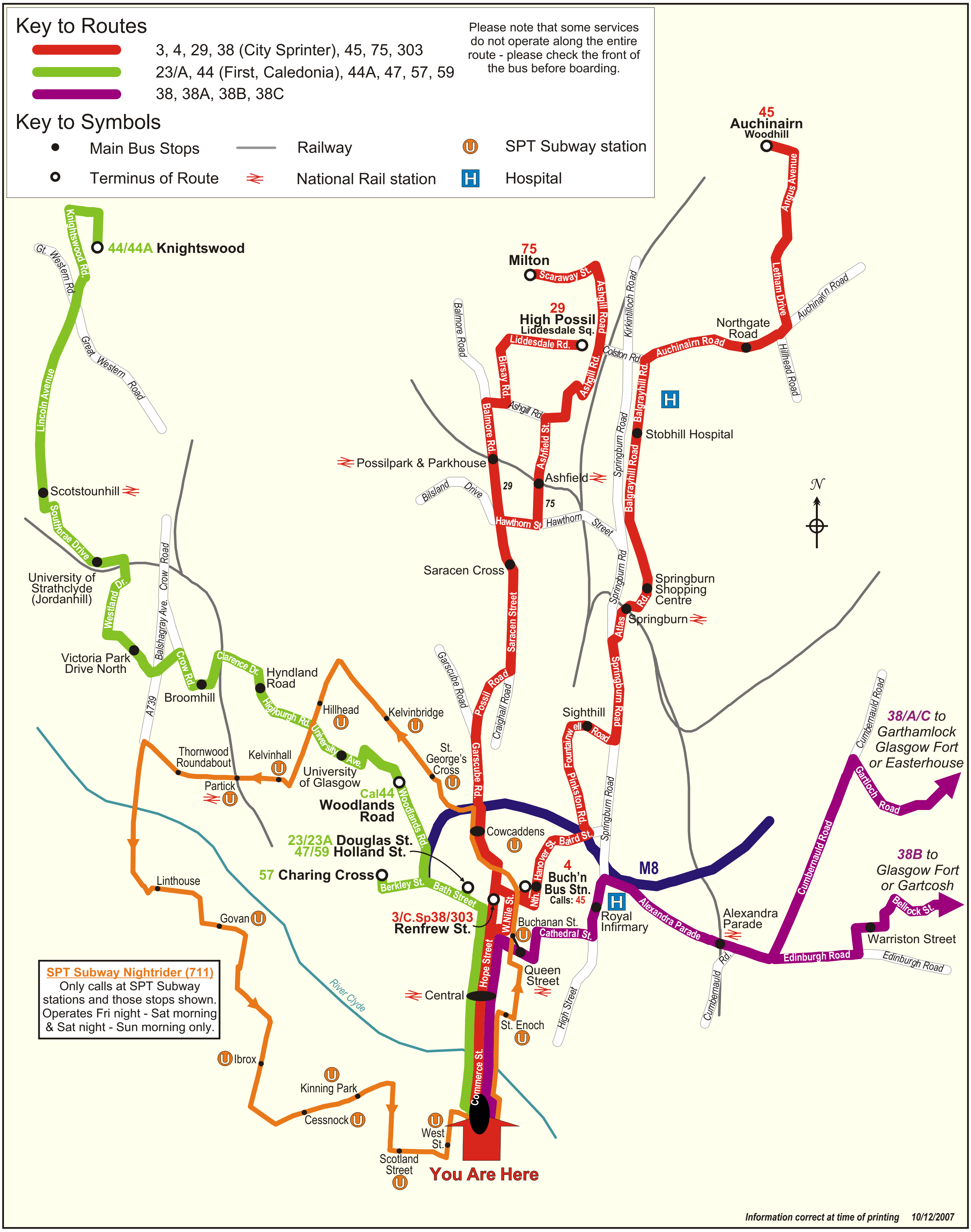
West Coates, at Kew Terrace



60902616

Buses from this Stop

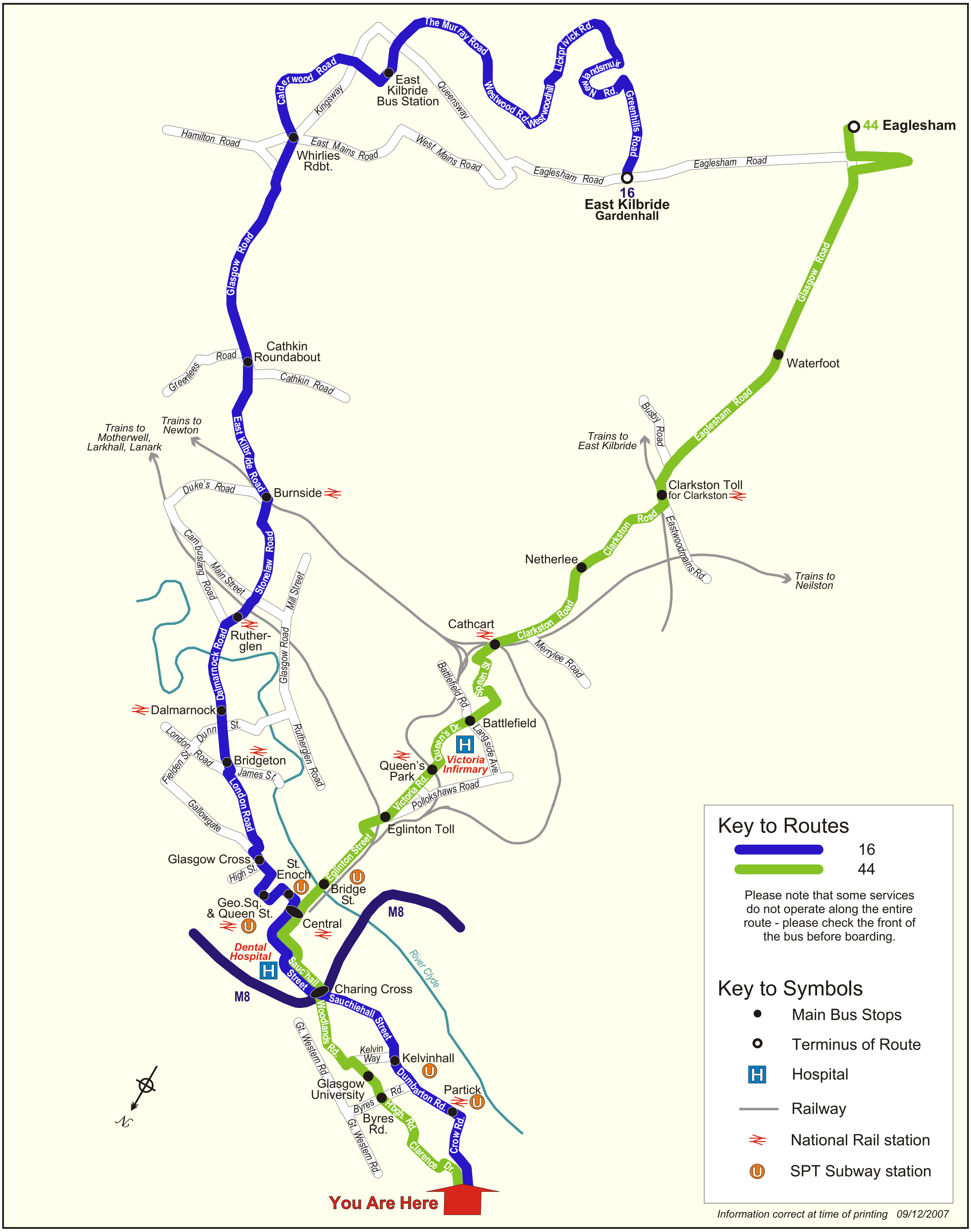
Eglinton Street, Bridge Street Underground



6090341

Buses from this Stop

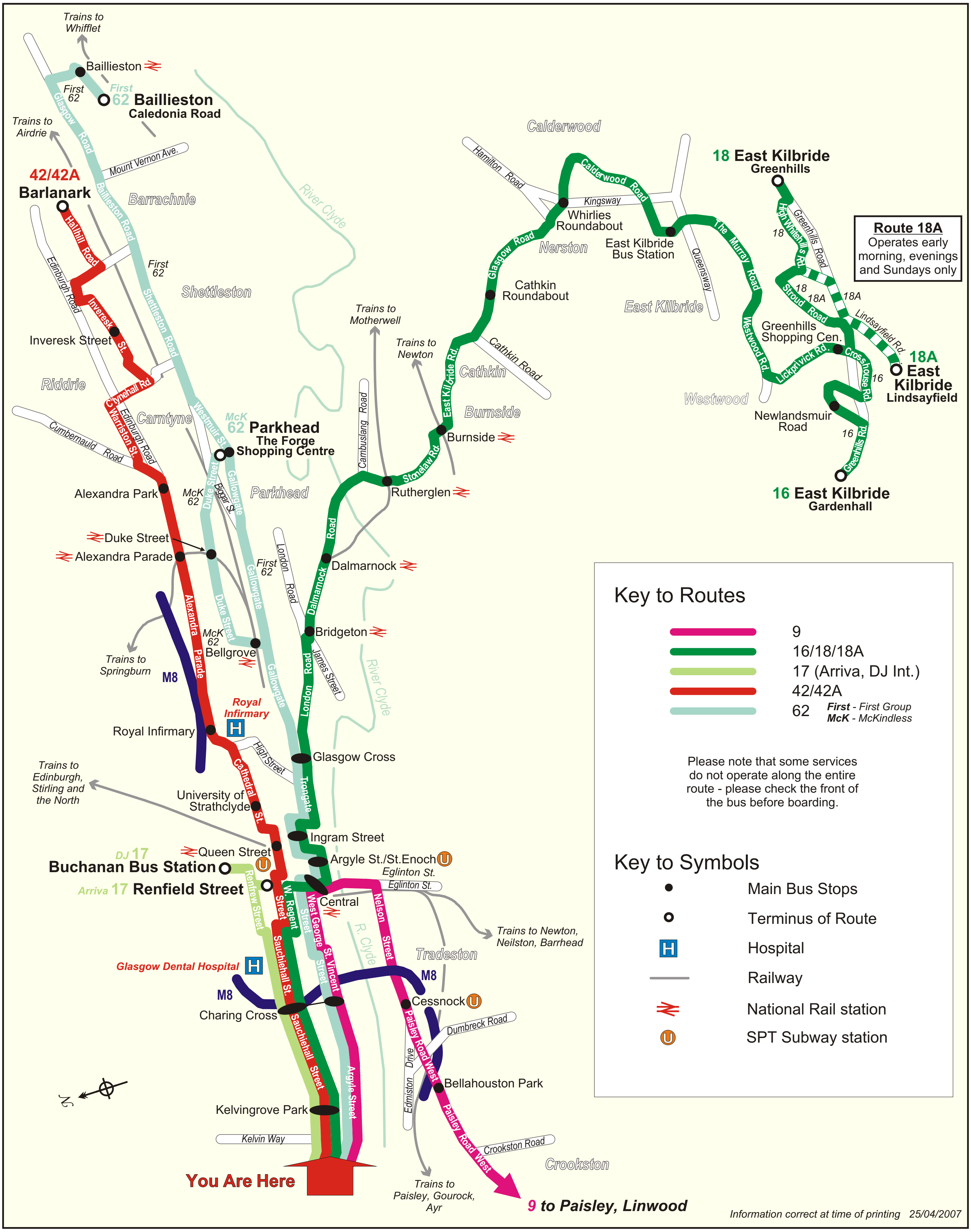
Crow Road, Marlborough Avenue



6090232

Buses from this Stop

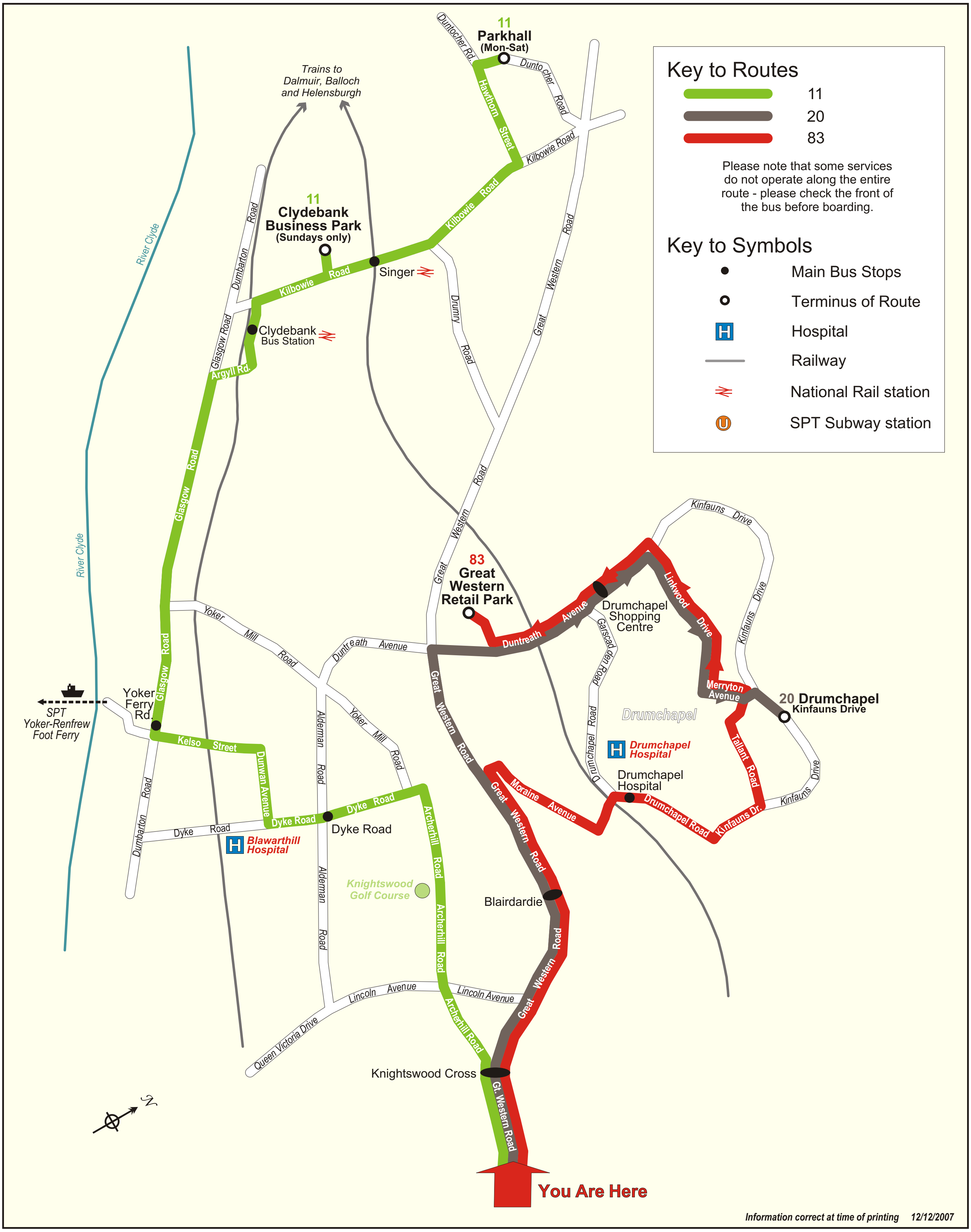
Dumbarton Road / Western Infirmary



6090383

Buses from this Stop

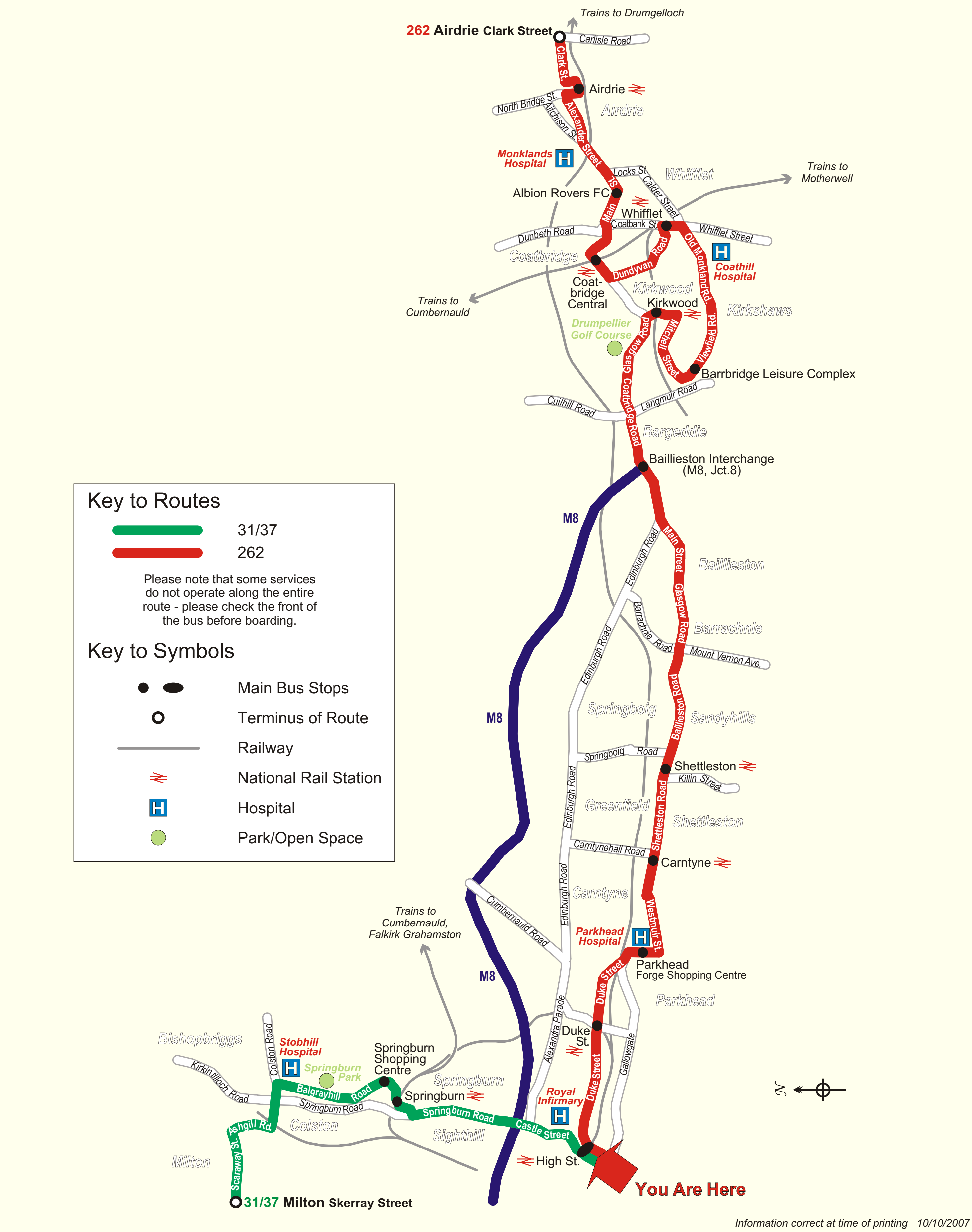
Great Western Road, opp. Bearsden Road (Anniesland Cross)



609097

Buses from this Stop

High Street before Blackfriars Street



Key to Routes

Green line	31/37
Red line	262

Please note that some services do not operate along the entire route - please check the front of the bus before boarding.

Key to Symbols

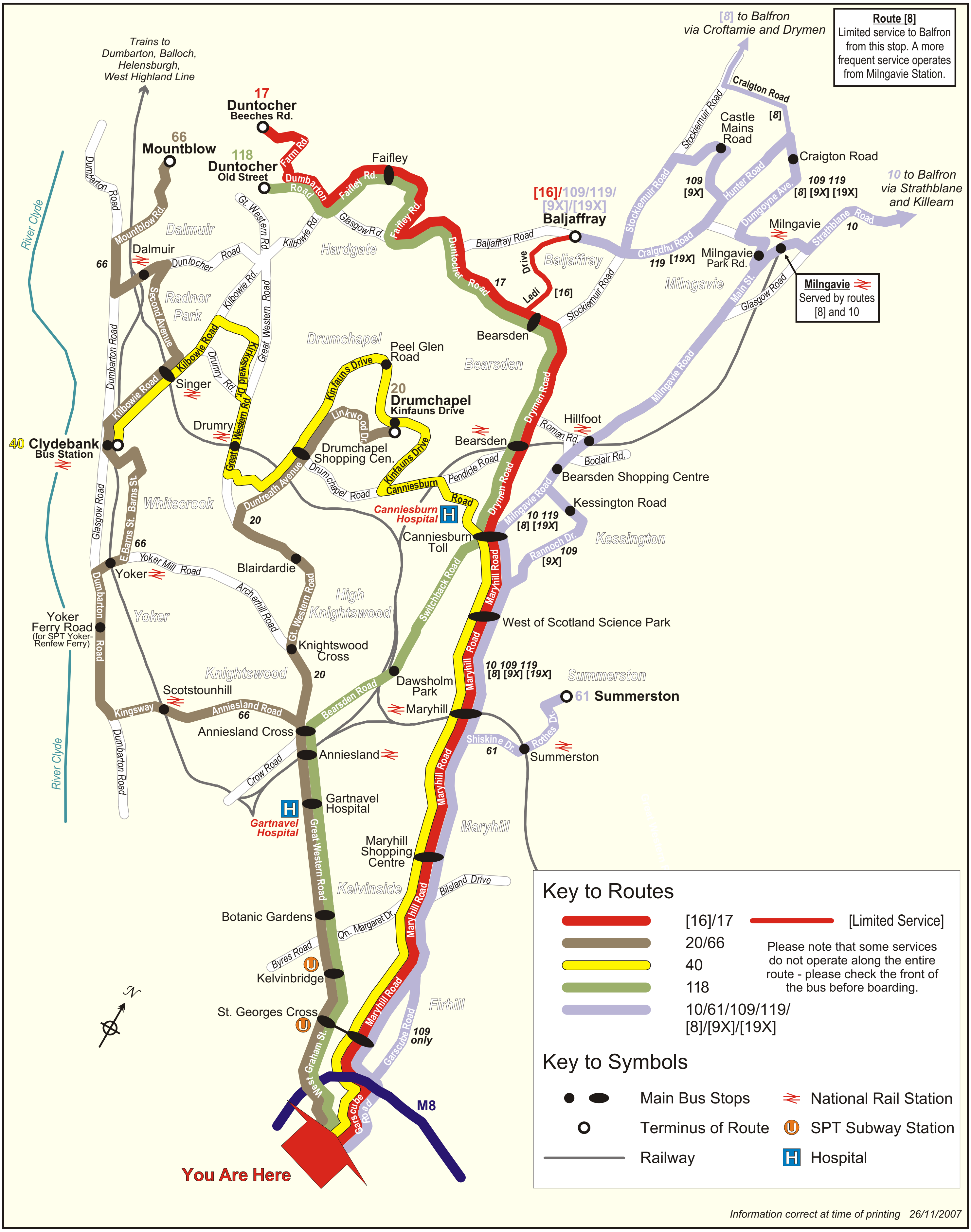
- Main Bus Stops
- Terminus of Route
- Railway
- National Rail Station
- Hospital
- Park/Open Space

Information correct at time of printing 10/10/2007

609018

Buses from this Stop

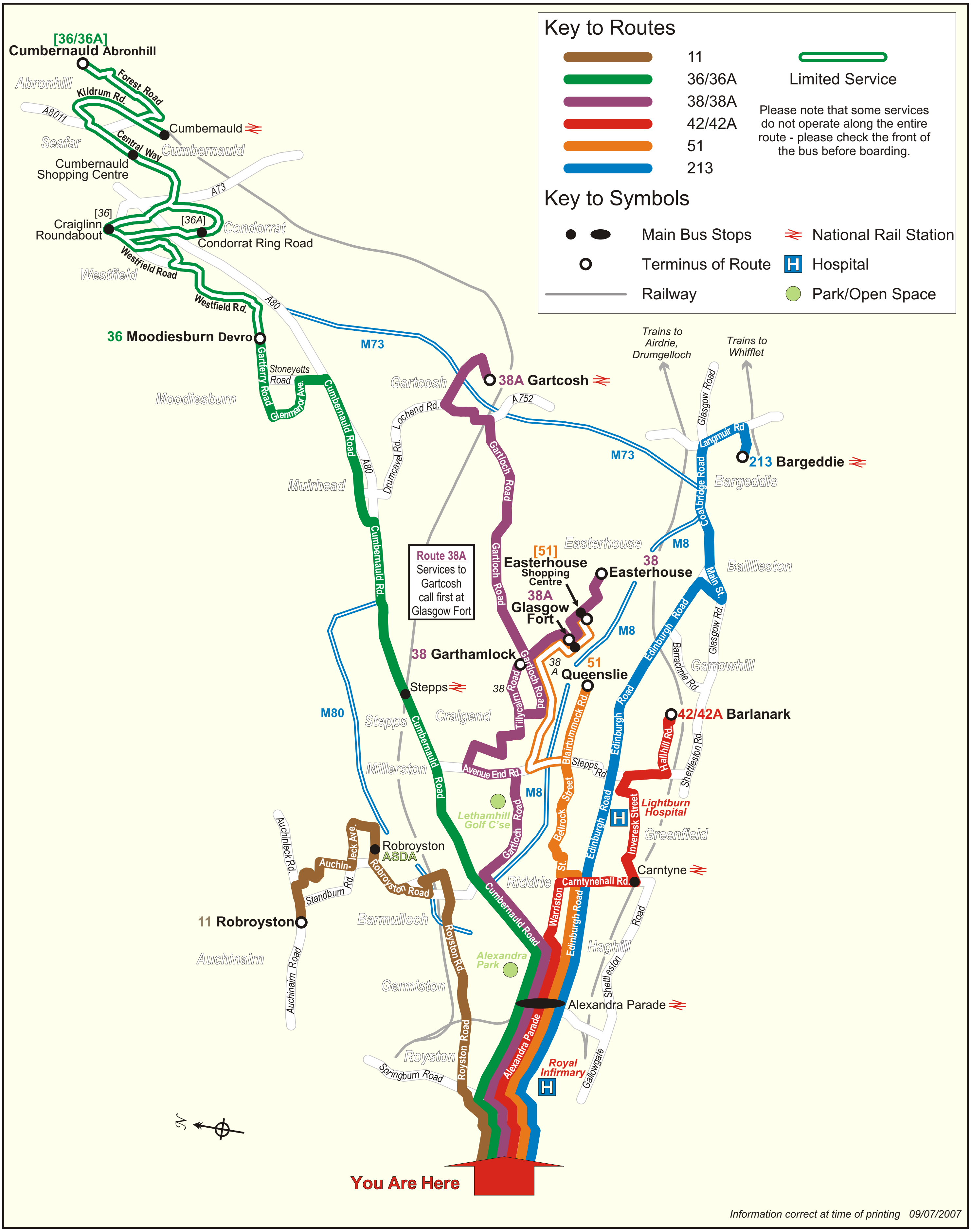
Hope Street opp. Theatre Royal



6090110

Buses from this Stop

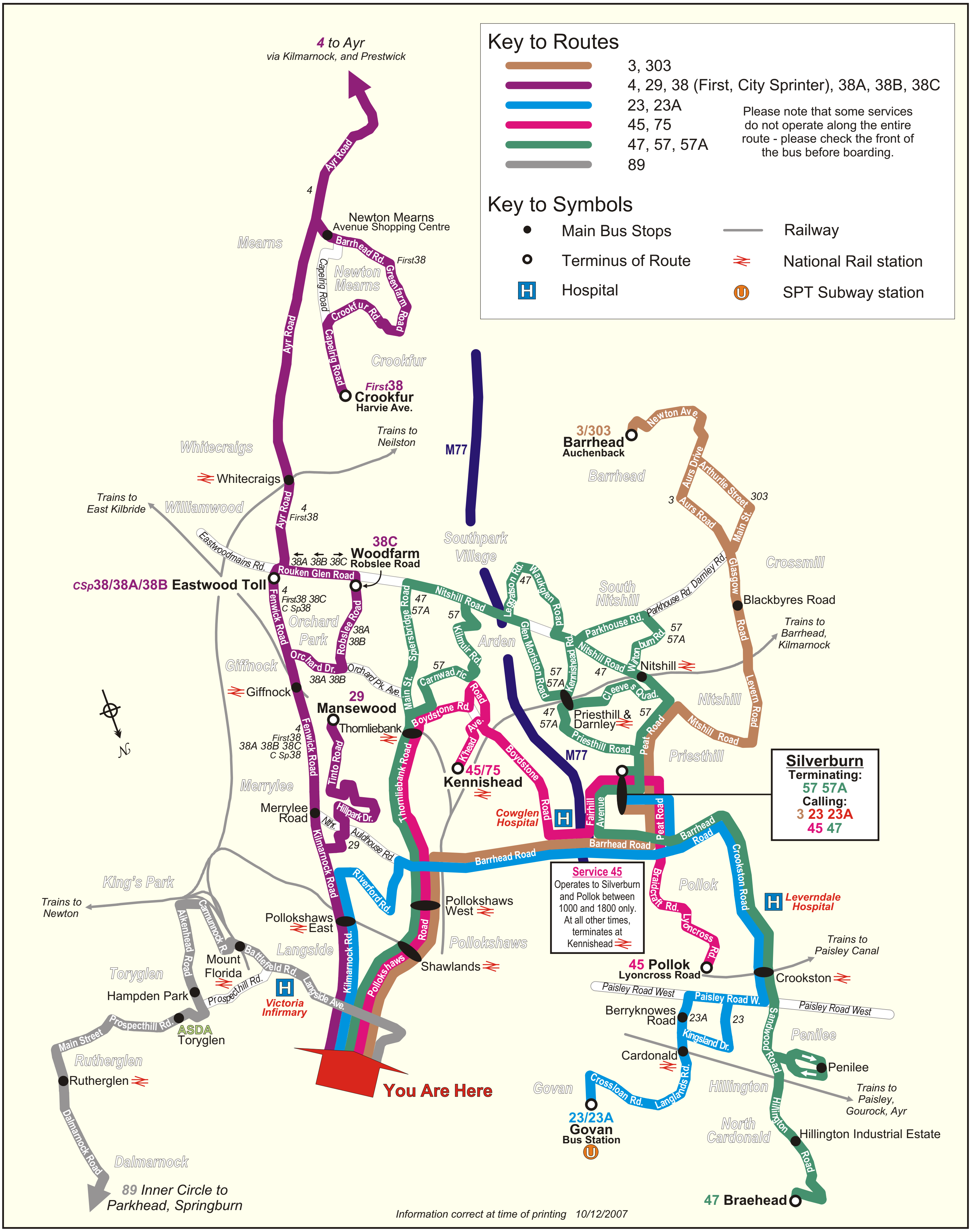
North Frederick Street after George Square (Stop 1)



60902646

Buses from this Stop

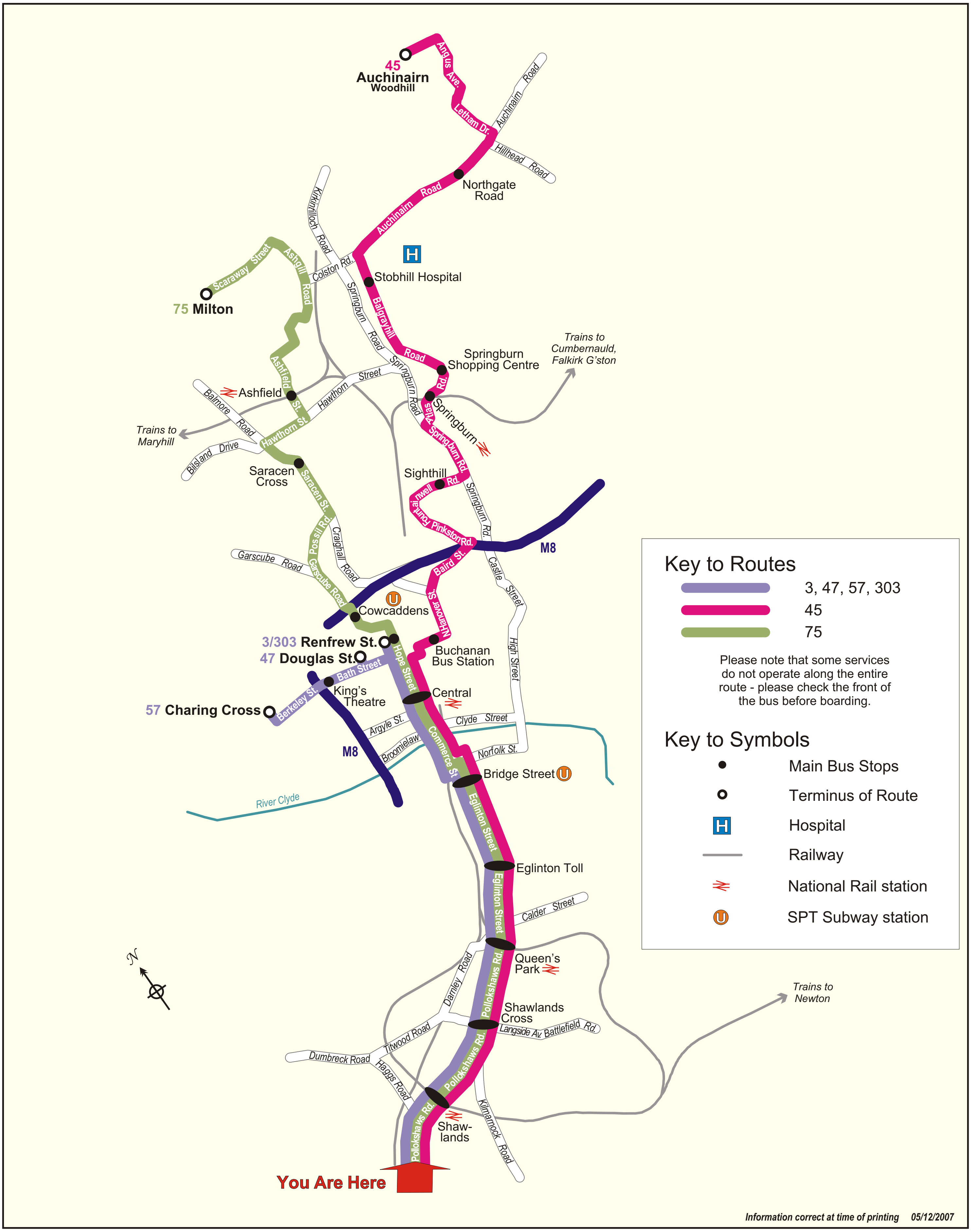
Pollokshaws Road opp. Marywood Square



60902680

Buses from this Stop

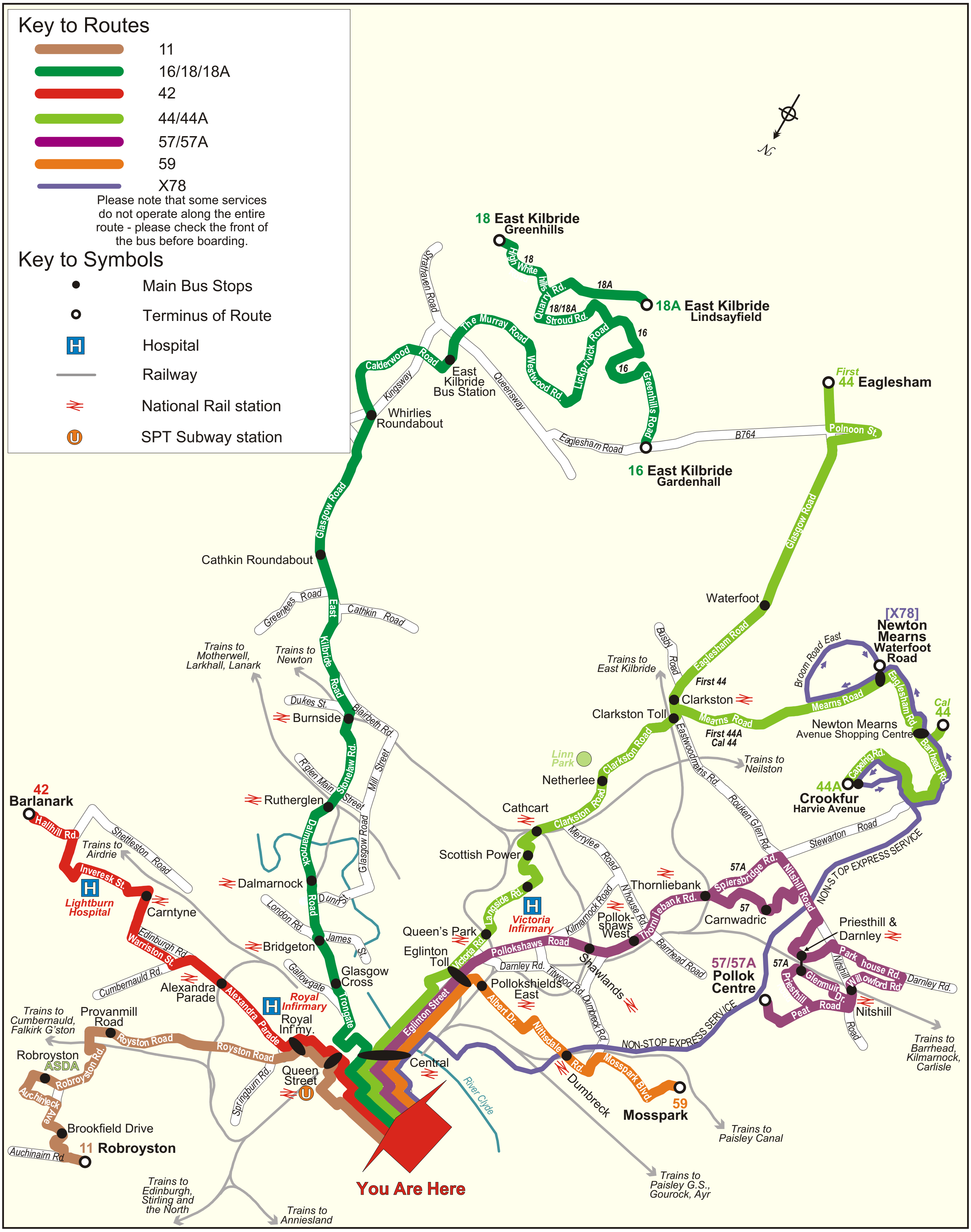
Pollokshaws Road, Pollokshaws West Railway Station



6090158

Buses from this Stop

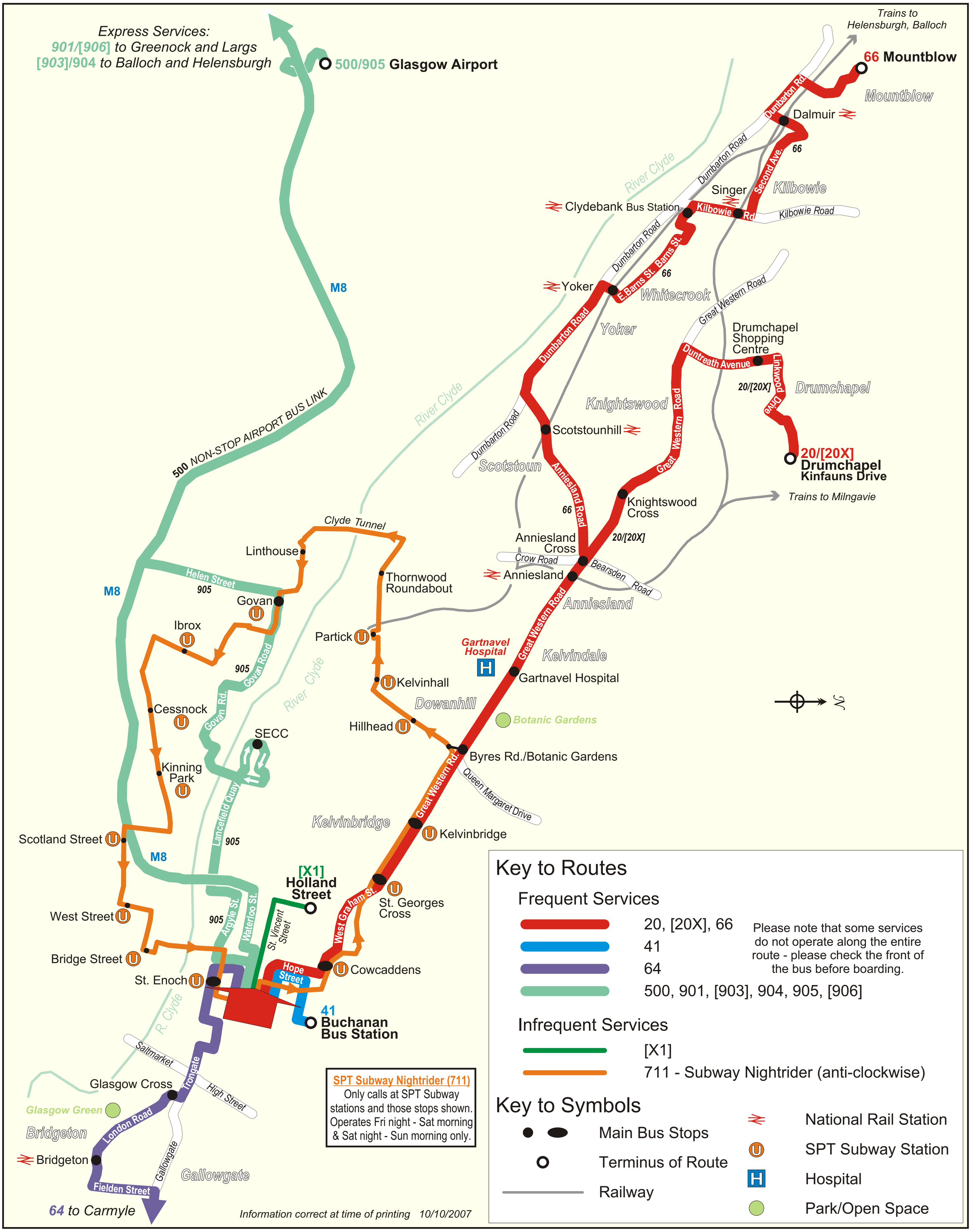
Sauchiehall Street, Charing Cross



609075

Buses from this Stop

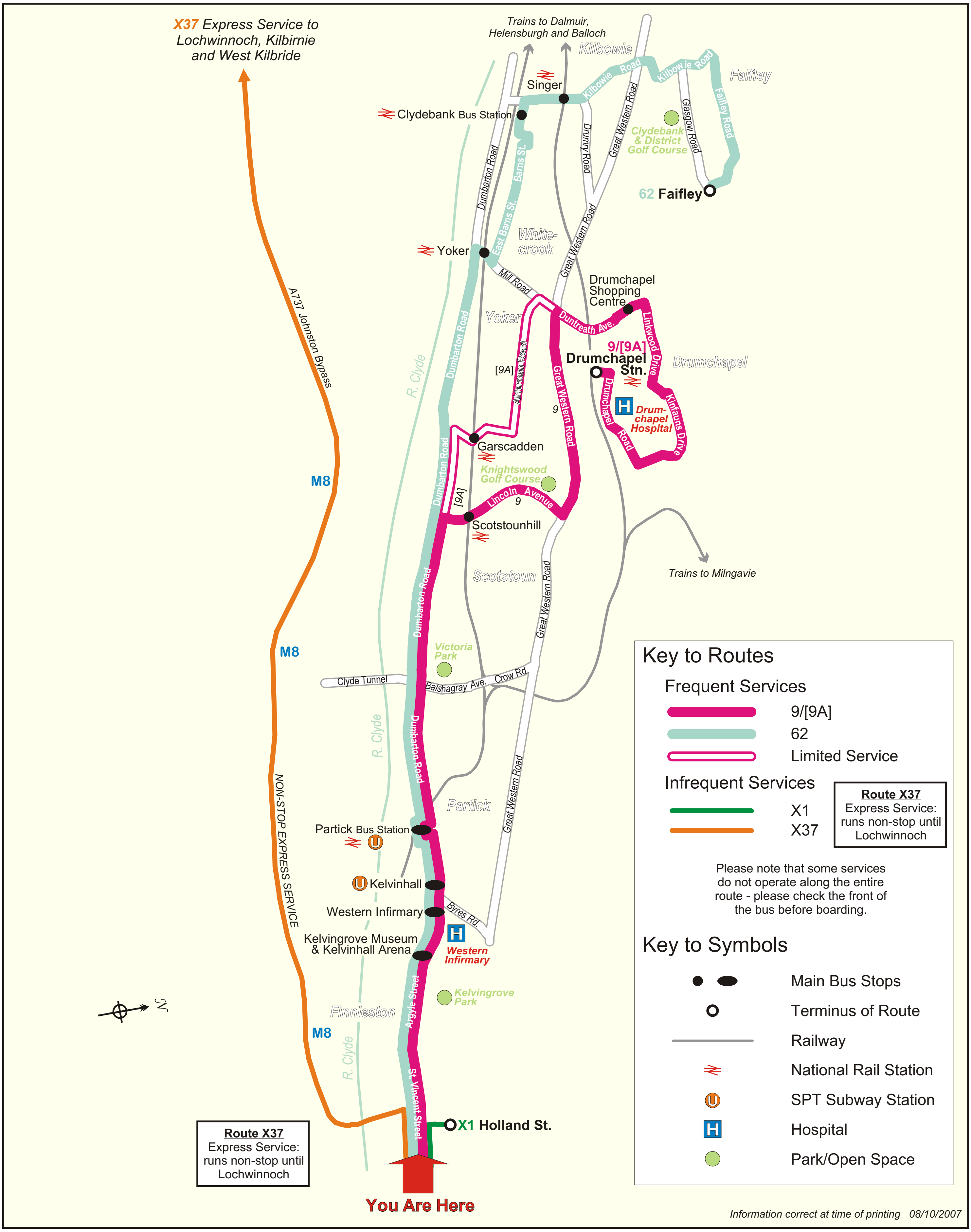
St. Vincent Place before Buchanan Street



609078

Buses from this Stop

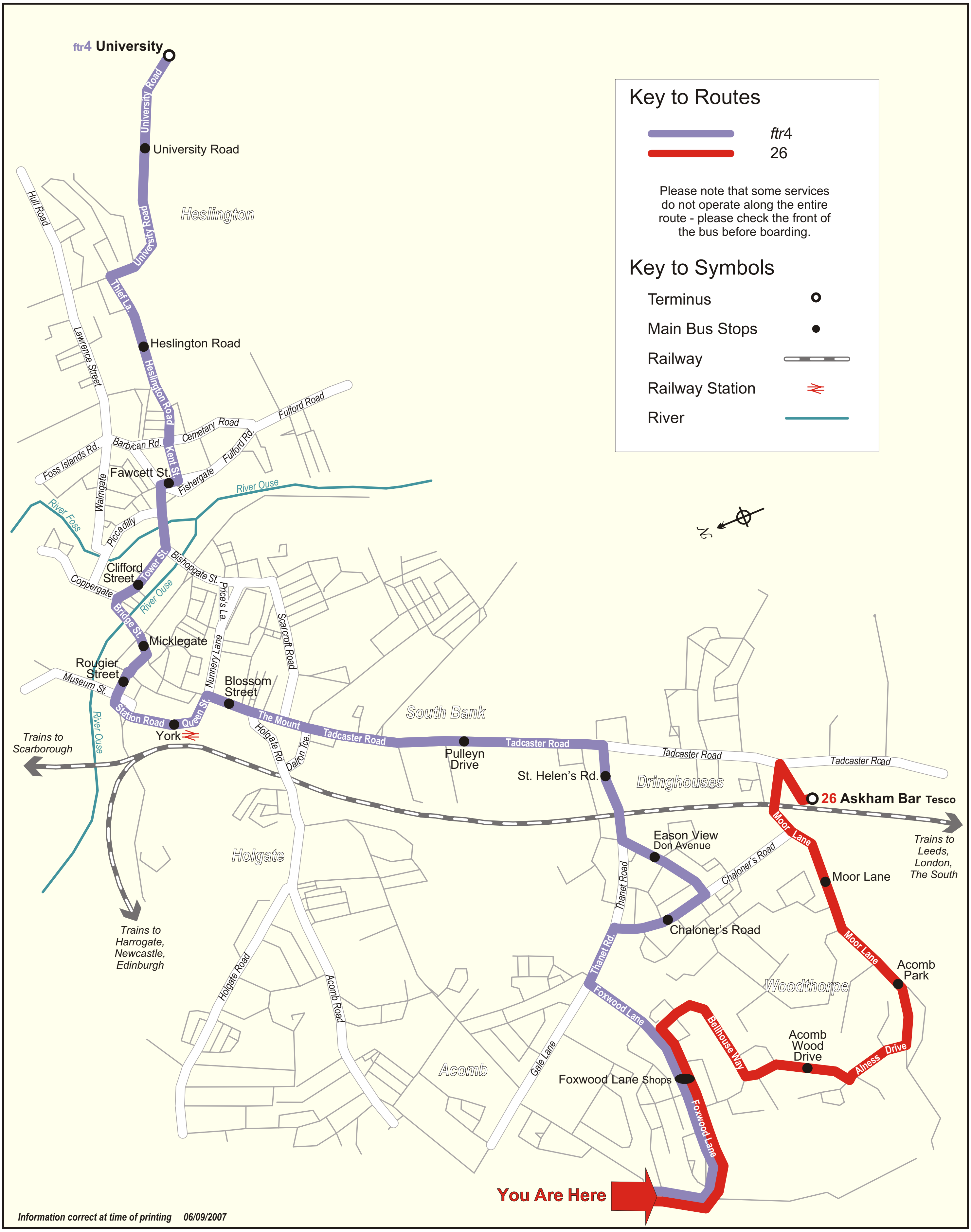
St. Vincent Street before West Campbell Street



3290YYA00037

Buses from this Stop

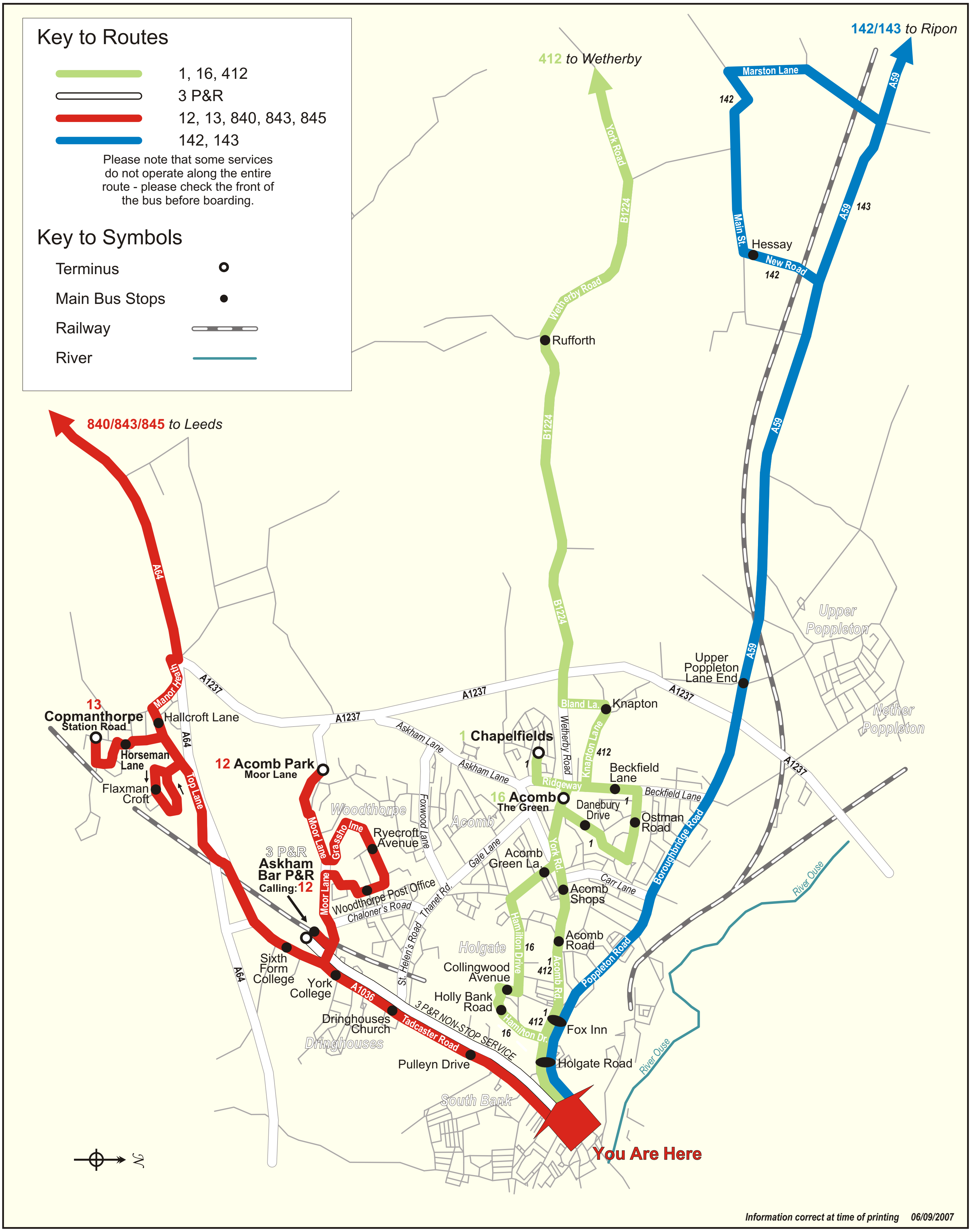
Askham Lane, West Field



3290YYA00149

Buses from this Stop

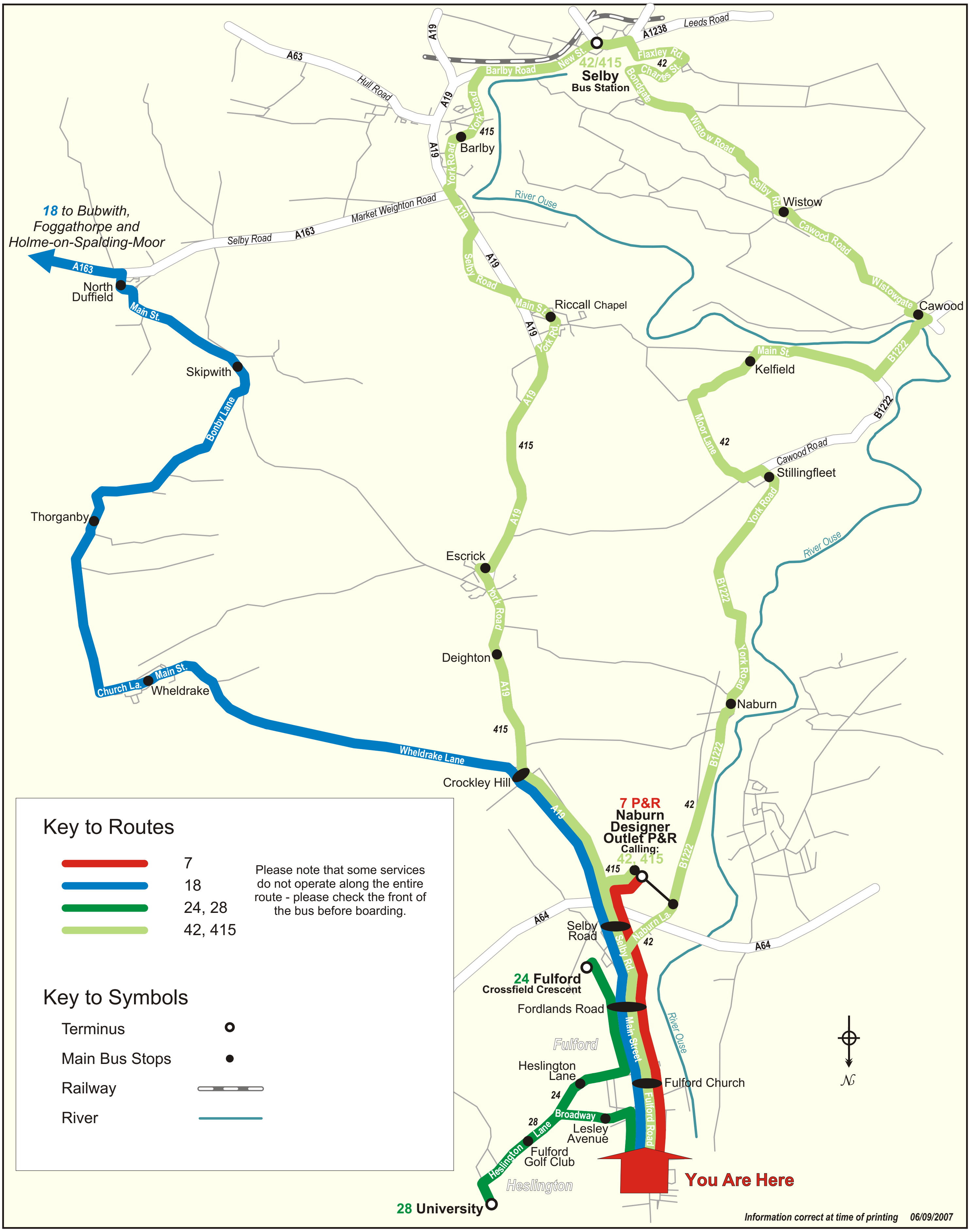
Blossom Street, Stop C



3290YYA00241

Buses from this Stop

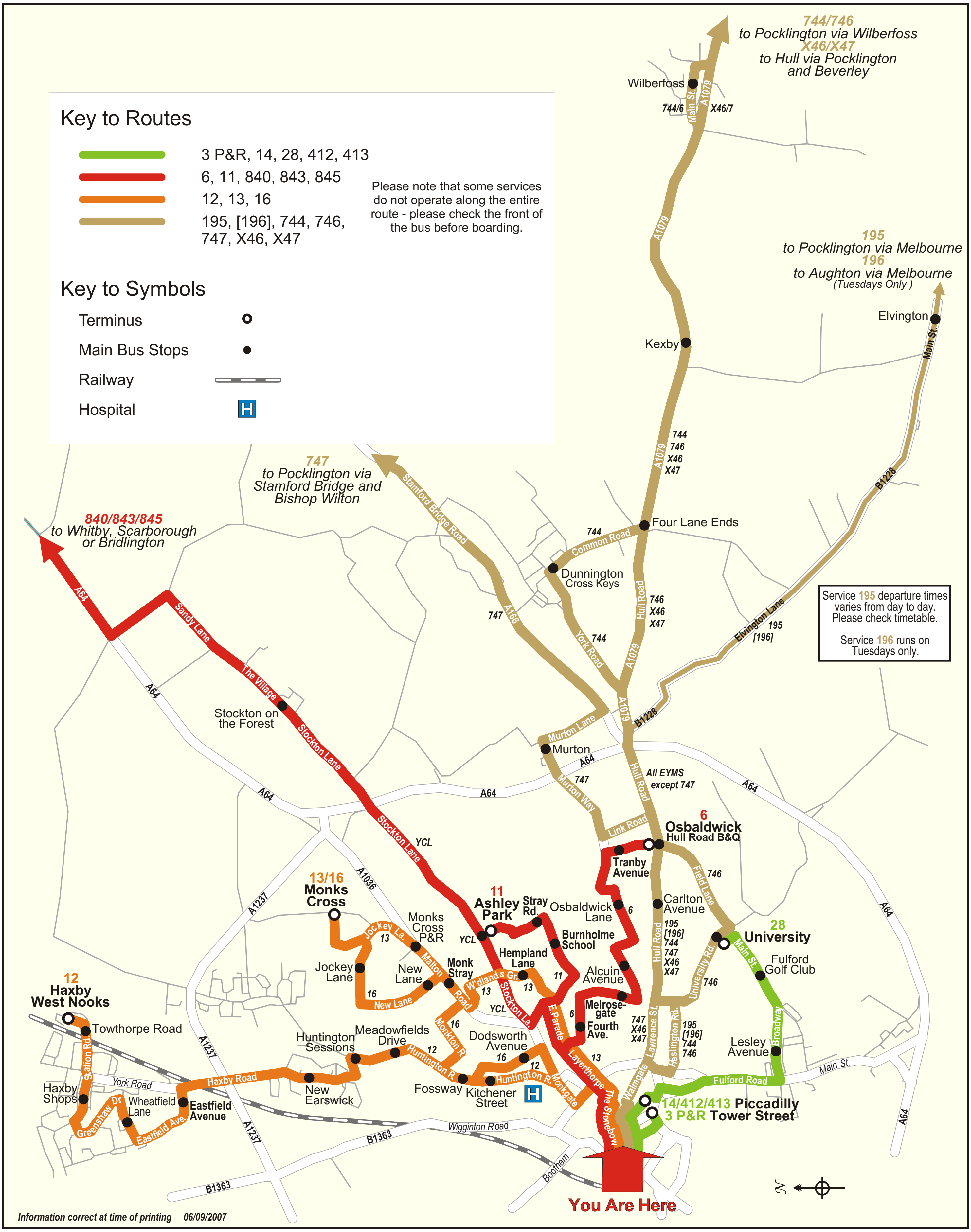
Imphal Barracks, Fulford Road, Fulford



3290YYA00097

Buses from this Stop

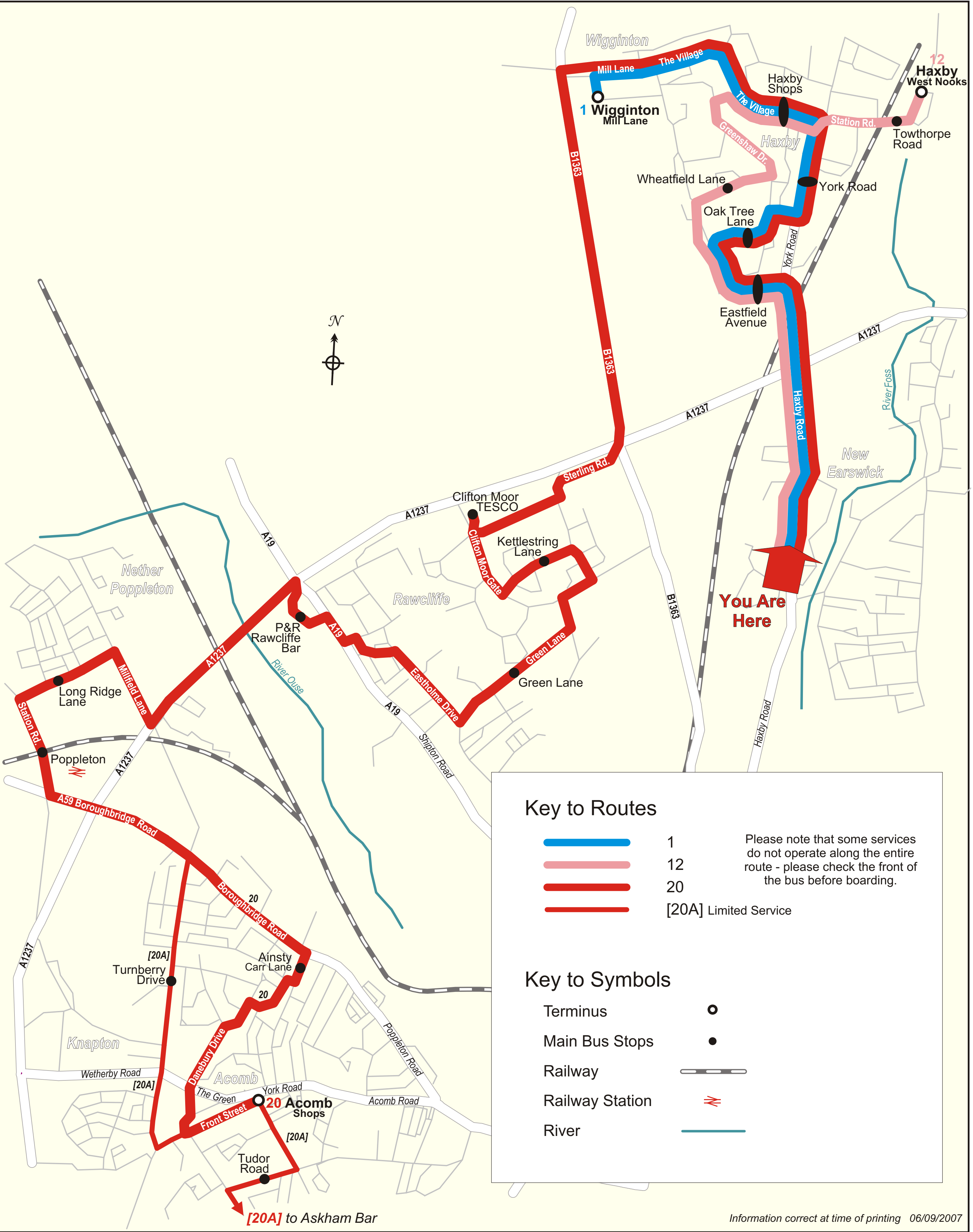
Micklegate, Stop A



3290YYA00646

Buses from this Stop

Folk Hall, Haxby Road, New Earswick



Key to Routes

- 1
- 12
- 20
- [20A] Limited Service

Please note that some services do not operate along the entire route - please check the front of the bus before boarding.

Key to Symbols

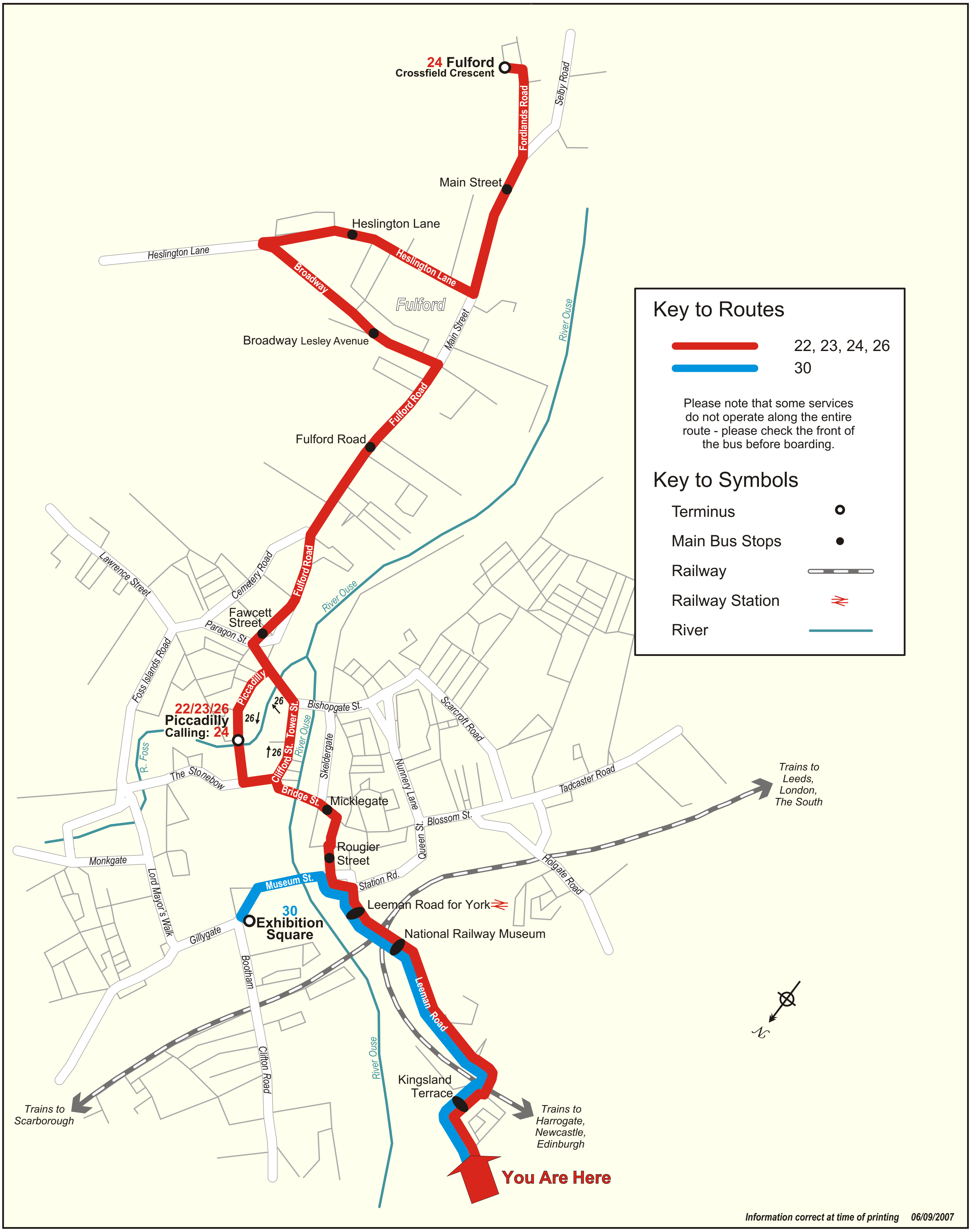
- Terminus
- Main Bus Stops
- Railway
- Railway Station
- River

Information correct at time of printing 06/09/2007

3290YYA00370

Buses from this Stop

Minster Vets, Salisbury Road, Clifton



5.1 In this Chapter

This Chapter describes how the SSBM concept was tested, beginning with a pilot study in Glasgow to identify any significant problems with either the SSBM design or the questionnaire used. Based upon these findings, refinements were then made to the SSBM specification and the questionnaire design, before the final SSBM tests were conducted at a range of stops across the four test locations.

5.2 Testing the SSBMs (Pilot Study)

In section 3.2, it was argued that rigorous map evaluation can feasibly be conducted by employing appropriate tasks in an appropriate environment. Once the prototype SSBMs had been completed, attention turned to determining exactly how they were to be tested in the bus stop environment.

The purpose of this research is to compare the performance of the SSBMs to the existing forms of PTI. Using the Task-Orientated approach defined by Robinson (1977), it was important to identify what forms of PTI would be available to the everyday traveller in each area, in order to compare the performance of the SSBMs accordingly. It was desirable to test SSBMs at all the different bus stops in the country, as well as all potential bus travellers. Therefore a suitable sample of towns, bus stops and respondents was sought through random sampling.

Controlled testing would have been chosen if the primary aim of the research was trying to make a choice between various alternative designs of SSBM, or if it was believed that SSBMs, Network Maps, and Timetables/At-Stop Information were alternatives to each other (instead of being complementary forms of information). In such circumstances, all conditions would need to be kept identical, except for the one being altered i.e. the form of PTI being tested. This controlled approach also needs a smaller number of subjects (akin to the concept of usability testing), yet the result is only valid for the conditions under which the tests were carried out, and cannot be generalised. However, for the randomised approach adopted in this study, a large sample of respondents would ensure overall representation of the population.

5.3 Public Transport Information Used

Regarding the Timetable/At-Stop Information, nothing could be done in this study to control what information appeared at each bus stop, nor could anything be done to influence what design of timetable was on display. There is great variation in at-stop PTI: in most instances it consists of one or more timetables, either in matrix form (listing the departure times for a complete service), or possibly in stop-specific form, whereby the timetable was designed to show the departure times of each service from the specific stop.

However, it was important to accurately represent the real world situation that a passenger approaching a stop would face. If other information such as individual straight line maps accompanying each timetable, a Network Map, real-time departure display, or fares information was also available at a bus stop, then respondents would not be prevented from consulting this during the journey planning tasks. Although the level of existing PTI provision is likely to vary between stops, and may have an effect on the results at each individual bus stop, the use of a relatively large stratified random sample of bus stops means that the bus stops used for the testing are representative and the overall results are reliable. This is also the situation that the passenger would face if they were making an everyday journey outwith the tests conducted for this study. A SSBM would ideally be integrated into the overall display of PTI (unfortunately this was not possible in this research), regardless of the other PTI provided by the LA or by the operators.

There was some control over which Network Maps were to be used for the tests as the most appropriate Network Map for each town would be directly provided to respondents during the testing. During the data capture process, Network Maps (in both hardcopy and online forms, depending on the location) were obtained for each test town to assist with identifying the different services in an area and the routes they followed. These maps varied from operator-specific maps to maps showing all services (usually produced by the relevant LA), and were in a range of styles from 'Classic' to 'French'. The final choice of Network Map would dictate the range of answers that could be returned by respondents, so the key criterion of the Network Map used would be that they were as close to a SSBM as possible i.e. an impartial, all services map (which are typically commissioned by the relevant LA).

In an ideal world, everywhere in the UK would have a single, standardised design of Network Map which would depict all the bus services in the area, regardless of the operator. This type of Network Map would be readily available at numerous locations across an area (for example, at bus stations, bus stops, Tourist Information Centres etc.) and would therefore be deemed as the most appropriate Network Map to use. Unfortunately for most towns in Britain, this is not the case. As discussed in Sections 1.3 and 3.4, there is not a standard British cartographic design of bus map, but instead many design variations on the 'Classic' and 'French' designs can be found, nor are maps readily available in many towns.

Therefore, a decision had to be made as to which map was the most appropriate Network Map in each of the test towns. As mentioned, if a Network Map was included in at-stop PTI, it could be used by test participants. However, as Network Maps do not appear in great abundance at bus stops, it was decided to obtain a portable, standalone Network Map for each area, which was defined as the map that would be obtained by a passenger if they went into a bus station, Travel Centre or Tourist Information Centre and asked for a 'bus map'. This procedure would introduce an element of random sampling into the selection of the Network Maps, and would also reduce any accusations of bias due to the deliberate selection of a poorly designed Network Map in order to give the SSBMs an advantage. A copy of the typical Network Map would be obtained in each of the test areas before the user testing commenced, but it was important to try and identify if a back-up map was also available, should this typical map not be available, or if it was deemed unsuitable for use after inspection. To test the SSBMs against a diverse range of Network Map designs, it would be beneficial if each test town had a different design of Network Map, but this was by no means guaranteed.

For the pilot tests in Glasgow, two Network Maps were available. Both were provided by First Group and were operator-specific maps. The first was the standard schematic 'Overground' map (see Figure 4.5) produced for all of First Group's Overground networks. The second map was the Greater Glasgow 'MapMate' (Figure 5.1) produced by Quickmap (which, at the time of writing, was no longer available). It was decided to use the 'MapMate' for the Glasgow pilot tests, as this shows all services provided by First within Glasgow and could therefore be said to be the closest map to an unbiased choice of Network Map. There was also the option of reverting to the standard 'Overground' map should the 'MapMate' prove unsuitable for use in a test situation.

The timetable information used was the information available at each stop at the time of testing (no network maps are posted at bus stops in Glasgow).

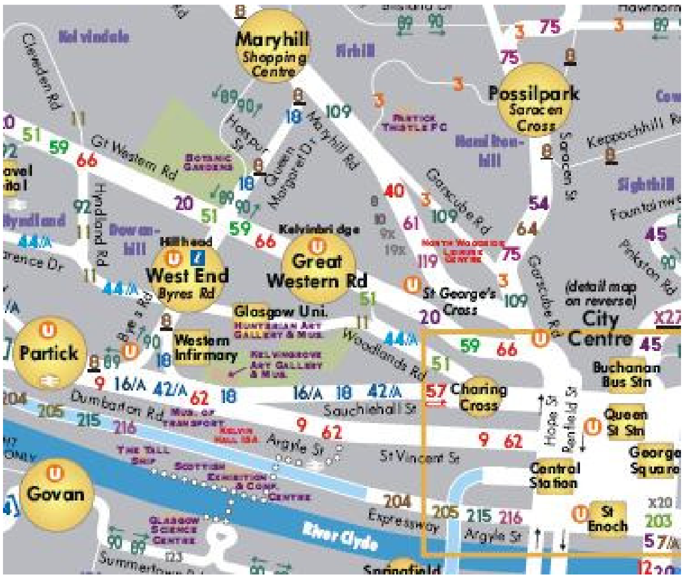


Figure 5.1. An extract from the Greater Glasgow 'MapMate'. (© QuickMap)

5.4 Survey Issues

The SSBMs were to be tested in the real world environment with a variety of people at a range of bus stops. However, the limited resources available to this study meant that the only available interviewer to design, administer and analyse the user tests would be the author himself. Although the author has previous personal experience of designing and administering on-street questionnaires, it would be important to try and develop a robust test procedure whilst working within these restrictions; the following issues that require some thought and attention will be discussed in the following sections.

5.4.1 Ethical Considerations

One of the first areas that must be addressed when undertaking any research with human participants is that of ethical considerations (Kent, 2000a; Celnick, 2000; Bulmer, 2001). Although there were no contentious or personal issues (such as attitudes to local political conditions or whether an individual was suffering from a terminal illness) that would be covered in this particular study, there was still to be some actual testing of human abilities and performance with the SSBMs and other PTI. It was therefore important to consider that although results of user testing were needed for this study, there was to be no means of forcing or tricking people to take part if they did not desire to do so.

All participants would be politely approached and asked if they would like to take part in the user tests, thereby adhering to the informed consent requirements (Kent, 2000b). If they agreed to do so, the purpose of the study and nature of the tests were then explained to them, thus covering the veracity element (Kent, 2000a), along with the reassurance that they would not be required to answer any question with which they were not comfortable, and all given answers could not be attributed to them, addressing the requirements of privacy and confidentiality (Kent, 2000a). Also, the tests would be conducted in such a way that other people in the immediate environment, but not involved with the tests, were not disrupted in anyway.

It was also important to consider the personal safety, security and comfort of the interviewer, who would be undertaking solo working in the field (Celnick, 2000) amongst members of the general public at public locations (bus stops), but primarily away from areas which were familiar to the interviewer. At all times, the whereabouts of the interviewer was known to people back in Glasgow and all bus stops to be used would be visited pre-testing to ascertain their surroundings to ensure no access issues (such as private property) were breached. During this reconnaissance, the location of the nearest safe place was identified, should the personal safety of the interviewer be compromised in any manner, as was the nearest rest and refreshment facilities, to minimise interviewer fatigue.

In light of this, full ethical approval was sought from, and granted by, the Department of Geographical and Earth Sciences' Ethics Panel following the standard departmental protocol.

5.4.2 Interviewer Attributes

"It has long been recognised that the job of the survey interviewer is the critical link between the survey organisation and address residents" (Campanelli and O'Muircheartaigh, 1999, p.59) and that "survey methodology has long recognized the essential role of the interviewer" (Durrant *et al.*, 2010, p.1). It should be noted here that the only interviewer available to this study (i.e. the author) is a middle-class male, of large build, in his mid-20s (with facial hair) which may not strike many as the classic description of the on-street surveyor and could have had an effect on response rate from different sectors of the population.

There is now an extensive body of literature on survey response rates versus the different aspects, characteristics, attributes and mannerisms of interview staff dating back to the 1970s, but there is variation in the findings depending on the topic of the survey, particularly as most studies attempt to isolate and analyse a specific characteristic (Durrant *et al.*, 2010). Overall, there appears to be no clearly defined results as to what are the key, desirable interviewer characteristics and it is very much dependent upon the survey environment (face-to-face versus telephone, on-street versus door-to-door), and the topic of the survey (Campanelli and O'Muircheartaigh, 1999; Pickery, Loosvelt and Carton, 2001; Blohm, Hox and Koch, 2006).

The issue of an interviewer's age is often discussed as a key factor in survey response rates as it can relate to the perceived level of experience of the individual as an interviewer. The findings of a US study from the 1980s indicated that "with respect to overall cooperation rates… age was significantly related both to screening and to response rates: Older interviewers obtained better cooperation" (Singer, Frankel and Glassman, 1983, p.80). However, this is not to suggest that younger interviewers are unable to achieve suitable response rates, albeit not as high a rate as their elders, as shown by results of analysis on the British Household Panel Survey by Campanelli and O'Muircheartaigh (1999) which found that "for a general population survey without sensitive items such as the BHPS [and this study], the age and gender of interviewers should not be a source of concern for interviewer recruitment or allocation" (p.73).

The issue of the gender of the interviewer and the respondent is quite complex, and is highly dependent on the relative content and topic of the survey, in particular those involving gender-related topics (e.g. women's equality of salaries), but there are wider issues such as race, socio-educational level and wealth which can also play a role in this gender debate (Kane and Macaulay, 1993; Huddy *et al.*, 1997).

The analysis by Campanelli and O'Muircheartaigh (1999) concludes that "the lack of significant effects by interviewer gender are particularly encouraging given the rapidly growing percentage of male interviewers in Great Britain" (p.73) and further analysis from the UK by Durrant *et al.* (2010) has found that interviewer-respondent similarities (such as same gender or equal educational level attained) can have a positive effect on response rates.

This would suggest that although the author might not fit the 'classic' description of the on-street surveyor (a middle-age, middle class female) this should have minimal impact as the topic of this study was not in looking at gender-specific issues or those of a controversial or private nature in any way. However, because of the limited resources available, it would not be possible to recruit a team of surveyors and therefore there was very little that could have been done to mitigate any possible issues that may have arisen regarding the personal characteristics of the author as he undertook the surveys. Responses were received from all sections of the general public, and there seemed to be no particular category of respondent who appeared to be put off by the characteristics of the surveyor.

5.4.3 Design of the User Questionnaire

Questionnaires are amongst the most widely used means of gathering data in social science attitudinal research, but they require careful thought, planning and execution in order to return useful and usable results (Simmons, 2001). It is important to design a questionnaire with the respondent in mind but also consider the task of the surveyor/interviewer. The final questionnaire needs to a) be easy to administer; b) obtain the required information in the correct manner; c) be answerable by a respondent without any confusion or fear of embarrassment; and d) not require a significant amount of time or effort on behalf of the respondent and the surveyor/interviewer (Hoinville and Jowell, 1978; Burton, 2000). This is clearly not a straightforward task, and there are a number of issues that need to be addressed when designing such a questionnaire.

White (2005) identified that any survey, interview or test to be undertaken in the bus stop environment had to be conducted as quickly as possible in order for it to be successful. This is particularly relevant at bus stops with numerous calling services where there is the potential for short headways between services, and thus limited time to stop and question those waiting for a bus. Once the decision had been made that the SSBM tests had to be conducted in the bus stop environment, it was important to design a questionnaire that was quick to complete, but to structure it in such a way that the overall testing was as efficient as possible, obtaining enough detail from each respondent yet minimizing the amount of disruption to the respondent and any other passengers waiting at the bus stop.

The length of the questionnaire would also have an effect on the overall response rate as “long questionnaires can put subjects off” (Burton, 2000, p.340). Analysis of an opinion survey from Denmark (Hansen, 2006) found that reducing the announced length (the duration stated before commencing) of an interview increased the completion rate by 25% and it has been suggested that there is a negative correlation between questionnaire size/length and response rates (Schaller, 2005). These findings are supported by the author’s past experiences of conducting on-street questionnaires, which suggested that many people were reluctant to participate when approached by an interviewer who was carrying a sizeable questionnaire. Of those who did agree to participate, there were signs that as the questioning continued, they became more and more exasperated, some even terminating the survey early.

A limited time window meant that the main purpose of the test i.e. the comparison between how people use the SSBMs and the existing PTI, had to be the very first stage of the overall survey, followed by a series of closed, scale-based questions designed to solicit opinions about the different forms of PTI. Finally the demographic questions, relating to the respondents’ age, gender, frequency of bus use, availability of a car etc. could be asked, as these only require simple ‘Yes/No/No Response’ answers. Personal demographic questions, such as age and sex, could even be estimated (age) or observed (sex) then completed post-survey by the interviewer, if time was short. It was important to avoid asking questions that were too simple in their nature, or attempted to obtain too much information in one go (Hoinville and Jowell, 1978; Robson, 1993; Burton, 2000; Simmons, 2001).

It was anticipated that the main disadvantage of this questionnaire structure would become apparent if respondents struggled with the initial PTI tests. To obtain consistent, unbiased results, the interviewer would not be allowed to give any assistance during the tests, but if the respondent was clearly struggling to accomplish the task and help was not available, it could create an awkward situation for all concerned. This situation would also reduce the amount of time available for the additional questions and there could be a chance that the respondent might wish to terminate the survey early, to avoid any further embarrassment. It is therefore good practice to include, and notify respondents about, an option for returning a ‘Don’t Know’ answer as this reduces the chances of the respondent feeling embarrassed if they are unable to provide an answer, but this also adds the possibility for no usable information to be obtained from a respondent.

Nevertheless, it was decided to retain the 'Don't Know' option where relevant, in order to allow for potentially awkward situations to be resolved with the minimum of fuss and embarrassment to all involved. Despite the possible disadvantages that could arise from using this order of questioning, it was felt that priority had to be given to achieving the primary objective of the study i.e. testing the various forms of PTI on offer, so this was the only feasible questionnaire structure for conducting these tests.

5.4.4 Designing the Questionnaire Framework

The user tests would be concerned with identifying a particular service which would take the respondent to a given destination from the current bus stop. Unlike the previous PTI user tests discussed in the Literature Review, the journey planning tasks for this research had a fixed factor in that all journey origins would be the bus stop at which the tests were currently being undertaken. This would limit the number of different Origin:Destination (O:D) pairs that could be used., and using a single O:D pair would only require respondents to use a limited amount of the information provided. To rigorously test the information on all forms of available PTI, it was decided to use four different destinations that could be reached using the services that called at each bus stop, without interchange. In selecting the destinations, it was important to ensure that they were distributed across the map face, ideally away from the central point of the map, but were not overtly obvious destinations. Previous studies (for example, Hardin, Tucker and Callejas, 2001) utilised clearly marked points on the map as O:D pairs and although these are not wholly representative of typical PT journeys, they do make the journey planning tasks achievable within a test situation.

This raises the question as to what O:D pairs should be used in journey planning tasks, as Hardin, Tucker and Callejas (2001) argue that there is little point in using obscure locations that the vast majority of respondents might not know, particularly those unfamiliar with how to use PT or with the local geography, and would struggle to complete the tasks. Even if lesser-known points were used for the O:D pairs, there is no direct measurement that can be applied to quantify the level of detail of a respondent's existing mental map – some people will have more detailed and extensive mental maps of an area than others – and so there is very little that can be done to control this experience aspect during the tests (Castner, 1979), other than attempting to achieve as representative a sample as possible.

It was therefore decided that to ensure respondents stood a chance of successfully planning a journey, three of the four destinations from each bus stop should be ones which were marked on the maps and listed on the timetables, whilst the remaining destination was one which was a well-known location, main road or tourist attraction, but was not specifically marked on the maps or timetables. This meant that some of the respondents would have to rely solely on their mental maps for some of the journey planning tasks, which introduced this element of unfamiliarity into the results and ensured that the overall mix of tasks was tolerably realistic.

As there was limited time available to conduct each individual at-stop survey, it was decided to ask respondents to plan two individual journeys from the stop, each journey using a different form of PTI and a different destination from one of the four destinations available. Not only would this increase the efficiency of the survey procedure, it would also introduce an element of control into the results. By dividing the PTI amongst the respondents so that one third used a SSBM and the Timetable/At-Stop Information, one third used a SSBM and the relevant Network Map, and one third used the relevant Network Map and the Timetable/At-Stop Information, this ensured that an equal number of respondents used each form of PTI whilst not weighting the results in favour of those who were more able to use mapping information. To minimise the possibility of bias occurring if a respondent overheard the answers of the previous respondent, it was decided that respondents should be allocated different destinations, so that no journey was planned to the same destination by consecutive respondents. It was not as critical to avoid use of a particular form of PTI between consecutive respondents.

As there were three different forms of PTI and four different destinations to be used, two (PTI, Destination) frameworks were designed, one for each journey to be planned. The assignment of respondents to each (PTI, Destination) pairing followed a process similar to that used for Latin Squares experiment design. Each respondent was assigned a (PTI, Destination) pairing (i, j) where i = the PTI index number {1, 2, 3} and j = the Destination index number, {1, 2, 3, 4}. Respondent 1 was assigned to pairing (1,1) and each index number was then increased by 1 for each subsequent respondent, until the upper limit of the index range was reached. The cycle of index numbers repeated until all 12 possible pairings were assigned. To avoid any duplication for the second journey, respondent number 1 was assigned the following form of PTI and the previous destination i.e. Journey 1 was assigned (1,1) and therefore Journey 2 was assigned (2,4).

Table 5.1: Framework for Allocating Journey 1 (PTI, Destination) Pairs
(Respondent number in each cell)

Journey 1	**Destination Number**			
Public Transport Information	***1***	***2***	***3***	***4***
1. SSBM	1	10	7	4
2. Network Map	5	2	11	8
3. Timetable/At-Stop Information	9	6	3	12

Table 5.2: Framework for Allocating Journey 2 (PTI, Destination) Pairs
(Respondent number in each cell)

Journey 2	**Destination Number**			
Public Transport Information	***1***	***2***	***3***	***4***
1. SSBM	6	3	12	9
2. Network Map	10	7	4	1
3. Timetable/At-Stop Information	2	11	8	5

This gave the final (PTI, Destination) pairings for each respondent as follows:

Table 5.3: Final (PTI, Destination) Pairings used in the Tests

Respondent Number	**Journey 1 (PTI, Destination)**	**Journey 2 (PTI, Destination)**
1	(1,1)	(2,4)
2	(2,2)	(3,1)
3	(3,3)	(1,2)
4	(1,4)	(2,3)
5	(2,1)	(3,4)
6	(3,2)	(1,1)
7	(1,3)	(2,2)
8	(2,4)	(3,3)
9	(3,1)	(1,4)
10	(1,2)	(2,1)
11	(2,3)	(3,2)
12	(3,4)	(1,3)

The design of this framework meant that by only approaching 12 respondents, two full iterations of all possible (PTI, Destination) pairs could be obtained whilst minimising the potential for biased results. If additional responses were required, another full iteration of the (PTI, Destination) pairs could be used repeatedly, without fear of any duplication between the destinations allocated to respondents 12 and 13, 24 and 25 etc.

5.5 Sampling of Respondents

Attempting to conduct user tests and surveys at a specific location such as an individual bus stop generally means that the availability and diversity of potential subjects is less than in a central location (such as a High Street or market square) where usually there is a greater number and variety of possible subjects. Given the restrictions of the bus stop locations combined with the limited resources available to this project, it was decided that a strict quota controlled sample would not be possible, especially in the more suburban locations.

An intercept survey (Schaller, 2005) approach was adopted, following a procedure similar to the 'mall interception' technique employed by Hardin, Tucker and Callejas (2001). Respondents were chosen by intercepting people who were waiting at the bus stop. The disadvantages of this approach have been shown by White (2005), but there are some advantages of this technique. It has been shown that intercept interviews generally return a better response rate than 'self-completion and return' questionnaires (e.g. a mail back questionnaire), as intercept interviews have a more personal face-to-face approach, which makes the respondent feel more valued and that their opinions are being recorded correctly (Schaller, 2005). The other main advantage of this approach is that it introduces a further element of random selection into the overall sampling procedure, as there was no direct control over who would be waiting for a bus at any given moment. Although the limited resources meant that it was not possible to adhere to a strict quota controlled sample, where possible, respondents were approached to ensure that an approximately even split between genders was obtained, and a range of responses were obtained from people in different age groups.

5.6 Conducting the Pilot Tests

As the pilot tests were intended to identify any problems with the overall testing procedure and not primarily to collect any usable data, it was decided to obtain responses from 12 individuals per stop i.e. one full iteration of all possible (PTI, Destination) pairs. A greater number of responses would eventually be acquired in the final tests to ensure a representative sample was obtained and that any statistical analyses would be valid.

For the purpose of the pilot tests, the concept of 'usability testing' (Virzi, 1992; Nielsen and Landauer, 1993; Nivala, Brewster, and Sarjakoski, 2008) was adopted. The theories behind usability testing state that a small number of individual tests are sufficient when attempting to identify any significant problems that the general population would encounter when using a product. Therefore, any issues with the overall testing procedure, the design of the questionnaire or the SSBMs would be highlighted through a single iteration of the framework at each bus stop.

The pilot tests were undertaken at various times from the morning peak through to the evening peak, on random days of the week (including weekends), in order to gain access to as diverse a range of passengers as possible. Following the ethical procedures discussed in Section 5.4.1, the interviewer positioned himself within the bus stop environment in clear view of anyone currently waiting for a bus (so as to not raise any suspicions), but away from any PTI displays and out of the main thoroughfare of passengers, to minimise any disruption to other people whilst they were waiting at the bus stop.

Respondents were intercepted whilst they were waiting for a bus with most approaches timed so that a bus had just departed from the stop. This normally resulted in fewer people remaining at the stop to provide distractions, but on many occasions some individuals did remain and waited for further buses, which goes someway to reflecting the average at-stop conditions. The approach also took advantage of maximum headways, thus giving as long as possible to undertake the individual survey but there were variations in the time and general space available at each stop for conducting each survey, depending on the number of calling services and the number of people waiting at the stop. It became clear that this method would need revising, and an alternative approach is discussed in the next section.

If the person approached declined to take part in the survey, they were politely thanked for their time, and the next approach was not made until new people had arrived at the bus stop. If they agreed to take part, but their bus arrived before the survey had been completed in full, the survey was terminated early and the respondent was allowed to board their bus. The pilot tests continued until 12 complete and usable surveys had been obtained at each stop.

5.6.1 Key Findings from the Pilot Tests

Overall, the pilot tests were completed successfully without encountering any significant problems, but they did reveal some important findings which would influence how the final tests should be conducted.

Perhaps the most important finding from the pilot tests relates back to White's reported experiences (2005) when attempting to survey people currently waiting at a bus stop. Within the first hour of the initial survey session at the first bus stop (Pollokshaws Road opposite Marywood Square) it was clear that it would be difficult to achieve a suitable response rate if the only people who were approached were currently waiting for a bus. As discussed by White (2005), the headway of service would dictate the amount of time available for the at-stop surveys, and where buses were arriving in quick succession this restricted the possibility for respondents to fully complete the questionnaire, and those that did tended to give hurried, unconsidered responses.

However, the main obstacle to conducting at-stop surveys appeared to be actually obtaining willing respondents. It was frequently observed that people waiting at a bus stop entered into a 'trance-like' state in which their attention was, understandably, directed solely at looking out for approaching buses, and subsequently identifying if an approaching bus was indeed one that they required. Very little conversation occurred between individuals, unless it was between friends or to ask someone else a travel-related question or for the time. The adoption of this temporary 'bus stop persona' meant that very few people who were waiting at a bus stop were willing to be distracted for long enough to participate in the survey.

As many people waiting at bus stops politely declined to take part, it was obvious that another approach was needed. Therefore, in addition to approaching people currently waiting at a bus stop, it was decided to intercept people passing by the immediate vicinity of the bus stop. For practical reasons, it was only feasible to approach those on foot who were unaccompanied (i.e. not in a group, and without prams or buggies, based upon White's (2005) observations), and not cyclists or drivers. Although this had the disadvantage to not allowing access to specific groups of travellers to take part, this was necessary in order to gather enough responses from a variety of users.

This revised approach proved to be a more fruitful method of obtaining respondents as the majority of passers-by were willing to stop and participate in the PT journey planning tasks, which greatly increased the overall response rate. Intercepting passers-by would also be essential at bus stops in more remote locations which tend to have fewer people using them, as was the case at 'Mosspark Boulevard opposite Tanna Drive', at which nobody boarded or alighted for significant periods during the pilot study. This finding has further implications for the methodology used in the selection of bus stops for each location, particularly in terms of maximising the efficiency of the testing phase.

The initial sample of stops in each area was screened by consulting a local street plan and considering the general surroundings of the bus stops. Any which appeared to be in similar isolated and quiet areas to the stop at 'Mosspark Boulevard opposite Tanna Drive' would be discarded and a suitable replacement selected. It could be argued that it is little-used stops at which PTI is most needed as this could boost patronage levels, but if there are very few people living near or passing by the stop then there is only a small number of potential passengers. For the purposes of this study, it was felt that with the limited resources available it would be highly inefficient to design and test a SSBM for a stop where there would, theoretically, be few people passing by. To minimise any bias introduced into the sample by replacing any isolated stops with those in more populous locations, the same random number process outlined in the previous chapter was used.

There are a number of possible reasons why this revised approach of intercepting passers-by was more successful. Passers-by were not currently waiting for a bus, so they were not under the influences of the temporary 'bus stop persona', and they also had more time to participate in the surveys and complete them in full – a task which proved to be difficult to achieve when questioning those waiting for a bus. However, a common excuse given by passers-by who declined to participate related, perhaps somewhat ironically, to them having to be somewhere at a given time. Passers-by were also more curious as to the purpose of the survey, with a couple of people commenting on how they would like to make greater use of PT services and consequently volunteered to take part. By conducting surveys in the immediate vicinity of the bus stop, but away from the bus stop itself, it was also possible to provide respondents with more confidential surroundings, as there were no other passengers to overlook the survey or to provide distractions.

The only exception to this was the journey planning tasks which required the use of the at-stop PTI but once these tasks were completed, the respondent was invited to accompany the interviewer to another location, away from the bus stop environment. In general, conducting the surveys in this manner appeared to put the respondents more at ease and so they were happier to spend time looking at the PTI and as a result, provided more considered answers.

The pilot study also revealed that the general mood of people was greatly influenced by both the time of day and the current weather conditions, which had a subsequent impact on their willingness to participate in the survey. To obtain a representative sample of bus users, the pilot tests were conducted across different times of the day to obtain responses from different categories of passenger, such as regular users versus occasional users, commuters versus leisure travellers, and students versus older people. Naturally, the range of potential subjects varied depending on the location of the bus stop and in some instances it was not possible to obtain answers from all categories of bus user, but it was believed that the final sample derived from both City Centre bus stops and suburban bus stops would minimise any sample bias.

It soon became apparent that approaching people in the morning, especially commuters, was not going to yield many responses, as many people were in a hurry to get to work, were still tired and were generally unresponsive. The author has personally been surveyed during his morning commute to University, but this was on a train where passengers are a more captive audience, albeit for as little as five minutes. In general, people became more responsive and willing to participate as the day progressed, and there was still a reasonable response rate in the late afternoon/early evening as people were returning home from work or study. However, fading light conditions meant that there was a limit to how late surveys could successfully be conducted. The general weather conditions also dictated how successful each survey period was going to be, as virtually no-one was willing to stop and be tested when it was raining, even where a bus shelter provided temporary shelter (all three bus stops selected for the pilot had a shelter). People were slightly more willing to participate when it was dry and cold or windy, but again they did not want to stop for too long, which meant the questionnaire length had to be kept at a minimum. After one long afternoon waiting at a dry, but very cold bus stop ('Pollokshaws Road opposite Marywood Square'), with very few people passing by and almost no-one agreeing to stop and participate in the surveys, the benefits of conducting indoor tests became all too apparent.

5.6.2 Alterations to the Questionnaire Design

As discussed, the limited amount of time available for at-stop testing required a questionnaire design which was as efficient as possible. There was great variation in the length of time it took to complete the whole survey, as some respondents provided short, straightforward answers to all questions, whilst others were keen to discuss issues surrounding PT and PTI at greater length.

The initial questionnaire and revised questionnaire can be found in Appendix D. Some lengthier questions (with multiple answers) had been included in the initial questionnaire (Questions 13, 14 and 15 in Questionnaire version 1) to ascertain if asking such questions under the time constraints was viable, but it quickly transpired that this was not the case and so these were removed from the final questionnaire.

Apart from the standard revisions of rewording questions to improve their clarity and removing any potential leading statements, there were no substantial changes required to the questions within the questionnaire. However, the layout was slightly altered to mix-up the questions that used a Likert-scale for answers and those which required a simple 'Yes/No' answer, to improve the fluency of the overall questionnaire (Burton, 2000) and to prevent respondents having to endure repetitive sets of questioning which returned monosyllabic answers. Very few pilot respondents returned substantial answers for the open-ended questions towards the end of the questionnaire, but it was deemed important to retain such questions to allow for any important comments and suggestions to be recorded.

To assist with the recording of answers from all the different respondents, and also to minimise the mass of paper that would be carried around during the fieldwork, an answer matrix (see Appendix D) was developed. This minimised the amount of individual questionnaires that needed to be printed (reducing expenditure on the Department's printing and paper resources), and made it easier for responses to be recorded and acted as a coding sheet for entering the answers into Excel for data cleaning and analysis purposes.

5.6.3 Appropriate Choice of Network Map

One final finding from the pilot study related to the choice of Network Map. Although it is desirable to test the SSBM against a number of different Network Map designs, it is also important to provide respondents with information that they are able to use under test conditions. The Glasgow 'MapMate' design (Figure 5.1) can be said to be quite busy in a visual and graphical sense, particularly upon first inspection. This proved to be challenging for a significant proportion of the respondents, particularly older respondents, with many not understanding the different design features and simply did not know where to begin the journey planning tasks. It was felt that in order to obtain any data at all, the Network Map used would have to be one that adopted a more standard design, so the final tests for Glasgow would use the schematic 'Overground' Map which features across all of First Group's networks through the country, and an appropriate map would also be selected for the other test locations.

5.6.4 Alterations to the Stop-Specific Bus Maps

The majority of respondents were able to successfully plan a journey with the SSBMs, but on reviewing the comments about the initial design used for the SSBMs, it was clear that the overall clarity had to be improved. There were two interrelated design issues identified from the pilot tests – the first related to the level of visual clutter on the more complex SSBMs; the second was concerned with the ability to follow an individual service (or service group) along sections of common route.

No specific solution was given by any respondent as to how the visual clutter problem could be dealt with. General comments such as "this section [pointed to on the SSBM] is too busy" and "I can't follow the different routes of each bus" suggested that the amount of detail shown on the SSBMs had to somehow be reduced, but without affecting the level of information provided. Upon a visual inspection of the busiest sections of the SSBMs, it was clear that these were either towards the origin bus stop and the trunk of the SSBM, or in the main urban areas, where many services converged. The busy areas were also ones where many individual bus roads required naming, and the presence of these individual names *alongside* each bus road essentially added an extra parallel item, which contributed to the undesirable level of visual clutter.

It was decided to experiment with superimposing the street names onto their corresponding road links to reduce the number of parallel items that appeared on the SSBMs, but this required an alteration to the width of the lines used for the service groups, which actually provided a solution to the second design problem, as discussed below.

A number of respondents commented on how they perceived the lines used to represent each service group as 'too thin'. Although contrasting colours for each service group were used where possible, respondents were still finding it difficult to follow the individual services, so the only suitable solution would be to increase the line width to one which would have more visual impact. The minimum line width initially used was 1.5mm (as defined by the specification) in order to minimise the visual dominance of the trunk section in relation to the remainder of the SSBM. The specification states that the maximum width of the trunk section should not exceed 10mm and upon reflection on the initial design, it was felt that a visually dominant trunk section could actually be a beneficial feature, especially on complex SSBMs, as it would emphasis the availability of services along this common section of route, presenting the user with an image of a PT system that was frequent and convenient to use.

It was therefore important to determine a new line width which would still generate a clean design of SSBM, but make it easier for users to follow individual routes. One further condition was that the new line width had to be able to accommodate superimposed text for the road names (as discussed above), and this condition would make it easier to quantify the new line width. The specification refers to two features which would also solve these design problems. The first requires the individual lines for each service group to be separated by an achromatic casing. As well as improving the contrast between individual lines (by reducing the problems of colour-spreading and simultaneous contrast) thus making it easier for the reader to separate the parallel lines, the casing also gives additional space for lettering. However, this solution was difficult to incorporate into the paralleling process used in the design flowline, as a greater separation between the lines resulted in larger-than-desirable spaces between the lines at sharp bends and along links with a high degree of sinuosity.

The second solution proposed by the specification was to superimpose the lists of service numbers upon the lines to which they correspond, using white numbers reversed out of rectangles in the same colour as the line, a similar method to that used on the Lothian Buses 'French style' Network Map for Edinburgh. This approach was not applied for two reasons: first, the road names were now to be superimposed on the lines, leaving little space for the service number lists. Second, these lists of service numbers were clearly defined in the legend, and individual service numbers appeared alongside specific sections of routes to clarify which services in the group had departed from their sections of common route. Therefore, it was felt that trying to superimpose the lists of service numbers on the individual lines would be a challenging task, which only served to duplicate information elsewhere on the map.

The initial SSBM design used 'Arial 6pt Italic' for the road names, as this allowed the road names to be accommodated into the available space on the SSBMs whilst still remaining legible. If a 6 point font was to be retained, to superimpose text of this size onto a line would require a minimum line width of $(6 \times {}^{1}/_{72} \times 25.4) = 2.1167$mm, which was rounded down to 2mm. Upon experimenting with this new line width, it was found that the road names could be successfully superimposed onto the relevant lines, with a slight shift in position required if words included letters with descenders (although using capitals, including SMALL CAPITALS, would also have been a possible solution as this removes any descenders, in most but not all fonts, from the text). A slight alteration to the font was also necessary, from 'Arial 6pt Italic, Black' to 'Arial Narrow 6pt Bold, White', to improve the fit of the words onto the lines and to increase contrast between the text and the service group lines. This adaptation of the standard line width resulted in a clearer SSBM design and it was felt that individual lines could now be followed with greater ease.

It should be acknowledged that these changes resulted in the SSBM undergoing a degree of improvement before the final testing, whereas the other forms of PTI (Network Maps and Timetables/At-Stop Information) were provided in the form as they would be found by the average PT traveller. However, as the discussion about existing PTI (Section 1.3) has shown, there is such variation in PTI design and provision between individual areas that this was something that could not be resolved through the use of a standard design of either the Network Map or the Timetables/At-Stop Information. The study therefore had to work with the PTI information that was readily available in each area. To mitigate any issues caused by the variation in PTI across all test towns, all forms of information were tested under the same environmental conditions, using the framework as described in Section 5.4.4 to provide as fair a test as possible for each form of PTI.

5.7 Final Testing of the SSBMs

Once the lessons had been learnt from the pilot tests, the above alterations were made to the test procedure, the design of the SSBMs and the questionnaire and then the final SSBMs were designed for each of the randomly sampled stops in all four towns.

The final testing of the maps took place throughout Summer 2007 in Cambridge and York, followed by the tests in Glasgow and Edinburgh in Autumn 2007 through to Spring 2008. It was not possible to undertake many tests through Winter 2007 due to poor weather conditions and the limited amount of daylight available during this time of year.

5.7.1 Network Maps Used

As there is great variation in Network Map design and provision, it was not a simple task to provide a consistent form of map for each of the test areas. Therefore, the final Network Maps selected were ones which could be deemed to be standard Network Maps which most people would be likely to obtain when asking for a bus map. Hardcopies of these maps were collected, and a printed copy of the respective online versions were also sought to be used as a back-up in case an appropriate network map was unavailable.

Although it was hoped that the mapping information obtained would be impartial, the vast majority of available Network Maps were produced by the dominant PT operator in the area. Network Maps were not readily available in Cambridge, as neither the Tourist Information Centre nor the main Bus Station (in Drummer Street) had copies which were available for the travelling public to obtain or even purchase. A map produced by Stagecoach showing their seven high-frequency ‘Citi’ services was available from a small Travel Information Centre located in the vicinity of the Bus Station, but it was felt that this map was too limited in its scope as it only covered the ‘Citi’ services across the Cambridge City area and was not comparable to the information available on the timetables or the SSBMs.

Whilst it could be said that this is the situation faced by the everyday traveller, there were plenty of individual service timetable leaflets with associated individual route maps on offer, so determined travellers would be able to find information about the majority of services if they persevered for long enough. Therefore, it was decided to use the back-up Network Map which was obtained from the Cambridgeshire County Council website. This version of the Network Map comprised two maps (both in the ‘Classic’ style), a main Cambridgeshire-wide map and a detailed Cambridge City map. Both maps showed all services provided by all operators but did not distinguish between the operators and so where different operators had services with identical numbers, it was not possible to tell who provided them.

In comparison, mapping information was available at many locations across Edinburgh, mainly due to the efforts of Lothian Buses. A3-sized ‘French’ style Network Maps were available at Lothian’s own Travel Centres, St. Andrew’s Bus Station and on the concourse at Edinburgh Waverley station, and were complemented by the diagrammatic SSBMs at the majority of bus stops. Poster versions of the A3 map also appeared at key bus stops across the city but, perhaps uniquely for a map produced by an operator and not an LA, also included the services of other operators (Figures 5.2 and 5.3). First Group also produced a schematic Overground map of their services, but this covered a substantial area including Dunbar and North Berwick in the East, Falkirk and Livingston in the west and Penicuik and Gorebridge in the South, and was only available online as a hardcopy could not be obtained before testing commenced. Therefore, it was decided that the Lothian Buses map should be used as it was the Network Map that was readily available and would be likely to be obtained when someone asked for a ‘bus map’ whilst travelling within Edinburgh.

Figure 5.2: Example of Lothian Buses’ Network Map showing all services in the Edinburgh Area

Figure 5.3: Legend of Lothian Buses’ Network Map

The situation surrounding Network Maps in Glasgow was similar to that in Cambridge. As discussed in the pilot study, many people found the MapMate design difficult to use so it was decided to revert to the standard Overground schematic map produced by First Glasgow. However, apart from the usual online source, this map was only found to be distributed as part of the timetable booklets of the Overground services, but not in the booklets of other (secondary) services.

All information was available at SPT Travel Centres, including Buchanan Bus Station, so it was assumed that travellers would have a good chance of obtaining a copy of this map. The only other Network Map that was found for the Glasgow area was an online version produced by Arriva West Scotland, but this map primarily covered the Paisley and Inverclyde areas, and thus was not suitable for testing in Glasgow.

As there was no dedicated Bus Station in York, the only other source of PT information appeared to be the Tourist Information Centre, which was located within York Railway Station. It transpired that this would be the only TIC visited during this research which actually had current bus information to hand. The Network Map obtained was produced by First York, and was more akin to a bus guide as it comprised *four* individual maps on one double-sided colour A2 sheet. As York's bus network was amongst the smallest of those used for the tests, the bus guide included the standard 'Overground' schematic map, a geographically true Network Map in the 'French' Style (which depicted the same information as the 'Overground' map) and a dedicated map showing the five park and ride services on one side of the sheet. On the reverse, was a City Centre inset map showing the stops served by each of the individual services, plus service frequency charts (for the 11 regular bus services) with accompanying line diagrams - a significant amount of information for a user to digest.

5.7.2 Overall Impressions of the Final Field Tests

In general, the final testing of the SSBMs proceeded without any significant problems. It was evident that in all four areas, some respondents were able to use the information provided whilst others had some difficulties. By comparing respondents' performance using the SSBMs with their performance using the Network Maps and Timetables/At-Stop Information actually available in each of four different towns, the overall results are more representative of those for Britain as a whole than the results for one town would have been. If somehow the same type and quality of Network Maps and Timetables/At-Stop Information which existed in one town was also available in the other three towns, the results would have been difficult to interpret. Most likely they would have been largely a four-fold replication of the results for the town taken as the standard. Any differences in results between towns would arise from the uncontrolled factors such as differences in patterns of streets and bus routes and in the innate ability of respondents, but these are not of primary interest in this investigation.

Regarding the intercept approach, once the method had been fully mastered, identifying and intercepting suitable passers-by proved to be an effective method of obtaining respondents and conducting on-street PTI surveys, although a reasonable proportion of responses were also obtained from people currently waiting for a bus.

One problem was encountered in York whereby two of the SSBMs designed prior to arriving in the city turned out to be incorrect upon investigation of the test locations. The stops in question were 'Blossom Street, Stop C' and 'Micklegate, Stop A', both of which were individual bus stops which formed part of a bus stop cluster. The data used for the compilation of the SSBMs was obtained from online sources, but it was not entirely clear as to which services called at each individual stop within the cluster – the result of this uncertainty was that both SSBMs showed services that actually called at different stops within the cluster. This was not detrimental to the overall fieldwork as tests that day were undertaken at other stops within York, then the offending SSBMs were rectified in the evening and were reprinted and tested the following day instead. Although this was a minor setback, the experiences from York illustrates how online information can be incorrect and potentially misleading, especially to someone who is not familiar with the location in question and is following a set of printed instructions to the letter.

The next chapter analyses the responses given for the different forms of PTI, and assesses how effective the SSBM concept could be compared to the traditional forms of PTI.

6.1 In this Chapter

This Chapter presents an analysis of the field tests to evaluate the potential impact of the SSBM concept. An assessment of whether the sample obtained in this study (using the bus stop interception technique) represents the national travelling population and travel patterns is followed by a detailed analysis of various aspects of the user tests to compare the performance of the SSBMs with that of the existing forms of information. The Chapter concludes with a discussion about the potential of SSBMs for increasing future bus use.

6.2 Analysis of Sample Profile

As a strict quota controlled sample was not achievable within the bus stop environment, it is important to ascertain how representative the final sample obtained through the intercept approach actually is. However, this research is concerned with conducting map (and other PTI) tests but every person is potentially a map user and there is no easily defined 'British map user' population to which the sample could be compared.

Therefore, as this is a study on *Public Transport* Maps, the sample has been compared on a transport and travel basis to the national travelling population. Appropriate comparisons have been made with data from the concurrent National Travel Survey from the period in which the user tests were conducted, referred to hereafter as NTS07 (DfT, 2008a, 2008b).

6.2.1 Gender of Respondents

The final sample consisted of 636 respondents, 108 from both Cambridge and York (six test stops each), 204 from Glasgow and 216 from Edinburgh (12 test stops each). Overall, there is a fairly even split between males and females, 45% and 55% respectively, which is acceptable given that for all respondents in the NTS07, the male-to-female split was 48.1% to 51.9%.

The gender split is consistent when broken down by location, as shown in Table 6.1, so overall the age profile of the sample obtained is representative across all locations.

Table 6.1: Sample Breakdown by Gender and by Location

Gender	Total		Cambridge		Edinburgh		Glasgow		York	
	Number	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Male	286	45	47	44	90	42	98	48	51	47
Female	350	55	61	56	126	58	106	52	57	53
Total	636	100	108	100	216	100	204	100	108	100

6.2.2 Age of Respondents

One factor that affects the travel needs, choices and behaviour of an individual is their current place within the life cycle (Opperman, 1995; Goodwin *et al.*, 2004; Olaru, Smith and Ton, 2005; Scheiner, 2006; Hudson, 2008; Avineri and Goodwin, 2009) where the "family life cycle… explains differences in individuals' [travel] behavior *(sic)* at varying stages of their life and particularly their family life" (Opperman, 1995, p.537) and that "travel patterns and destinations vary as people move through their life cycle" (Hudson, 2008, p.52).

Analysis of cohorts (where participants are grouped into birth year classes) by Goodwin *et al.* (2004) of car-ownership over time revealed a pattern where "a *life-cycle effect* [is present, where] car ownership increases until the head [of a household] is in his/her early 50s, and then declines" (p.5) whilst the NTS07 identified that bus use is greatest amongst 17-20 year olds (51% of all NTS07 respondents in this age group stated they travelled by bus at least once a week), before declining throughout the adult years, then increasing again from the age of 60 onwards. This pattern of bus use is attributed to the increasing level of availability of a car and possession of a driving licence (as shown by Goodwin *et al.*, 2004), plus the introduction of concessionary bus fares for the over 60s throughout the UK.

As a result, age categories of varying periods were defined in the questionnaire to account for the various personal stages of the life cycle (Hoinville and Jowell, 1978; Settersten Jr. and Mayer, 1997) which have an effect on respondents' travel behaviour. It should be acknowledged that in taking a purely social science perspective, this life cycle approach could be said to be not as clearly definable as it is "…neither descriptive nor conceptual but metaphorical, suggesting an underlying sequence of events that everyone experiences rather than clear external milestones of development" (Austrian, 2008, p.1).

The breakdown of the sample by age group and comparison with the NTS07 sample (all respondents) is shown in Table 6.2a. This breakdown shows that most age groups are reasonably well represented in comparison to the NTS07, although the 35-49 age category is possibly over-represented, which is reflected in the under-representation of the 65 and over category.

Table 6.2a: Comparison of Age Distributions between the Study and the NTS2007

Study Sample			***NTS07 (Comparable Age Groups Used)***		
Age	**Number**	**%**	***Age***	***Number***	***%***
18-24	61	10	*17-20*	*977*	*7*
25-34	129	20	*21-29*	*2294*	*16*
35-49	215	34	*30-49*	*2902*	*21*
50-64	171	27	*50-64*	*4190*	*30*
65 & over	60	9	*65 & over*	*3646*	*26*
Total	636	100	*Total*	*14009*	*100*

However, it must be noted that the way in which responses to the NTS07 are categorised into age groups meant that direct comparisons with the life cycle approach were not possible; therefore the closest comparable age groups had to be used for some of the age categories used in this study. To provide a further check on the sample's representativeness using equal age groups, individual age group data was obtained from the respective English/Welsh and Scottish Censuses recorded in 2001. These were combined to give the same age groups used in this study and proportions calculated based upon the total population of those aged 18 or over in England, Wales and Scotland (n = 44,209,827) to provide an exact comparison with the sample's attributes (Table 6.2b):

Table 6.2b: Comparison of Age Distributions between the Study and the 2001 Census

Study Sample			***2001 Census (England/Wales & Scotland) those aged 18 and over***		
Age	**Number**	**%**	***Age***	***Number***	***%***
18-24	61	10	*18-24*	*4,810,980*	*11*
25-34	129	20	*25-34*	*8,118,326*	*18*
35-49	215	34	*35-49*	*12,163,938*	*28*
50-64	171	27	*50-64*	*9,998,909*	*23*
65 & over	60	9	*65 & over*	*9,117,674*	*21*
Total	636	100	*Total*	*44,209,827*	*100*

The comparison with the 2001 Census figures also indicates whilst most age groups are well represented, the 35-49 age category is over-represented and the 65 and over age category is under-represented, thus supporting the findings of the previous comparison using the NTS07.

It was notable that there were relatively few respondents from the 18-24 age category, and although it is not entirely clear why this is so, it is possible that this age category was the typical age of respondents who are at University or College and were thus unavailable at the time of the tests. One reason for the low numbers in the 65 and over category could have been that a number of people of this age were reluctant to take part in the journey planning tests and thus refused to complete the entire survey. However, comparing the samples by town (Table 6.3) suggests that the proportion from each age category is reasonably consistent. In general, although a strict quota controlled sample was not adhered to, a careful application of the interception survey approach appears to have prevented any serious age bias in the final sample.

Table 6.3: Sample Breakdown by Age Group and by Location

Age	Total		Cambridge		Edinburgh		Glasgow		York	
	Number	%	Number	%	Number	%	Number	%	Number	%
18-24	61	10	8	7	20	9	25	12	8	7
25-34	129	20	22	20	53	25	42	21	12	11
35-49	215	34	35	32	76	35	66	32	38	35
50-64	171	27	32	30	48	22	55	27	36	33
65&over	60	9	11	10	19	9	16	8	14	13
Total	636	100	108	100	216	100	204	100	108	100

6.2.3 Travel Habits of Respondents

One secondary area of interest to this study is whether SSBMs could have an impact on how people choose to travel. At the time of writing, there is an increasing concern for the environmental impacts of car travel and increasing oil prices have resulted in the cost of petrol and diesel reaching record levels. These factors appear to have had some effect whereby many people are now seriously considering whether to leave their cars at home if there is a suitable alternative mode of travel. Nevertheless, people still have a desire to drive a car, viewing it as essential in their daily lives (Banister, 2002).

The interception method of testing used dictated that the sample of respondents comprised mainly people on foot passing by a bus stop, but also included those who were actually waiting at a bus stop. Those in the latter group were already bus users, and it was likely that those in the former group were potential bus users, but it was not at all obvious what other forms of transport they currently used. Therefore, it is worthwhile comparing respondents' answers to questions on their travel habits with the results of the NTS07.

The breakdown of the sample shows that the majority of subjects can drive, 70% of respondents stating that they have a current licence (Table 6.4), a figure comparable with the NTS07 figure of 71%. Breaking the responses down by gender reveals that male drivers are perhaps under-represented whilst female drivers are slightly over-represented.

Table 6.4: Availability of Driving Licence, by Gender

Driving Licence	**Total**			**Males**			**Females**		
	Number	**%**	***NTS07 %***	**Number**	**%**	***NTS07 %***	**Number**	**%**	***NTS07 %***
Yes	447	70	*71*	208	73	*80*	239	68	*63*
No	189	30	*29*	78	27	*20*	111	32	*37*
Total	636	100	*100*	286	100	*100*	350	100	*100*

Regular access to a car presents a different picture, as 67% of the sample has regular access to a car compared to the NTS07 figure of 81%, as shown in Table 6.5.

Table 6.5: Regular Access to a Car (either as a driver or passenger)

Regular Access to a Car	**Total**			**Males**			**Females**		
	Number	**%**	***NTS07 %***	**Number**	**%**	***NTS07 %***	**Number**	**%**	***NTS07 %***
Yes	427	67	*81*	191	67	*84*	236	67	*78*
No	209	33	*19*	95	33	*16*	114	33	*22*
Total	636	100	*100*	286	100	*100*	350	100	*100*

It is well documented that areas suffering from social deprivation are often those with the lowest level of car ownership and thus people living in these areas are more reliant upon PT services. Therefore, it was also important to compare accessibility to a car between the individual locations. Table 6.6 shows the availability of driving licences by area and indicates that Cambridge and York have above average levels of driving licence possession. This could be due to the rural nature of areas surrounding both Cambridge and York, where people will rely on their cars more than in other areas, although some respondents in Cambridge commented on how they do have a driving licence but prefer to cycle around the city instead.

In contrast, both Glasgow and Edinburgh have slightly below average levels of driving licence possession, but this could be explained by the fact that both cities have the lowest level of cars per head of population in Scotland, Glasgow at 0.25 cars per head of population and Edinburgh at 0.32 cars per head of population (Scottish Government, 2008). Despite a difference in the number of current driving licences, regular access to a car is remarkably consistent across the towns: at least 66% of all respondents in each area have regular access to a car (Table 6.7).

Table 6.6: Availability of Driving Licences, by Town

Driving Licence	**Total**		**Cambridge**		**Edinburgh**		**Glasgow**		**York**	
	Number	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Yes	447	70	80	74	143	66	138	68	86	80
No	189	30	28	26	73	34	66	32	22	20
Total	636	100	108	100	216	100	204	100	108	100

Table 6.7: Regular Access to a Car (either as a driver or passenger), by Town

Car Access	**Total**		**Cambridge**		**Edinburgh**		**Glasgow**		**York**	
	Number	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Yes	427	67	74	69	146	68	135	66	72	67
No	209	33	34	31	70	32	69	34	36	33
Total	636	100	108	100	216	100	204	100	108	100

Current frequency of bus use is another factor which may have an effect on both users' performance in the PTI use tests and also on their impressions about the SSBM concept, based upon respondents' previous exposure to, and experience with, existing forms of PTI. However, comparing the sample with the NTS07 responses indicates that the sample collated in this study is not representative as a whole, as shown in Table 6.8. Only 27% of NTS07 respondents used the bus at least once a week, whilst 44% said they never used the bus. In comparison, 77% of the sample used the bus at least once a week, and less than 1% said they never used the bus.

Table 6.8: Frequency of Bus Use

Frequency of bus use	**Total Sample**		***NTS07***	
	Number	**%**	***Equivalent Frequency***	***%***
5+/week	82	13	*3+/week*	*17*
3-4/week	150	24		
1-2/week	255	40	*1-2/week*	*11*
1-2/month	139	22	*<1/week or 1-2/month*	*12*
<1/month	8	1	*<1/month or 1-2/year*	*16*
Never	2	< 1	*<1/year or never*	*44*
Total	636	100	*Total*	*99*

There are a number of reasons why the sample obtained for this study appears to be so unrepresentative of the overall population's bus use. One key factor is the location in which the data was obtained. The NTS07 is a *national* survey and so will include responses from both urban and rural areas, and each area will have different levels of PT provision. In the rural areas, PT provision is limited and it is highly likely that most people will rely on their cars as their primary means of transport and so bus use will, in general, be relatively low. In contrast, all responses gathered for this present study were obtained in urban areas where there is greater PT availability and thus more opportunities to travel by this mode.

The NTS07 is a diary- and interview-based survey in which participants record all their travel patterns over the course of a week, including responses from people who drove everywhere and consequently never used buses. In comparison, respondents in the sample obtained for this research were surveyed in and around bus stops, including people who were actually waiting for a bus, thus greatly increasing the likelihood of obtaining a response from someone who made regular bus journeys. It was not possible to stop anyone who was driving by the bus stop, those on bicycles or generally anyone who was not on foot, and therefore every respondent surveyed was a potential bus passenger.

Also, the format of the questioning used might have had an influence on the actual answer given as peoples' bus use can vary from week to week, so for this research they were asked how often *on average* did they use bus services in their local area, which takes into account their general bus use, compared to the weekly 'snapshot' obtained for the NTS07. By asking how often on average people made use of bus services, it is quite possible that they will slightly overestimate their actual bus use, influenced by occasions when they made frequent bus journeys.

Table 6.9 shows the breakdown of the sample by frequency of bus use and by individual town, and suggests that frequent bus use – defined as being at least once a week – is highest in Edinburgh (83%) and lowest in Cambridge (69%). Glasgow and York fall between the two, at 75% and 74% respectively.

Table 6.9: Frequency of Bus Use, by Town

Frequency of bus use	**Total**		**Cambridge**		**Edinburgh**		**Glasgow**		**York**	
	Number	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
5+/week	82	13	9	8	38	18	26	13	9	8
3-4/week	150	24	30	28	54	25	41	20	25	23
1-2/week	255	40	36	33	87	40	86	42	46	43
1-2/month	139	22	30	28	35	16	49	24	25	23
<1/month	8	1	2	2	2	1	2	1	2	2
Never	2	0	1	1	0	0	0	0	1	1
Total	636	100	108	100	216	100	204	100	108	100

Overall, it can be said whilst there might be some slight discrepancies between the general national picture of British travellers provided by the NTS07 and that obtained in the present sample, the breakdowns in this section show that the respondents are reasonably representative of what can best be described as 'British bus users and potential bus users'. Although the analysis of the sample suggests respondents do not have easy access to cars and make more use of buses compared to the 'general travelling public', they do include a sufficient proportion of respondents who currently make substantial use of cars, thus ensuring that the test results do not rely solely upon the experiences and opinions of existing bus users.

6.3 Effectiveness of the Different Forms of Public Transport Information

Respondents were asked to plan two individual journeys from the particular stop, using a different form of PTI for each individual journey. The overall performance of all forms of PTI would be compared to assess whether people were able to use SSBMs more efficiently than the existing, traditional PTI.

To minimise any bias, if respondents stated that the journey they had been asked to plan was one which they made on a regular basis, and were thus familiar with it, their answer was removed from the final dataset to minimise any effects that might occur due to previous knowledge. The aim was to eliminate those replies where the respondent could have provided a correct answer without referring to the PTI whatsoever, whilst not preventing respondents with local knowledge from using this knowledge to help them in tasks relating to other journeys, which required reference to the PTI. This left 411 valid journeys planned with the SSBM, 413 with the Network Maps and 415 with the Timetables, a total of 1239 valid journeys. As in Gill's study (1986), all of these valid answers relied solely on the information within PTI provided.

6.3.1 Statistical Techniques Used

The user tests collected a variety of results, both in terms of respondents' performance (e.g. time taken to return an answer; the correctness of an answer) and opinions (e.g. ease of use of different PTI, potential level of future bus use), which were sought through the use of Likert scales. Whilst some analysis would be straightforward, there is much debate surrounding the use of parametric statistical analysis (such as *t*-tests) on non-continuous, interval or ordinal data, as is typically obtained when employing a Likert scale. Likert scales require users to give a response to questions that are constrained to a particular level of agreement or opinion (e.g. Disagree/Neutral/Agree, Low/Medium/High etc.), or on a scale from one to five (or sometimes one to seven) where each interval between two points on the scale cannot necessarily be deemed as equal. However, some argue that Likert scales concerned with personal or emotional questions represent a psychological continuum which cannot be easily limited to five or seven clearly defined intervals[1] and therefore parametric tests *are* suitable for analysing Likert scale data.

Romano *et al.* (2006), Allen and Seaman (2007) and Achyar (2008) provide detailed discussions about the most suitable methods for analysing ordinal and Likert scale data, the general consensus being that although it is possible to consider such data as being continuous, "[a] Likert Scale is most suitable being analyzed *(sic)* by non-parametric procedures such as frequencies, tabulation, chi-squared statistics, and Kruskall-Wallis" (Allen and Seaman, 2007). Although non-parametric statistical tests are not as powerful as their parametric equivalents, they are not constrained by as many underlying assumptions about the datasets used. The Likert scale responses collected through this research will not be assumed to be continuous and therefore, non-parametric tests will be used where necessary.

6.3.2 Correctness of Answer

When using PTI, the desired result of the user is to identify the correct service for their journey. It is of little use having beautifully designed, wonderfully detailed PTI if people are unable to find the correct answer to their queries, so it is important to examine what type of answers people were giving with each form of PTI. All valid answers were assigned one of four possible categories of correctness, derived from the categories adopted by Morrison and Forrest (1995):

1. Correct service, optimum
2. Correct service, non-optimum
3. Wrong service
4. No response/Don't Know

One key feature of the SSBM concept is that it should initially allow the user to quickly identify the subset of calling services which would take them towards their desired destination, and from this work out which service(s) would be the optimum choice for their journey. As many people are happy with simply finding a service that would eventually get them to their destination (Bronzaft, Dobrow and O'Hanlon, 1976), it was important to provide some measured difference between the 'correct' categories (1 and 2), as it was

[1] One such example can be found in a discussion between three medics, Drs. Seelig, Burke and Solomon, in the Journal of General Internal Medicine (1992), volume **7**(5), p.567.

envisaged that the answers given when using the SSBMs would have a greater proportion of the optimum service(s). It is also important to distinguish between a given answer that is wrong (category 3), and where no answer is given (category 4). If the journey in question was actually undertaken, then those in the former category would be in danger of boarding an incorrect service which would not take them to their intended destination, whilst those in the latter category would possibly seek assistance from another person waiting at the bus stop or directly from a bus driver. The eventual outcome of this enquiry should enable them to be directed towards a correct service.

Table 6.10 presents the breakdown of the answers into the different categories of correctness and clearly shows the superior performance of the SSBMs over the other forms of PTI. Chi-squared analysis suggests that there is a significant difference between the distribution of responses between the SSBMs and Network Maps ($\chi^2(3) = 63.986$, $p < 0.001$) and between the SSBMs and Timetables ($\chi^2(3) = 65.584$, $p < 0.001$).

Table 6.10: Breakdown of Responses by Category of Correctness

Public Transport Information Used	**Correct Answers**				**Incorrect Answers**			
	Optimum		**Non-Optimum**		**Wrong Service**		**No Response**	
Stop-Specific Bus Map	315	76%	37	9%	19	5%	40	10%
Network Map	223	54%	32	8%	87	18%	85	20%
Timetable/ At-Stop	234	56%	31	7%	14	4%	136	33%

Respondents were able to find more 'correct, optimum' answers using the SSBMs: 76% of all valid answers given were in the 'correct, optimum' category compared to 54% for the Network Maps and 56% for the Timetables. Overall, 85% of answers given with the SSBMs were correct and so the respondent would have been able to make the journey successfully. This is a figure comparable to the previous study into PTI use by Cain (2004) who found that 93.6% of all subjects were able to successfully use a PT map during the journey planning process, although in the present study, only 62% of respondents were actually able to obtain a correct answer using the Network Maps. The SSBMs also performed best with respect to incorrect answers, returning the smallest proportion of 'wrong service' or 'no response' answers of all three forms of PTI: 15% of respondents who used a SSBM gave an incorrect answer, compared to 38% for the Network Maps and 37% for the Timetables. This finding contrasts somewhat with the results from previous studies where Network Maps generally outperformed timetable information, although it must be noted that there is only a slight difference between the two groups in this study.

6.3.3 Time Taken to Plan a Journey

"A symbol whose correct meaning is perceived only after great thought is almost as inefficient as a symbol whose meaning is quickly, but incorrectly, perceived" (Kilkoyne, 1973, cited in Morrison and Forrest, 1995, p.128). As well as monitoring the correctness of the answers given, respondents were timed to see how long it took them to arrive at an answer, correct or otherwise, including instances where they were unable to find an answer and eventually admitted defeat. Table 6.11a and Figure 6.1 present the average journey planning times (in seconds) for each form of information, for the total sample and by individual town.

Table 6.11a: Average Journey Planning Times (in seconds)
for Each Form of Public Transport Information, by Town

Public Transport Information Used	Overall	Cambridge	Edinburgh	Glasgow	York
Stop-Specific Bus Map	16.76	15.25	16.24	17.89	17.20
Network Map	20.19	20.79	18.42	20.83	22.07
Timetables/ At-Stop	21.05	20.60	20.55	22.69	19.38

The results clearly show that, on average, people were able to arrive at an answer between three and four seconds faster when using a SSBM compared to the traditional forms of information. Although the magnitude of the differences are reasonably small, statistical analysis of the overall results indicates that the average journey planning time using a SSBM is significantly less than when using either a Network Map ($t_{(822)} = 6.69$, $p < 0.001$) or existing Timetables/At-Stop Information ($t_{(824)} = 8.40$, $p < 0.001$).

Looking at the times on an individual town-by-town basis, the most noticeable difference in performance occurred in Cambridge, where the SSBMs were around five seconds faster than their information counterparts, whilst performances varied across the other three towns. Further statistical analysis (Table 6.11b) reveals that the average journey planning time using the SSBMs is significantly faster than all forms of information in all towns, with the exception of Timetables/At-Stop Information in York:

Table 6.11b: Results of *t*-tests Comparing Average Journey Planning Times (in seconds) for Each Form of Public Transport Information, by Town

Town	SSBM versus	Difference in Average Time (sec.)	*t*-statistic	*p*-value
Cambridge	Network Maps	5.54	3.86	<0.001
	Timetables/At-Stop	5.35	3.92	<0.001
Edinburgh	Network Maps	2.18	2.85	0.005
	Timetables/At-Stop	4.31	5.46	<0.001
Glasgow	Network Maps	2.94	3.21	0.002
	Timetables/At-Stop	4.81	5.12	<0.001
York	Network Maps	4.86	3.85	<0.001
	Timetables/At-Stop	***2.18***	***1.82***	***0.07***

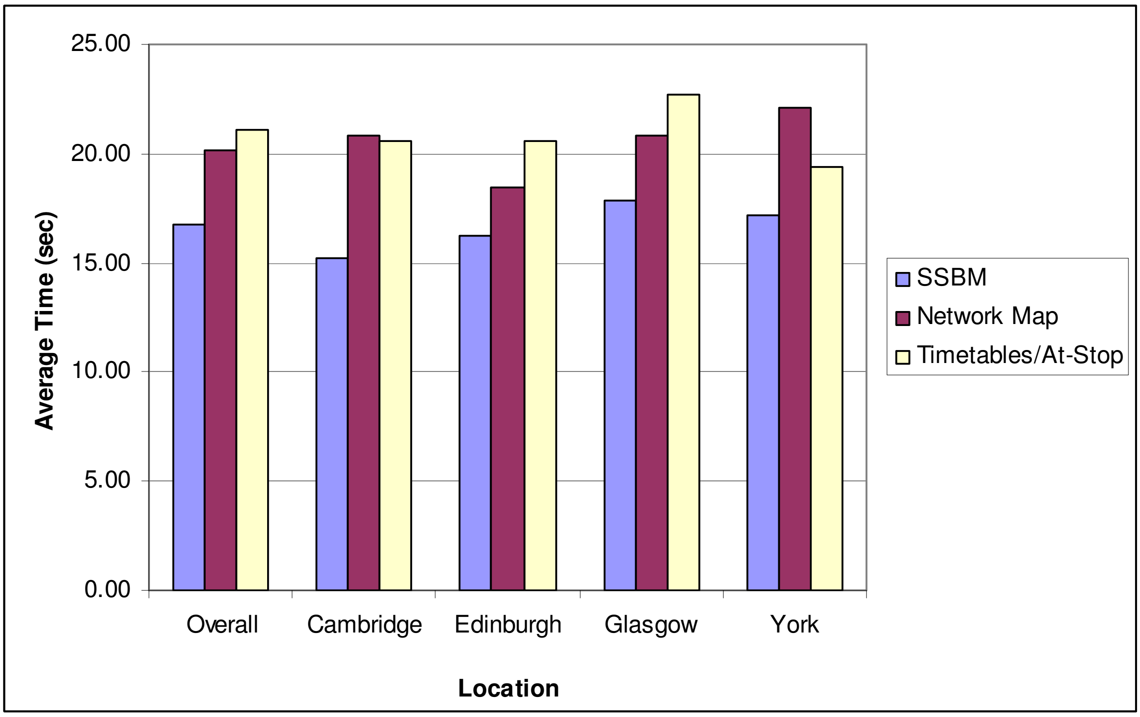


Figure 6.1: Average Journey Planning Times for Each Form of Information

6.3.4 Time Taken to Get a Correct Result

The analysis of both the degree of correctness and average journey planning times clearly show that, in general, respondents performed best when using the SSBMs. Cross-tabulation of all the results across the four test towns shows that the SSBMs were fastest in assisting respondents in finding a correct answer.

Table 6.12 shows the breakdown of response times by category of correctness and reveals that respondents using the SSBMs were significantly faster in finding a 'correct, optimum' answer than both the Network Maps ($t_{(536)} = 5.60$, $p < 0.001$) and the Timetables/At-Stop Information ($t_{(547)} = 6.56$, $p < 0.001$).

Table 6.12: Breakdown of Answer Times (in seconds) by Correctness

Public Transport Information Used	Correct Answers		Incorrect Answers	
	Optimum	**Non-Optimum**	**Wrong Service**	**No Response**
Stop-Specific Bus Map	15.80	17.15	15.97	24.35
Network Map	19.04	19.92	19.08	24.28
Timetables/ At-Stop	19.57	22.86	18.42	23.46

Respondents were also fastest in identifying 'correct, non-optimum' answers with the SSBMs, although in this instance the difference in performance between the two forms of mapping information could only just be considered as significant ($t_{(67)} = 1.65$, $p = 0.05$) whilst the performance of the SSBMs was significantly faster compared to the Timetables/At-Stop Information ($t_{(66)} = 3.21$, $p = 0.001$).

There are two interesting findings from this analysis. The first is that respondents were fastest in locating a wrong service with the SSBMs, with an average time similar to that of the 'correct, optimum' answers. One explanation for this could relate to the fact that respondents were conducting a journey planning task for a journey they were not actually going to undertake at that particular moment. Therefore, any answer they gave would not have any real consequence to them so it would not necessarily matter whether it was correct or otherwise. However, the relatively short amount of time in which respondents were finding an incorrect answer could indicate that they were accepting their initial answer, and not checking to see whether the service they had selected was correct.

The second interesting finding is that among the respondents who eventually gave up and could not find an answer there is little difference between the average times for each form of PTI. Respondents did spend slightly longer studying the two map-based forms of information, which could suggest that they are actually willing to persevere with this information more than with timetable information in order to find an answer to their query.

6.3.5 Possible Explanations for Wrong Answers

Although only 19 respondents (5% of all valid SSBM answers) provided a wrong answer, it is of interest to try and identify why these answers were given. Upon investigating these answers, it was apparent that the vast majority of errors were due to the user selecting the incorrect service number from the group of services represented by a single colour.

One example of this is illustrated in Figure 6.2, where two of the respondents (EDIUSH18 and EDIUSH23) who were asked to plan a journey to Slateford Station both gave service 1 as their answer when the required answer was service 34. Although they correctly identified the colour group (pink), it seems that they were unaware of the small route numbers alongside the relevant road links where services split from the common section of route for that particular group.

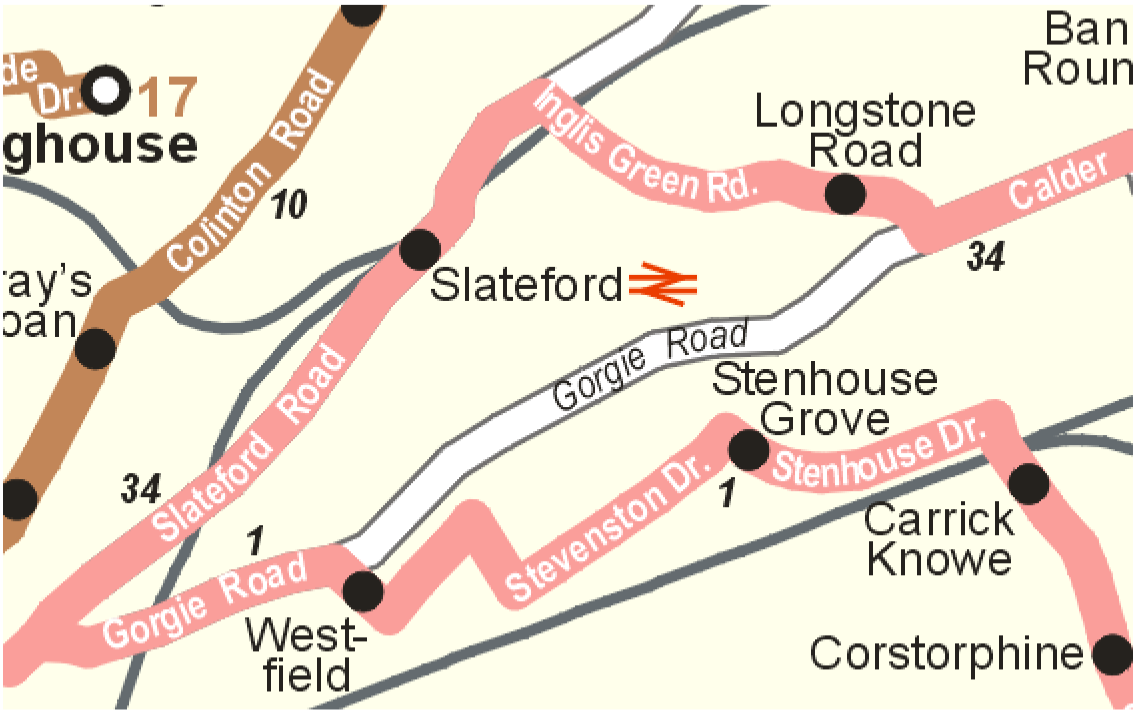


Figure 6.2: Sample from a Stop-Specific Bus Map showing the area around Slateford Station, Edinburgh (© G. Evans, 2008)

This has potential design implications for future SSBMs, as possible solutions include increasing the size of the text used for these labels or increasing their frequency along each relevant section. However, the compromise made here would be one affecting the overall clarity of the SSBM, as it is important to provide the user with a map that does not appears too cluttered on the initial viewing, yet both of these possible solutions could affect the final aesthetic quality of the SSBM.

Alternative solutions might include swapping the position of the route numbers and road names, so that the route numbers were superimposed onto the lines representing the bus routes, and were thus more easily related to the sections where services had split from their common route sections, whilst street names would be placed alongside the appropriate road sections.

This arrangement was experimented with in earlier SSBM prototypes and, in general, was suitable but only on SSBMs with less than 10 services, where there were generally fewer roads to be labelled. On SSBMs showing upwards of 10 individual services, it was found that positioning the numerous road labels alongside the relevant road sections, as opposed to superimposing them, resulted in a SSBM that appeared visually cluttered, and there were occasions where it was not possible to place a label such that it would be easily associated with its relevant section of road. In addition to this problem of potentially mislabelling roads, the space required for legible road labels, even when using common abbreviations (for example in Glasgow, where 'Great Western Road' can be shortened to 'Gt. Western Rd.') compared to that required for a service number, or even a list of service numbers, meant that it was usually easier to find enough room on the map face to include service numbers in a logical place.

One further solution that was not considered was the application of different styles, such as dotted lines, dashes or broken lines (all using the same base colour) to represent the individual sections of routes beyond the various points where services split from their common section of route. This approach would have to be carefully applied so that any other line styles used for infrequent or limited services, peak hours only routes and other service alterations are still easily distinguishable.

Where a wrong answer was given which could not be attributed to choosing an incorrect service from a group of services, there was no definite reason for the answer other than human error in reading the map. Nevertheless, as 86% of answers given when using the SSBM were classed as correct, it appears that most people are able to identify the correct service when using SSBMs, even where answers require the identification of an individual service which has split from its common section of route.

Turning to the wrong answers given with the other forms of information, of particular concern are the 18% of answers given for the Network Maps that were wrong, a much higher proportion than for the other forms of information (Table 6.10). Further investigation into the potential causes of these answers provided some possible reasons as to why people were unable to use this information successfully, ranging from human error to poor map design.

a) Selecting Incorrect Service Numbers

One example of a wrong answer that can be attributed primarily to poor map design, can be found in Cambridge (CAMGAZ2). The answer provided for a journey to 'The Leys School' was service 010, which actually corresponds to a National Express coach service which, although presented on what is essentially a local bus map, is not clearly distinguished in the legend.

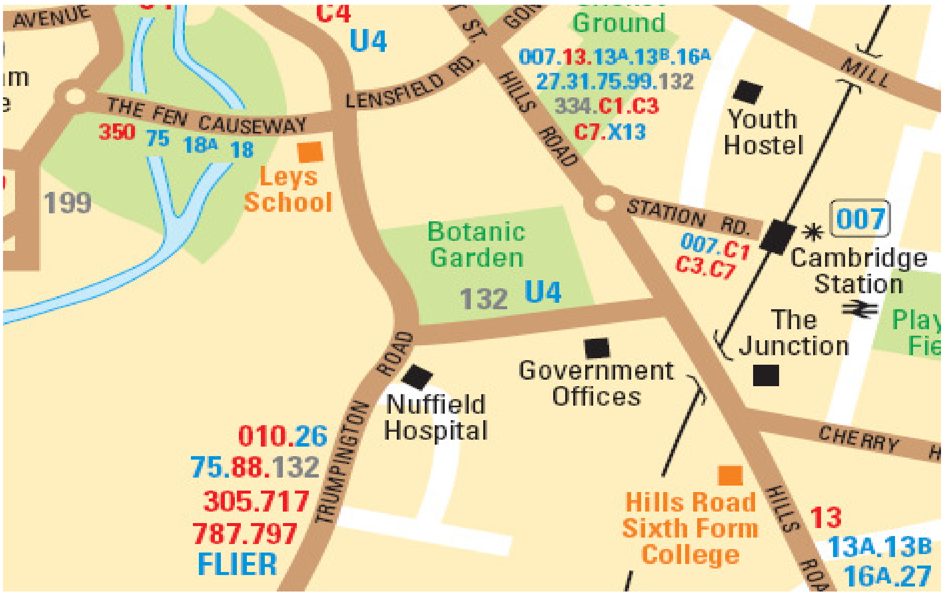


Figure 6.3: Confusion Caused by Lists of Service Numbers on 'Classic' Style Maps

As shown in Figure 6.3, the 010 appears in red which indicates it operated seven days per week, so users could be forgiven for thinking this was a local bus service, particularly as throughout the period of testing Stagecoach operated a peak service 007 between the city centre and the railway station (this service no longer operates). The erroneous answer possibly occurred because service 010 was placed first in the numerical list of service numbers running along the relevant road (as shown in Figure 6.3). The particular respondent appeared to get quite frustrated with the map, and eventually gave the first answer he could find. This can be forgiven, however, as whilst it is true that service 010 does pass by The Leys School it does not stop there.

Although there are additional issues about showing coach services on local bus maps, this answer highlights one of the main disadvantages of the ‘Classic’ style of PT map, as it is difficult to tell from the map alone where services stop as there are usually no symbols used to represent any bus stops, let alone those bus stops served by limited stop services. Although ‘French’ style maps are able to represent individual bus stops, this is by no means an easy task to achieve, and many maps in this style also refrain from doing so, instead relying upon key bus stops and other important landmarks (Figure 6.6).

b) Misinterpreting line colours

Another possible human error is misinterpreting or misreading the different line colours used on ‘French’ style maps. As Morrison (1996a) identified, the maximum number of individual colours that should be used to represent the different services on a PT map is nine, as this should maintain clarity and minimise confusion between services. However, the Network Map used in Edinburgh attempted to show around 40 individual services with unique line symbology, assigning an individual colour to each route and not attempting to group services following common route sections (with a couple of exceptions where a service had two route variants e.g. 15 and 15A). Although it appears that colours have been selected so that for the majority of the map the routes of services assigned similar colours do not coincide, there is still some potential for confusion.

Figure 6.4 shows the area of Edinburgh within which West Coates test stop is located. One journey that respondents were asked to plan from here was to Musselburgh, on the opposite side of the city (Figure 6.5), with the required answer being service 26 (red line). At this stop, two individual respondents (EDIWCO13 and EDIWCO20) both gave service 30 as their answer, which does actually serve and terminate in Musselburgh, but does not serve West Coates bus stop. Comparing the information on the map in both areas suggests they were possibly confused by the subtle difference in the orange colouring applied to both service 30 and service 31, even though the lines are labelled with the respective service numbers at reasonably regular intervals. This Network Map used in Edinburgh is a prime example of a bus map design which contradicts the findings of Morrison (1996a), and highlights the particular problem of attempting to represent a large number of services on a single map with unique colours.

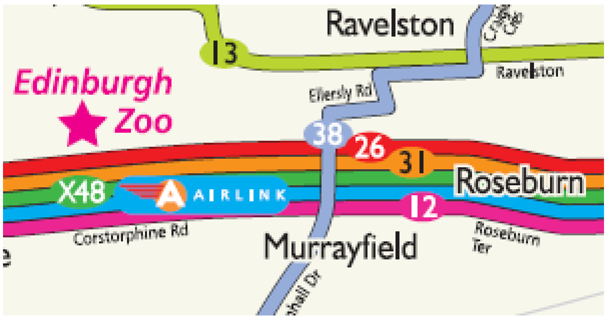


Figure 6.4 (above):
Area around West Coates,
Edinburgh (© Lothian Buses, 2008)

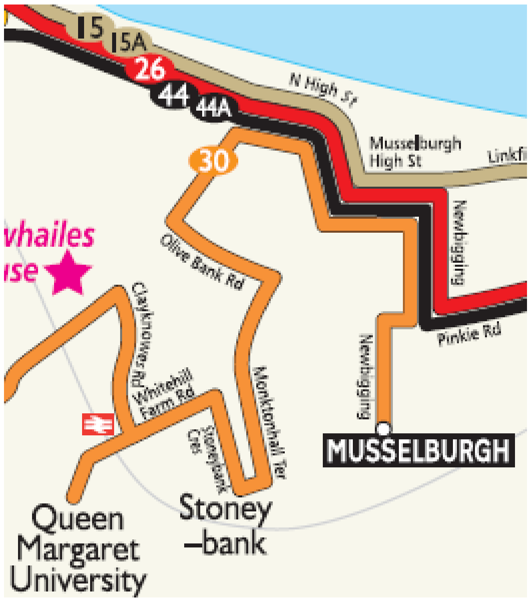


Figure 6.5 (right):
Area around Musselburgh, Edinburgh
(© Lothian Buses, 2008)

c) Identifying a correct route that does not leave from the particular stop

The above example from Edinburgh is one instance where the respondent did locate a service that would take them to the desired destination but only if he had been waiting at a different stop. When using a Network Map, the user first has to locate their current position, find the intended destination and then plan a journey between the two points. It seemed that a number of respondents were able to locate the destination and the routes passing by this location, but did not give much consideration to locating their current position on the map, and thus the available services operating from that point. In areas where many services converge, it is often difficult to represent the route taken by every individual service with enough clarity to make this part of the map useful and legible.

Many Network Maps resort to using a City Centre area mask on the main map although some also provide a separate City Centre inset map. Whilst this alleviates the problem of representing detailed areas, without an inset map it can be very difficult for users to identify their current location within the City Centre and almost impossible to determine which services call at a specific stop. This problem is illustrated by Figure 6.6.

Respondents were asked to plan a journey to Baillieston from a stop located on High Street, Glasgow City Centre, the location of which was not specifically shown on the map but was instead contained within a beige rectangle with 'Glasgow City Centre' written in its centre.

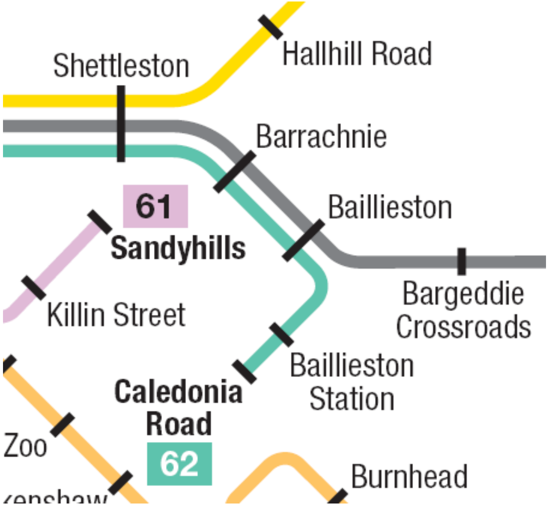


Figure 6.6: Extract from Overground Schematic Network Showing the Area Around Baillieston, Glasgow (© First Group, 2008)

One respondent (GLAHST4) gave service 62 as their answer. Whilst service 62 does indeed serve Baillieston, it does not depart from the actual bus stop on High Street at which the tests were being conducted. The actual answer required was service 262 which is shown on the network map in dark grey, and could possibly be mistaken for a main road, whereas service 62 is shown in turquoise and thus appears more prominent on the map. Another possible feature on this particular part of the map is the terminus point of service 62 at Caledonia Road, which is located in close proximity to Baillieston. It is possible that this respondent's answer might have also been partially influenced by the existence of the label showing service 62's route number at the terminus.

6.3.6 Measuring Respondents' Confidence Levels

The results of the journey planning tests clearly indicate that respondents were able to use SSBMs more successfully than the traditional forms of PTI. With such a high percentage of SSBM answers being classed as correct, it could be said that respondents would generally find the SSBMs easy to use. However it would be erroneous to assume that such a link exists, especially when the findings of the Literature Review suggest that many people are not confident when using mapping information.

After undertaking the journey planning tests, respondents were asked to rate how easy they found using the different PTI they were presented with, and also how confident they felt that they had found the optimum service for the given journey. Measuring how easy someone perceives a task is partly dependent on personal feelings, and is thus subject to some discrepancies between individual subjects. Previous studies have used bipolar or Likert scales to measure how easy subjects have found tasks, but a number of studies (for example, Bronzaft, Dobrow and O'Hanlon, 1976) adopted scales which appear too detailed to provide a useful measure of easiness. For example, just how different is a rating of 12/20 from 13/20? A confident person who finds a task 'very easy' could give a rating of 20/20 whereas someone who also finds the task 'very easy', but is more modest in their views, might give the same task a score of 17/20. Although using a scale with fewer graduations might not give the subjects the range of possible answers they may desire, it does allow for answers to be more defined and provide more consistency throughout the results. As discussed earlier, this then raises the question as to which statistical analysis approach is most suitable. Given that a five-point scale was used for both questions pertaining to the level of easiness and user confidence, non-parametric techniques will be employed here.

6.3.7 Ease of Use

Respondents were first asked to state how easy they found using each form of PTI presented to them for the journey planning tasks, on a bipolar scale of 1 to 5 where:

1 = Very Difficult
2 = Slightly Difficult
3 = Neither Easy nor Difficult
4 = Slightly Easy
5 = Very Easy

Figure 6.7 presents a comparison between the easiness of use for the three different forms of PTI across the entire sample, from which it appears that respondents found the SSBMs easier to use than both the Network Maps and the Timetable/At-Stop Information.

Overall, 53% of those who used a SSBM for one of their journey planning tasks stated that they found it 'slightly or very easy' to use, compared to 37% for the Network Maps and 28% for the Timetables/At-Stop Information. At the opposite end of the scale, SSBMs also performed best with only 17% finding them 'slightly or very difficult' to use, compared to 31% for the Network Maps and 34% for the Timetables/At-Stop Information.

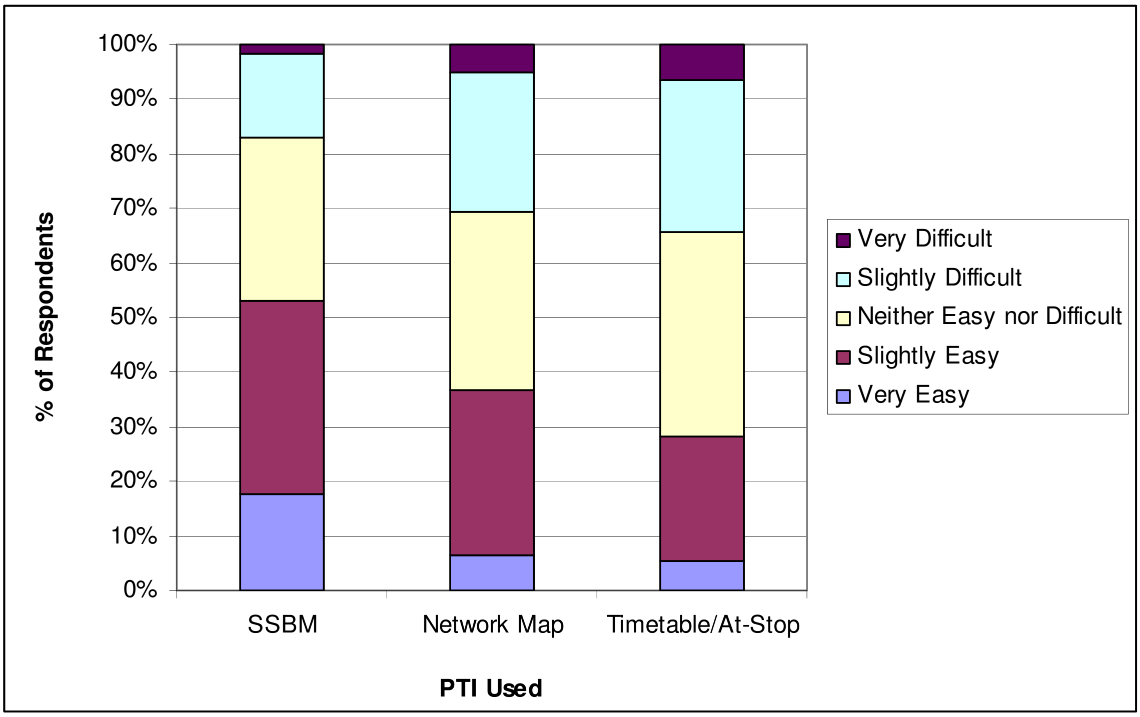


Figure 6.7: Ease of Use for Each Form of Public Transport Information

A Kruskal-Wallis one-way analysis of variance by ranks (Table 6.13) suggests that there is indeed a significant difference (at the 95% level) in the reported easiness of the three forms of information ($H_{adj}(2) = 73.21$, $p < 0.001$). The higher Z-value returned for the SSBMs indicate that the mean rank of all the SSBM responses was greater than that of the other forms of information. Additional Nemenyi post-hoc comparisons support this finding, revealing a significant difference (at the 95% level) between both the SSBMs and Network Maps, and the SSBMs and the Timetable/At-Stop Information.

Table 6.13: Easiness Scores Given to Each Form of Public Transport Information

Public Transport Information Used	**Median Score**	**Average Rank**	***Z*-value**
Stop-Specific Bus Map	4	752.4	7.96
Network Map	3	605.0	-2.17
Timetables/ At-Stop	3	552.2	-5.19

It is of interest that more respondents found the Timetables/At-Stop Information difficult to use rather than easy to use, although the primary function of a timetable is to assist people in identifying when a bus is due to depart from a particular stop. Nevertheless, it is reasonable to assume that as timetables are likely to remain the most common form of bus stop information for some time to come, passengers will have to continue to additionally rely upon them for journey planning purposes. The results of this analysis suggest that increasing the availability of mapping information (of all varieties) would be a suitable, and welcome, alternative.

6.3.8 Confidence with Using Public Transport Information

As well as finding the PTI easy to use, it is also important that people feel confident in their choice of service. If they are confident they have found a service which will take them to their destination, they are more likely to attempt the journey using PT and thus have more faith in the PT system for future use. Ideally, the service selected will be the optimum choice which is one that takes the most direct route to the intended destination, as this will instil the belief that PT is efficient and easy to use, and that it can fulfil journey requirements with a minimum amount of effort by the user.

Therefore, respondents were asked to state how confident they were that they had identified an optimum service for the given journey, again on a scale from 1 to 5 although this time a Likert-based scale was used where 1 = 'Not At All Confident' through to 5 = 'Very Confident'. The breakdown of the confidence ratings for each form of PTI is shown in Figure 6.8.

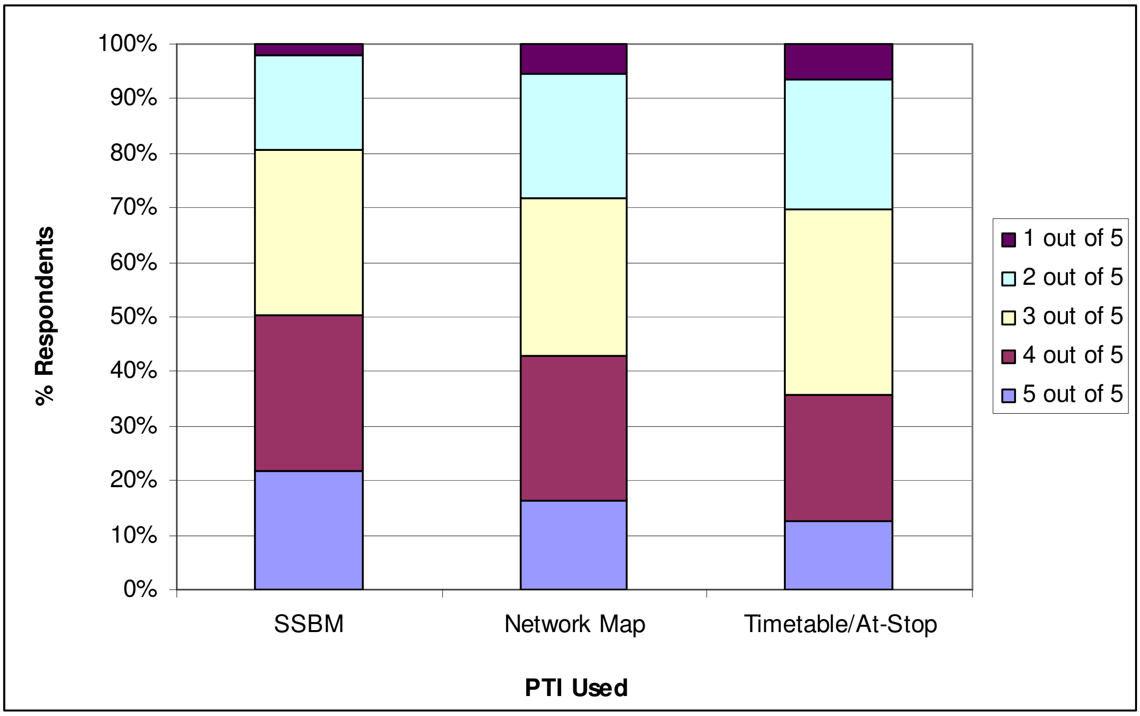


Figure 6.8: Confidence Scores for Each Form of Public Transport Information

As with all answers to personal preference questions, there is a tendency for respondents to slightly overstate how confident they felt, in order to not appear ‘weak’ or ‘unintelligent’. There were a few respondents (mainly younger males) who stated they were very confident, yet they had clearly appeared to struggle with the journey planning tasks. Figure 6.8 shows that respondents also appeared to be more confident when using the SSBMs compared to the other forms of PTI.

A Kruskal-Wallis one-way analysis of variance by ranks (Table 6.14) suggests that there is a significant difference (at the 95% level) in the reported confidence of users ($H_{adj}(2) = 25.34$, $p < 0.001$). Again, the higher Z-value returned for the SSBMs indicate that the mean rank of all the SSBM responses was greater than that of the other forms of PTI, and additional Nemenyi post-hoc comparisons support this finding, revealing a significant difference (at the 95% level) between both the SSBMs and Network Maps, and the SSBMs and the Timetable/At-Stop Information.

Table 6.14: Confidence Scores Given to Each Form of Public Transport Information

Public Transport Information Used	**Median Score**	**Average Rank**	***Z*-value**
Stop-Specific Bus Map	4	702.8	4.55
Network Map	3	625.4	-0.77
Timetable/ At-Stop	3	581.4	-3.79

Given these results, it can be said that SSBMs perform better than the traditional forms of PTI, with 50% of all respondents stating they felt ‘confident’ (4 out of 5, or 5 out of 5) that they had found an optimum service when using the SSBMs, compared to 43% for the Network Maps, and 36% for Timetables/At-Stop Information. Fewer people also felt unconfident with the SSBMs, as only 19% stated they did **not** feel ‘confident’ (1 out of 5, or 2 out of 5) about finding an optimum service, compared to 28% with the Network Maps and 30% with the Timetables/At-Stop Information. These results are perhaps to be expected, as the findings of past research in the Literature Review indicate that people naturally prefer graphical geospatial information when planning a journey or route, but these results also reinforce the belief that simplified graphical geospatial information would instil confidence into PT users and potential PT users.

6.4 Impact of Bus Stop Attributes

Thus far, the results indicate that there is definite potential for the SSBM concept. During the bus stop sampling process, it was identified that there are different bus stop attributes which contribute to the final cartographic design of the respective SSBM. The main attributes that were considered in the sampling framework were the number of individual services calling at the stop, the general directionality of services (towards the main urban centre or away from this centre) and whether the stop was located within the urban centre or the suburbs. At present, the length of time required to produce a single SSBM by manual processes means that to produce a SSBM for each and every bus stop in an area would not be commercially viable. One area of further work that will be necessary is the development of a system for the semi-automatic production of SSBMs from a GIS database, which will be discussed in more detail in a later chapter. In the meantime, if SSBMs were to be adopted before such an automated system exists, it would be advisable to target resources towards the production of SSBMs for those stops at which a SSBM would have the greatest effect. The difference in performance (level of correctness, and time taken to return an answer) between the different forms of PTI will be analysed for each of the above attributes, to attempt to identify which bus stops would be most suited to having a SSBM on display.

6.4.1 Number of Calling Services

It was thought that the number of calling services would be the particular bus stop attribute that would have the greatest effect on performance. This was primarily due to the fact that as the number of calling services increases, there will be more information to be portrayed on an individual SSBM. It is also likely that there will be a greater proportion of common sections of route and also a higher probability for interactions between individual services at a later stage in their routes, after they have split from their common section(s), resulting in a greater need to group services together in a sensible fashion on the SSBMs. A similar impact was observed for timetable information – a greater number of calling services require more individual timetables to be displayed at a bus stop. The only form of information unaffected by the number of calling services is a Network Map, as these do not change depending on the number of calling services, although the source of the map (namely an operator-specific versus an all-service LA map) could have some effect on which of the calling services were shown on the map.

The sampling framework divided the bus stops into three categories – those with one to five calling services, those with six to nine calling services and those with ten or more calling services. Table 6.15 shows the breakdown of responses with respect to their 'correctness' for the bus stops with one to five calling services and clearly shows the superior performance of the SSBMs: 89% of SSBM answers were categorised as 'correct, optimum', compared to 64% and 56% for the Network Maps and Timetable/At-Stop Information respectively.

Table 6.15: Breakdown of Responses by Category of Correctness
for Stops with One to Five Calling Services

1-5 Calling Services	**Correct Answers**				**Incorrect Answers**			
	Optimum		**Non-Optimum**		**Wrong Service**		**No Response**	
Stop-Specific Bus Map	97	89%	9	8%	1	1%	2	2%
Network Map	70	64%	7	6%	11	10%	21	19%
Timetable/ At-Stop	61	56%	6	6%	2	2%	40	37%

A chi-squared analysis of the differences in distributions shows that there is a significant difference between the SSBMs and the Network Maps ($\chi^2(3) = 28.644$, $p < 0.001$) and between the SSBMs and the Timetables/At-Stop Information ($\chi^2(3) = 43.517$, $p < 0.001$).

It is interesting to note that a higher proportion of respondents returned a wrong service when using the Network Maps than the other forms of PTI, whilst over one-third of respondents were unable to give an answer when using the Timetable/At-Stop Information. This latter result is particularly worrying, but it is possible that the limited amount of information on display did not instil enough confidence into the respondents to allow them to give a definite answer.

As the number of calling services increased, it was anticipated that the true benefit of the SSBM concept would be revealed. Tables 6.16 and 6.17 present the respective breakdown of answers for stops with six to nine calling services and ten or more calling services, and it appears that the results are not as initially anticipated. For stops with six to nine calling services (Table 6.16), there is a significant difference between the distribution of answers between the SSBMs and the Network Maps ($\chi^2(3) = 27.214$, $p < 0.001$), indicating a superior performance of the SSBMs. A greater proportion of correct answers were returned from the SSBMs compared to the Timetables/At-Stop Information (79% compared to 72%) which also demonstrates the advantages of the SSBMs, but the difference between the distribution of answers between the SSBMs and the Timetables/At-Stop Information was found not to be significant. At these stops, the Timetables/At-Stop Information also had a significant difference in distribution compared to the Network Maps ($\chi^2(3) = 23.896$, $p < 0.001$).

Table 6.16: Breakdown of Responses by Category of Correctness
for Stops with Six to Nine Calling Services

6-9 Calling Services	**Correct Answers (%)**				**Incorrect Answers (%)**			
	Optimum		**Non-Optimum**		**Wrong Service**		**No Response**	
Stop-Specific Bus Map	104	72%	10	7%	6	4%	24	17%
Network Map	70	48%	7	5%	31	21%	38	26%
Timetable/ At-Stop	98	65%	10	7%	5	3%	38	25%

It is not entirely clear why the Timetables/At-Stop Information performed well whilst the Network Maps did not. The higher proportion of wrong services returned with the Network Maps could suggest that people were having difficulties with identifying the set of services which called at a particular stop and thus were having trouble identifying a correct service. This is particularly relevant where there may have been more than one calling service which could be deemed to be correct, as the stop-specific content of the Timetable/At-Stop Information at each bus stop may increase the probability of identifying a correct answer, whilst the Network Maps used in the testing had no stop-specific content whatsoever.

For stops with ten or more calling services, the results again showed a superior performance of the SSBMs compared to the other forms of PTI (Table 6.17). For these stops, the SSBMs answers had a significantly different distribution to those of the Network Maps ($\chi^2(3) = 16.874$, $p = 0.001$) and of the Timetables/At-Stop Information ($\chi^2(3) = 36.500$, $p < 0.001$).

Table 6.17: Breakdown of Responses by Category of Correctness
for Stops with Ten or More Calling Services

10+ Calling Services	**Correct Answers**				**Incorrect Answers**			
	Optimum		**Non-Optimum**		**Wrong Service**		**No Response**	
Stop-Specific Bus Map	114	72%	18	11%	12	8%	14	9%
Network Map	83	53%	18	11%	31	20%	36	16%
Timetable/ At-Stop	75	48%	15	10%	7	5%	58	37%

Overall, it can be said that the SSBMs outperform the other forms of PTI, but it is interesting to note the similar level of SSBM performance between those stops with six to nine calling services, and those with ten or more calling services. Previous analysis of the correctness of answers suggested that misinterpretation of the grouping of services was the main reason for the incorrect answers given with the SSBMs. The main benefit of grouping services together is that it reduces the actual number of individual lines on a SSBM and thus maintains a degree of clarity on the map face.

As Morrison (1996a) identified, to allow individual service groups to be distinguishable from one another a maximum of nine individual colours should be used, so it was originally proposed that grouping would be *essential* on the SSBMs with ten or more calling services, whilst on those with six to nine calling services it would be possible to represent each service with a unique colour, but grouping would be applied when deemed suitable. During the SSBM design process, it became clear that the vast majority of services always followed a portion of common route (usually along a bus corridor) and it was actually quite rare to find a bus stop which was served by multiple services where each individual service followed a completely unique route after leaving that stop. This meant it was possible (in most instances) to apply an effective grouping scheme to each map, resulting in SSBMs from both the six to nine and ten or more categories having no more than five service groups on the map, fewer groups being utilized where possible. It is therefore a possibility that one unforeseen, yet desirable, side effect of the grouping process adopted during the design procedure was to reduce the design of all SSBMs to a comparable level of complexity, which in turn meant that there was no substantial difference in the overall search process required.

With respect to average answer times, it has been shown throughout this analysis that the SSBMs perform significantly faster than their traditional PTI counterparts. Given the increase in cognitive workload (the amount of information that needs to be studied, processed and then a decision made), it was expected that the time saving of the SSBMs would become more substantial as the number of calling services increased. Tables 6.18 to 6.20 show the breakdown of answer times by the number of calling services.

Table 6.18: Valid Answer Times (seconds), One to Five Calling Services

Public Transport Information Used	Mean Time	Std. Dev.	Minimum Time	Maximum Time
Stop-Specific Bus Map	14.60	5.83	4.25	31.97
Network Map	18.88	7.11	6.09	42.44
Timetable/ At-Stop	19.12	6.84	7.19	33.22

Table 6.19: Valid Answer Times (seconds), Six to Nine Calling Services

Public Transport Information Used	Mean Time	Std. Dev.	Minimum Time	Maximum Time
Stop-Specific Bus Map	17.59	7.52	5.29	40.17
Network Map	20.42	7.39	6.54	48.12
Timetable/ At-Stop	21.31	8.00	6.12	43.40

Table 6.20: Valid Answer Times, Ten or More Calling Services (seconds)

Public Transport Information Used	Mean Time	Std. Dev.	Minimum Time	Maximum Time
Stop-Specific Bus Map	17.50	7.29	4.83	44.81
Network Map	20.89	8.01	7.57	42.95
Timetable/ At-Stop	22.16	7.36	7.94	42.08

A one-way ANOVA statistical analysis (at the 95% level of confidence) of the answer times from each category demonstrates that there is a significant difference in the average answer times for each form of PTI for one to five calling services ($F_{(2,\ 324)} = 16.12$, $p < 0.001$), six to nine calling services ($F_{(2,\ 438)} = 9.47$, $p < 0.001$) and ten or more calling services ($F_{(2,\ 468)} = 15.69$, $p < 0.001$). Post-hoc Tukey comparison tests indicate that the SSBMs perform significantly faster than the other forms of information, regardless of the number of calling services. As with the correctness of answers, there is also a remarkable similarity in the average answer times between the SSBMs with six to nine calling services and those with ten or more calling services. It was originally anticipated that there would be a negative correlation between the answer times of the respondents and the number of services shown on a SSBM. This is indeed the case with respect to the SSBMs with one to five calling services but, as discussed, the similarities in design and general complexity of the SSBMs with six to nine, and ten or more calling services, could explain why the overall answer times and standard deviations of these latter categories are so similar. All the results from this section suggest that the grouping of services on SSBMs works well, for any number of calling services that are to be represented on the map.

6.4.2 Directionality of Services

The second bus stop attribute used in the sample framework relates to the general directionality of the services. There are a number of possible route types – transverse, radial, peripheral and circular – the combination of which usually results in the typical pattern of SSBM designs exhibiting a tree-like structure with a common section of route forming the tree trunk, the length of which is primarily dictated by the general directionality of the services.

From stops on inbound services, routes tend to operate along a long section of common route (usually a bus corridor) into the city centre before diverging to their respective destination, thus the SSBM will have a long trunk section. In comparison, from stops on outbound services, after leaving the stop in question buses split from the common section of route within a short distance (forming the branches of the tree) and thus the trunk section is typically much shorter.

Whilst every SSBM design is different, it is possible to draw some generalisations relating to the differences in design due to the general directionality of services. These generalisations are a) the range of available destinations from a particular stop and b) the number of different services available to each destination. For inbound stops, there is usually a single primary destination, namely the city centre, which will be served by the vast majority of services. For outbound stops, there are a number of potential destinations and most are served by only one or two services, as each individual service normally follows its own unique route to its eventual terminus. In certain situations where a bus stop is served by a peripheral or circular service, this may add further complications to the range of destinations on offer and to the final SSBM design.

These design factors essentially result in inbound SSBMs having less information for the user to mentally process and should thus be (theoretically speaking) easier to use than the other forms of information. In comparison, the content of outbound SSBMs means that users have a lot more information to mentally process, and so it was thought that the difference between these SSBMs and other forms of information would not be as discernible. Tables 6.21 and 6.22 show the breakdown of answers by direction of service:

Table 6.21: Breakdown of Responses by Category of Correctness for Inbound Stops

Inbound Services	**Correct Answers**				**Incorrect Answers**			
	Optimum		**Non-Optimum**		**Wrong Service**		**No Response**	
Stop-Specific Bus Map	151	82%	8	4%	8	4%	17	9%
Network Map	98	53%	8	4%	49	26%	31	17%
Timetable/ At-Stop	115	61%	11	6%	5	3%	58	31%

Table 6.22: Breakdown of Responses by Category of Correctness for Outbound Stops

Outbound Services	**Correct Answers**				**Incorrect Answers**			
	Optimum		**Non-Optimum**		**Wrong Service**		**No Response**	
Stop-Specific Bus Map	164	72%	29	13%	11	5%	23	10%
Network Map	125	55%	24	11%	24	11%	54	24%
Timetable/ At-Stop	119	53%	20	9%	9	4%	78	35%

The results suggest that the performance of the SSBMs is again superior compared to the other forms of PTI, regardless of the direction of travel. For the inbound stops, 86% of answers returned with the SSBMs were correct compared to only 57% for the Network Maps and 67% for the Timetables/At-Stop Information. Of the incorrect answers given, it is interesting to note that 26% of responses from the Network Maps were wrong answers, whilst 31% of respondents who used the Timetables/At-Stop Information were unable to return an answer.

Chi-squared analysis shows that for the inbound bus stops, there is indeed a significant difference in the distributions between the SSBMs and the Network Maps ($\chi^2(3) = 44.846$, $p < 0.001$) and between the SSBMs and the Timetables/At-Stop Information ($\chi^2(3) = 28.390$, $p < 0.001$).

The difference in performance between the SSBMs and the other forms of information at the outbound bus stops was still found to be significant, chi-squared analysis revealing a significant difference in the distributions between the SSBMs and the Network Maps ($\chi^2(3) = 23.044$, $p < 0.001$) and the SSBMs and the Timetables/At-Stop Information ($\chi^2(3) = 38.957$, $p < 0.001$). The expected reduction in the difference in performance between the forms of PTI was not observed, as for the outbound stops, 85% of answers returned with the SSBMs were correct compared to only 66% for the Network Maps and 62% for the Timetables/At-Stop Information.

Comparing the performance of the inbound and outbound SSBMs suggests that although respondents were able to use both types of SSBM to correctly identify an answer, the higher percentage of 'correct, non-optimum' answers returned by the outbound SSBMs supports the notion that these SSBMs are slightly more complex than their inbound counterparts. This is because there are more instances where an individual destination can be reached by more than one route. There was also a slight increase in the percentage of respondents who were unable to return an answer, for both the Network Maps and the Timetables/At-Stop Information, which again supports this theory.

Based upon this analysis it was expected that the inbound bus stops would give a superior performance in terms of the time it took for respondents to return an answer. Tables 6.23 and 6.24 present the breakdown of the answer times for the inbound and outbound bus stops, again demonstrating the superiority of the SSBMs over the other forms of PTI, and also the faster answer times for all forms of PTI at inbound bus stops.

Table 6.23: Valid Stop-Specific Bus Map Answer Times, Inbound Services (seconds)

Inbound Services	**Mean Time**	**Std. Dev.**	**Minimum Time**	**Maximum Time**
Stop-Specific Bus Map	16.74	7.10	4.25	40.17
Network Map	19.61	7.11	6.09	42.95
Timetable/ At-Stop	19.94	7.38	6.12	43.40

Table 6.24: Valid Stop-Specific Bus Map Answer Times, Outbound Services (seconds)

Outbound Services	**Mean Time**	**Std. Dev.**	**Minimum Time**	**Maximum Time**
Stop-Specific Bus Map	16.78	7.15	4.58	44.81
Network Map	20.67	7.94	6.54	48.12
Timetable/ At-Stop	21.98	7.58	7.19	42.08

A one-way ANOVA statistical analysis (at the 95% level of confidence) of the average answer times from each category demonstrates that there is a significant difference in the average times for both inbound services ($F_{(2, 556)} = 11.12$, $p < 0.001$) and outbound services ($F_{(2, 677)} = 28.92$, $p < 0.001$). Post-hoc Tukey comparison tests indicate that the SSBMs perform significantly faster than the other forms of PTI, regardless of the directionality of services.

It was noted previously that there was a remarkable similarity between the general performance of SSBMs with six to nine calling services and those with ten or more calling services. It is of interest that there is only 0.04 seconds difference in SSBM performance between the inbound and outbound stops, and overall there is very little to differentiate between the performance of the SSBMs for inbound services and outbound services, the only noticeable difference being the proportion of 'correct, optimum' and 'correct, non-optimum' answers, as discussed above. All these findings suggest that the SSBM concept would be suited to all bus stops, regardless of the directionality of the calling services.

6.4.3 Location of the Bus Stop

The final bus stop attribute used in the sampling framework was the location of the test stop, either in the centre or in the suburbs of the test city. The main reason for differentiating between the city centre and suburban locations is that most services tend to converge within the city centre, whilst in suburban areas the density of services is sparser and generally decreases as the distance from the centre increases. Another factor which requires this city centre/suburban differentiation is the peak flow of passengers, which is usually *from* the suburbs *to* the city centre in the morning, then *to* the suburbs *from* the city centre in the evening, although the regular, familiar passenger will have already acquired the information they need to make their journey.

Looking at the breakdown of answers by their 'correctness', as shown in Tables 6.25 and 6.26, it is again encouraging to see that both sets of SSBMs returned a sizeable proportion of 'correct' answers, compared to the other forms of information. At the City Centre bus stops (Table 6.25), 83% of SSBM answers were classed as correct compared to 62% for both the Network Maps and the Timetables/At-Stop Information. The difference appears to be that respondents were still confident enough to give an answer, albeit a wrong one, with the Network Maps whilst the Timetables/At-Stop Information proved to be more challenging for the respondents. A chi-squared analysis of the differences in distributions shows that for the City Centre bus stops, there is indeed a significant difference in distributions between the SSBMs and the Network Maps ($\chi^2(3) = 33.448$, $p < 0.001$) and the SSBMs and the Timetables/At-Stop Information ($\chi^2(3) = 36.849$, $p < 0.001$).

Table 6.25: Breakdown of Responses by Category of Correctness for City Centre Stops

Public Transport Information Used	**Correct Answers**				**Incorrect Answers**			
	Optimum		**Non-Optimum**		**Wrong Service**		**No Response**	
Stop-Specific Bus Map	179	73%	25	10%	14	6%	27	11%
Network Map	129	53%	22	9%	52	21%	42	17%
Timetable/ At-Stop	126	53%	21	9%	11	5%	81	34%

Table 6.26: Breakdown of Responses by Category of Correctness for Suburban Stops

Public Transport Information Used	**Correct Answers**				**Incorrect Answers**			
	Optimum		**Non-Optimum**		**Wrong Service**		**No Response**	
Stop-Specific Bus Map	136	82%	12	7%	5	3%	13	8%
Network Map	94	56%	10	6%	21	13%	43	26%
Timetable/ At-Stop	108	61%	10	6%	3	2%	55	31%

For the Suburban bus stops, it is again apparent that the SSBMs had a much superior performance compared to the other forms of information (Table 6.26). Here, 89% of SSBM answers were classed as ‘correct’ compared to 62% for the Network Maps (identical to the result from the City Centre bus stops) and 67% for the Timetables/At-Stop Information. A chi-squared analysis of the differences in distributions shows that for the Suburban bus stops, there is again a significant difference between the SSBMs and the Network Maps ($\chi^2(3) = 33.758$, $p < 0.001$) and the SSBMs and the Timetables/At-Stop Information ($\chi^2(3) = 29.569$, $p < 0.001$).

What is noticeable for the Suburban stops is the higher proportion of incorrect answers for the Network Maps, in particular the ‘no response’ answers, which, combined with the analysis of other attributes discussed in previous sections, suggests that respondents had difficulties in ascertaining exactly which services passed by each bus stop, or indeed called at them. For the Timetables/At-Stop Information the results are more definitive as very few responses were wrong, so it appears respondents were either able to identify a correct answer (optimum or otherwise), or else they were unable to find an answer at all. This finding suggests there is some benefit to be had by having stop-specific PTI, be it in textual or graphical form.

The amount of information and the more complex designs of the city centre SSBMs should, in theory, require a greater length of time for the respondents to absorb and process all the required information on the maps. The amount of Timetable/At-Stop Information should be directly proportional to the number of calling services, which is generally higher at City Centre stops, whilst respondents have to identify a greater number of services on the Network Maps. Therefore, it is reasonable to assume that the performance times will be faster at Suburban stops than at City Centre stops, but that the SSBMs would still have an advantage over the other forms of information at City Centre stops. Tables 6.27 and 6.28 present the breakdown of answers for stops in both locations:

Table 6.27: Valid Stop-Specific Bus Map Answer Times, City Centre Bus Stops (seconds)

Public Transport Information Used	Mean Time	Std. Dev.	Minimum Time	Maximum Time
Stop-Specific Bus Map	17.91	7.58	4.83	44.81
Network Map	20.69	7.74	6.54	42.44
Timetable/ At-Stop	21.41	7.73	6.12	43.40

Table 6.28: Valid Stop-Specific Bus Map Answer Times, Suburban Bus Stops (seconds)

Public Transport Information Used	Mean Time	Std. Dev.	Minimum Time	Maximum Time
Stop-Specific Bus Map	15.06	6.01	4.25	35.58
Network Map	19.47	7.32	6.09	48.12
Timetable/ At-Stop	20.56	7.30	8.17	41.12

The breakdown of the results demonstrates the superior performance of the SSBMs over the other forms of information, and also highlights the increase in performance at the Suburban bus stops, which given their simpler nature was expected. Again, a one-way ANOVA statistical analysis (at the 95% level of confidence) of the average answer times from each category demonstrates that there is a significant difference in the average times for both City Centre bus stops ($F_{(2, 726)} = 14.05$, $p < 0.001$) and for the Suburban bus stops ($F_{(2, 677)} = 29.98$, $p < 0.001$). Post-hoc Tukey comparison tests indicate that the SSBMs perform significantly faster than the other forms of information, regardless of the location of the bus stop.

6.4.4 Bus Stops Most Suited to the Stop-Specific Bus Map Concept

This final result confirms the notion that SSBMs are applicable to all kinds of bus stop and generally have a superior performance regardless of the different bus stop attributes, further strengthening the argument for the greater adoption of the SSBM concept. As discussed in the introduction to this study, one of the primary roles of a SSBM is to enable the user to quickly identify the subset of services which they could board in order to travel (close) to their intended destination, from a complete set of calling services which, at some stops in city centres, can be upwards of 20 services. However, the analysis of all bus stop attributes does not unequivocally identify at which stops SSBMs are most suited, so it is necessary to use some logical process of elimination to give some guidance.

Although this analysis has demonstrated the superiority of SSBMs over existing PTI at stops with one to five calling services, one has to question the potential practicality of these SSBMs compared to those displayed at stops with multiple calling services. At the majority of stops with multiple calling services, there is a greater range of destinations and more potential combinations of services to different destinations. The theory behind the SSBM concept would lead us to assume that it is at these stops where SSBMs are most suited, and therefore it would be sensible to concentrate any future efforts towards the production of SSBMs with multiple calling services.

As there were no substantial differences between the performance of inbound and outbound SSBMs, the argument here has to be centred on the general topology of a bus network. Along the inbound direction of travel, routes tend to converge upon a section of common route (a bus corridor) towards the city centre, with the opposite applying along the outbound direction of travel. When travelling away from the city centre, routes eventually split from their common section of route, so it is perhaps more important for the user to know at what point services split from the main corridor and after this point, which areas are served by each service. This would therefore suggest that SSBMs might have more potential if they were initially displayed at outbound bus stops. Alternatively, a trial could be conducted by displaying SSBMs at **all** inbound and outbound bus stops along a specific bus corridor, not just a sample of bus stops as used in this study, and a suitable conclusion drawn from this approach.

Finally, with respect to the most suitable location for the SSBMs, this is perhaps the most difficult aspect to resolve logically. One of the motivations behind the SSBMs concept was to encourage infrequent and non-bus users to consider making greater use of buses in the future, and the argument here really depends on what type of destinations are the most attractive to these potential passengers. If promotional efforts were to be targeted at attracting new commuters to and from their workplaces located in the city centre, then it would be sensible to initially design and display SSBMs at inbound suburban stops.

However there also needs to be some consideration for the potential number of users who will actually view the SSBM on display. At suburban stops, it was noticeable that fewer people boarded services here whilst there were often numerous people waiting at city centre bus stops.

One further factor that must be considered (particularly in larger and historic cities) is that a section of the infrequent user market will be made up of tourists and those on business, who are unfamiliar with the local geography and are usually more concerned with travelling around the city centre than to and from the suburbs. This is typified by one respondent in York (YORMIC20) who was an American tourist on a sightseeing holiday of the UK. After the test was complete, this respondent specifically commented on how “it would be nice to be able to board a bus other than those ridiculously expensive tour buses [a commercially operated, ‘hop-on hop-off’ circular bus service of major landmarks in the city with commentary from a tour guide, a 24 hour ticket costing £9] to go somewhere different – but we just cannot find out where they go!” This would therefore suggest that SSBMs might actually have the greatest benefit if they were displayed at city centre stops, especially as Network Maps typically represent the higher level of detail required for city centre areas either by using a separate inset map, or even neglecting these areas altogether and instead opting for a generic ‘City Centre’ mask.

To conclude this discussion, whilst all types of bus stops have a certain level of potential for having a SSBM on display, a logical argument can be made for these maps to initially appear at city centre bus stops, with multiple calling services that are generally heading in an outbound direction.

6.5 Increasing Future Bus Use

In this chapter, the results have supported the greater adoption of SSBMs. Not only have respondents been able to use them faster, and find a greater proportion of correct answers, compared to the performance of their traditional PTI counterparts, but it also appears that respondents find SSBMs easier to use and gain greater confidence in their answers when using them. Whilst these findings might be of interest to commercial PT operators, it is probable that they would predominantly be interested in whether the SSBM concept could increase patronage levels, and consequently increase their overall profits.

As discussed in the introduction, an increase in bus patronage is also one of the key goals of modal shift away from the private car, and so one of the aims of this research is to identify whether the wider adoption of the SSBM concept could perhaps encourage people to make greater use of available bus services in the future. Respondents were asked to state how likely it would be that they would make greater use of buses in the future should SSBMs become more abundant in their area, on a scale from 1 = ‘Not At All Likely’, through to 5 = ‘Very Likely’. As with any Stated Preference approach, answers given have to be treated with a slight degree of caution. Here, people are being asked to consider potential future actions, but it is often the case that actual future actions do not directly correlate with stated future actions, especially when people are asked to think about a specific action which could be considered as a good deed, such as increasing their PT use.

In this question, not only were respondents asked to consider the potential effects of a novel form of PTI, but they could possibly compare their experience of using the SSBMs to their own previous experiences of using existing forms of PTI. Depending on how successful these previous experiences of PTI were in comparison to their experience with using a SSBM, there could be a tendency for respondents to slightly overstate their potential future bus use. Another important aspect that must be considered here relates to the aforementioned issues surrounding modal shift. Improvements to PTI, such as the SSBM concept, are just small pieces of the ‘jigsaw’ of factors that can contribute towards increased bus use. It must be recognised that if other aspects of the overall bus service are not improved, then why should non-users give any consideration to using the bus in future?

Attempting to explicitly measure the potential influence of improvements to PTI on peoples’ future bus use is a difficult task because it is also difficult to directly measure peoples’ subconscious views about existing bus services and their impacts on potential future bus use. There will always be some people who are sceptical about bus travel but have not travelled by bus for many years, whilst other people are open to new ideas and so will have a different subconscious view about bus travel. All of these factors may have a subtle effect on the answers given for this research.

6.5.1 Potential Scores by Town

Figure 6.9 presents the breakdown of responses for the whole sample, and by each individual town, and indicates that, in general, respondents felt that the SSBM concept could indeed have a positive influence on their future bus use.

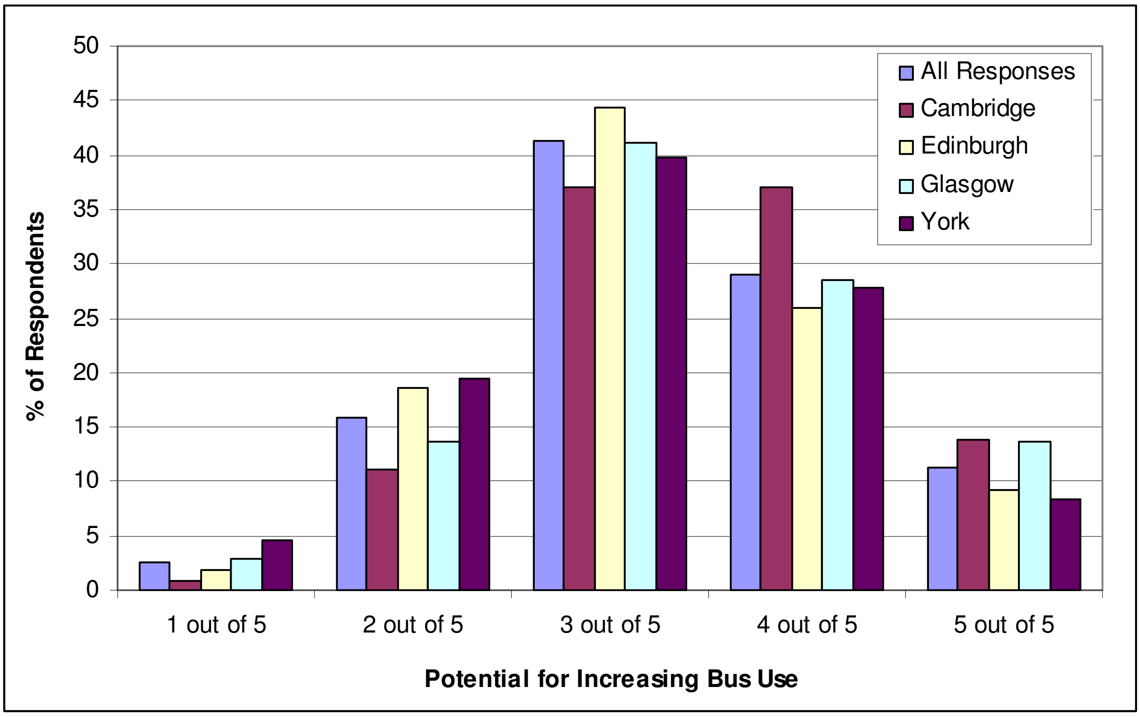


Figure 6.9: Breakdown of Potential Future Bus Use scores

Across the entire sample (blue bars in Figure 6.9), the median score was 3, which suggests that SSBMs could indeed have a modest impact on future bus use. However, there is a very slight negative skew ($\gamma_1 = -0.03$) towards the upper end of the scale, 82% of all respondents stating that it was likely (a score of 3 out of 5 or greater) they would make greater future use of bus services. Only 3% stated that it was 'Not At All Likely' (1 out of 5) that they would make greater use of buses, but in giving such an answer some respondents commented on how they currently made as much use of buses as was practical in their daily lives, so it was almost impossible for them to increase their bus use anymore. Other comments related to how respondents considered PT to be too inflexible and impractical for their daily travel patterns, so there was little they could do to increase their bus use without drastically altering their daily schedules.

The distribution of scores given by respondents in each area shows that there appears to be moderate potential for the SSBM concept in all areas. However, a Kruskal-Wallis one-way analysis of variance by ranks (Table 6.29) suggests that there is actually a significant difference between the towns (at the 95% level) in the stated potential level of future bus use ($H_{adj}(3) = 10.55$, $p = 0.01$), the greatest level of potential appears in Cambridge and a moderate potential in Glasgow (both have positive *Z*-values) and lower potential in both Edinburgh and York (both having negative *Z*-values).

Table 6.29: Potential Future Bus Use Scores

Town	Median Score	Average Rank	Z-value
Cambridge	4	358.1	2.46
Edinburgh	3	301.3	-1.69
Glasgow	3	328.7	0.97
York	3	293.9	-1.53

6.5.2 Influence of using a Stop-Specific Bus Map

All towns had a median score of 3 or 4, which indicates that the SSBM concept clearly has some potential for increasing future bus use across all four towns, an encouraging finding given the diverse range of bus services and PT system attributes found in each location. It was of interest to see whether actually using a SSBM to plan a journey could also have had an impact on peoples' opinions. The framework used for the allocation of (PTI, Destination) pairs meant that two-thirds of the total sample used a SSBM for one of their journey planning tasks, so these respondents had direct experience with using a SSBM, whereas the remaining third used a Network Map and the Timetable/At-Stop Information for their tasks, and were only shown the SSBM for the particular test stop at the relevant point in the questionnaire to allow them to form some opinion about the concept.

Comparing the answers between those respondents who did use a SSBM and those who didn't (Figure 6.10) further illustrates the positive impact that the SSBM concept could possibly have on future bus use. A one-way Mann-Whitney *U* test was conducted to test whether those respondents who had used a SSBM for one of their tests gave a higher rating to the SSBM potential, compared to respondents who only used the Network Maps and Timetables/At-Stop Information. Although both sets of respondents have a median score of 3, the results of the Mann-Whitney test ($U_{adj}(424, 212) = 138962.5$, $p = 0.03$) indicate that those respondents who used a SSBM did indeed have a higher rating of the concept.

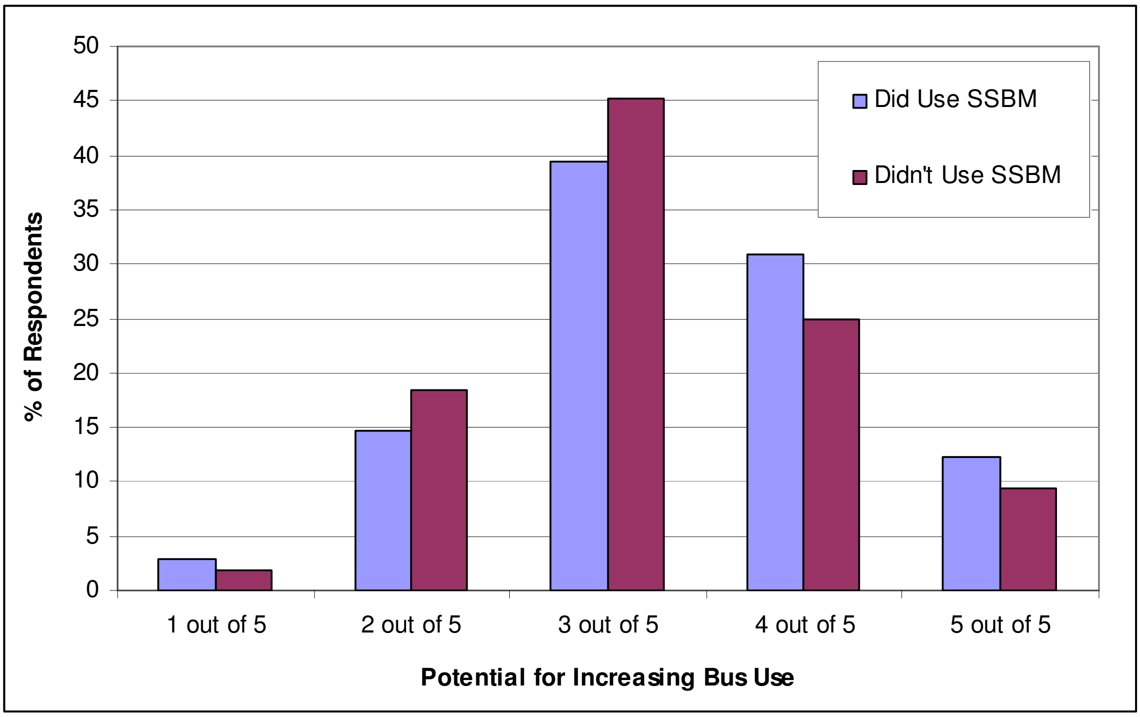


Figure 6.10: Comparison of 'Potential Future Bus Use' scores, by Use of Stop-Specific Bus Map

This is not to say that those who did not use a SSBM were unable to see the potential benefits of having simplified PTI, as a number of respondents who did not actually use a SSBM gave positive comments about the idea after they had viewed a SSBM and considered the potential benefits. A couple of respondents specifically commented on their challenging experience of using the Network Maps during the tests, and how they thought the level of information provided by the SSBMs was more appropriate for the point of use which, they believed, would make it a lot easier to plan future PT journeys.

6.5.3 Influence of Travel Choices and Availability

Continuing on the theme of modal shift, a further area of interest was to establish whether there was any difference in views on the potential of the SSBM concept between drivers and non-drivers, and between those with regular access to a car and those without. Previous studies (Kingham, Dickinson and Copsey, 2001; Mackett, 2001; Garvill, Marell and Nordlund, 2003) suggest that improved PTI can have some impact on drivers' modal choice, albeit a small one, and a key finding of Garvill, Marell and Nordlund's study was that the greatest impact of improved PTI was found in those perceived to have strongest car use habit.

Respondents were categorised into four groups of increasing reliance upon PT services:

1. Those with a current drivers' licence **and** with regular access to a car
2. Those without a current drivers' licence **but** who have regular access to a car
3. Those with a current drivers' licence **but** without regular access to a car
4. Those without a current drivers' licence **and** without regular access to a car

A Kruskal-Wallis one-way analysis of variance by ranks was calculated but it was found that there was no significant difference between the median scores of each category (all medians = 3), although the *Z*-value for respondents with a drivers' licence and regular access to a car was the only one to be positive (+0.89) indicating the average rank of these respondents was higher than that of the entire sample, and the absolute *Z*-value for respondents in category 1 was greater than those of the other categories: (-0.51), (-0.29) and (-0.40) for categories 2, 3 and 4 respectively. Whilst this suggests that there might be a slightly greater influence of the SSBMs on those with the strongest car habit, the potential impact of SSBM does appears not to be significantly influenced by current car habit. This is unfortunate, as it was hoped that the simplified nature of the SSBM would appeal to those with assumed strong car habits and make bus travel more appealing to those who would previously not even consider it as an option.

However, this conclusion is based upon a slight generalisation as it takes into account whether respondents had a drivers' licence and if they had regular access to a car, and does not directly account for the frequency of their car use. As discussed, this limitation of the sample is mainly due to the restrictions of testing in the bus stop environment, whereby most respondents were likely to use bus services at some time, and so the probability of questioning someone with an actual strong car habit was relatively low. It would therefore be more meaningful to compare the potential future bus use scores by frequency of bus use, and so respondents were re-categorised by their frequency of bus use (excluding the two respondents who said they never used buses). As with car use and drivers licences, an additional Kruskal-Wallis test indicates that there is no significant difference between respondents' views on future bus use as a result of their current frequency of bus use. Again, the medians for each category of bus use equalled 3, demonstrating a modest potential for the SSBM concept, whilst comparing the *Z*-values suggests that the greatest potential for increasing bus use was amongst those who used the bus 3-4 times per week (*Z* = +1.07) i.e. those respondents who already used the bus on a regular basis and could therefore easily make additional journeys.

6.6 Review and Discussion of Key Findings from Field Tests

The results of the field tests demonstrate the advantage that the SSBM concept has over existing, traditional forms of PTI for conveying geospatial information to passengers about the bus services calling at a specific stop. Not only do the SSBMs improve the proportion of respondents who are able to find a correct answer to a journey planning query, but they also allow respondents to do so in the shortest time possible.

Key to increasing modal shift is the notion of improving confidence when travelling by PT, and SSBMs also appear to instil a greater degree of confidence in the respondents, improving the image of PT as a mode of transport that is easy to use. Many respondents stated that they would consider making greater use of buses in the future should SSBMs become more abundant. Although there was no difference with respect to the various levels of car and bus use, the results do indicate that there is potential to increase bus use amongst all types of user, whether they have regular access to a car or if they only use the bus on an occasional basis.

The tests undertaken here were attempting to evaluate the performance of PTI in real world conditions. It could, however, be argued that the comparison between the different forms of PTI in the testing for this study were perhaps not wholly fair to the Network Maps and Timetable information because both forms of information were not primarily intended to assist the tasks which were being asked of the respondents. SSBMs are only intended to show the possible onward journeys using only the buses which call at that stop, whilst Timetables are intended to show the departure times of each service, although depending on the design of Timetable available, a textual list of bus stops or even street names can allow for the route of each service to be determined.

Network Maps are primarily intended for showing an overview of the PT services in an area but, returning to the notions of simplicity and legibility, are also used for journey planning and reassurance purposes whilst the user is *en route* to the final destination. Returning to the analysis of the incorrect answers given with the Network Maps, most of the criticisms given to the Network Maps in Figures 6.3 to 6.6 do not suggest these are particularly poor examples of Network Maps but the problems are inherent in the general nature of a Network Map.

The Cambridge example (Figure 6.3) is of a design which is widely used in Britain and must therefore be considered by LAs and bus operators as a good design to adopt. The particular map would be regarded as a well-designed example of Morrison's 'Classic' style Network Map, however, the difficulty of tracing bus routes on such maps is always present and is the inherent weakness of this design. Tracing individual bus routes is more achievable using the 'French' style example from Edinburgh (Figures 6.4 and 6.5), however the errors described arose from the disadvantages of any such 'French' style Network Map used for the journey planning tasks being carried out here: not only is the origin point of the journey not clearly highlighted, but there is a much larger number of routes on the Network Map than on an SSBM, so it is difficult to easily identify distinguishable colours for all adjacent lines, or to group routes without confusion.

If a Network Map was posted at a bus stop (which is unfortunately a relatively rare occurrence in the UK), a 'You Are Here' sticker on the map could be a valuable addition to this form of information when carrying out the kind of task used in this research, as it removes the need for the user to search for their current location and assists with orientation within the system. However, many Network Maps made available are portable forms of information and so this 'You Are Here' information could only be relevant at one particular point during the journey and therefore serve little useful purpose.

Considering schematic maps, the Glasgow map (Figure 6.6) is, again, a well-designed example of a schematic bus network map produced for FirstGroup, and therefore appears in great abundance on FirstGroup's networks throughout the UK. The errors arose from the difficulty in depicting detailed City Centre locations on a city-wide map, and the unavoidable allocation of bus services to different bus stops in the City Centre, not from any defect of map design. All Network Maps would have the same failing whilst SSBMs would not, because they are stop-specific.

All the errors noted above would occur even if the map design was technically excellent, and well displayed. It is of course possible that a map in a display case might have been vandalised, portable maps viewed in poor illumination, or had inadequate font sizes and styles, but this would not be the primary reason for these errors. Considering the SSBMs, the errors in answers described in relation to the SSBM shown in Figure 6.2 could equally be linked to poor design aspects also found on Network Maps, as the visual prominence given to the service numbers in this experimental design proved not to be adequate.

It is therefore reasonable to assume that the better scores of SSBMs are not simply due to better design caused by the processes adopted in this study. To provide some evidence that the SSBM concept is worthy of further adoption and research, SSBMs needed to be compared to the existing forms of PTI that are often available at bus stops or bus shelters and are likely to be used when trying to plan and undertake a PT journey, including at the point in the Journey Chain when the passenger needs to identify which service(s) will take them to their intended destination. It is acknowledged that SSBMs are only intended to assist with this particular decision, but as stated in Chapter 1, they are not a replacement for existing forms of PTI, but a complement to them.

It must be noted however, that these results are based upon user tests conducted at four different locations across the UK, over a relatively short period of time. To truly assess the impact of the concept would require actual SSBMs to be posted at a range of bus stops for a significant period of time, which would allow users (both current and potential) to become familiar with them. One means of evaluating the SSBMs could be to monitor the changes in bus usage, not only in terms of actual patronage levels, but also in the variety of PT journeys people are making and whether they are choosing different routes to the ones on which they previously travelled. Alternatively, different designs of SSBM could be displayed for equal periods of time at an identical set of bus stops, and user opinion and performance tests conducted to ascertain what the best design of SSBM could be. This latter research question would also be suited to laboratory based testing, as discussed in the next Chapter.

7.1 In this Chapter

This Chapter provides a final overview of the thesis, its research aims, and the tasks involved, and also reflects upon the implications of this research. Key findings and potential limitations of this study are discussed. Finally, proposals are made for future research in this area, outlining potential avenues for developing the work conducted throughout this study.

7.2 Summary of Research Aims and Tasks

This thesis set out to evaluate the worthiness of the SSBM concept, as proposed by Morrison. At this point, it is useful to revisit the research aims and tasks, and assess whether they have been achieved successfully.

There were three aims guiding this research, all of which have been achieved successfully. The first aim was to establish if SSBMs could be developed manually, based upon Morrison's original specification (undated) for the automated development of SSBMs. The output of the process described in Chapter 4, and the subsequent set of 36 SSBMs, illustrate that it has been possible to develop SSBMs for a variety of bus stops across the four test towns. However, it is acknowledged that the time taken to develop some of the more complex SSBMs would not be feasible in a commercial environment and automation would greatly improve the efficiency of the design process.

The next aim of the study was to assess just how effective SSBMs could be in assisting people when planning a bus journey, compared to existing forms of PTI. The results of the user tests demonstrate that the SSBMs do have a significant advantage for the purpose of planning a specific journey from a particular bus stop. The final aim was to identify whether the greater adoption of SSBMs could play a role in promoting bus use. The results of the survey indicate that in all of the test towns, the SSBMs do indeed have potential for increasing bus patronage, although further, more detailed survey work is needed on this aspect.

In meeting the above aims, there were four main research tasks. To establish a case for conducting this research, the first task required an investigation into the current issues surrounding the provision of geospatial information about bus services. Although previous work by the author (Evans, 2004) noted the lack of existing research specifically in the area of bus mapping, this task was achieved through a detailed Literature Review encompassing the wider aspects and implications of information provision, looking at the issues surrounding *all* forms of PTI, not just geospatial forms of PTI.

The second task involved the preparation of a robust experimental design to ensure that the map user tests were conducted in such a way that the results achieved were as unbiased as was practically possible within the resources of this study. Given the variation in PT provision throughout the UK, it was deemed important to test the SSBM concept in a number of different towns, and at a variety of bus stops within each town. The experimental design incorporated a number of demographic, geographic and bus network attributes into random sampling and post-sampling screening techniques, to sample the test locations and bus stops. A design framework was used to control the different forms of PTI and the destinations of the journey planning exercises, to ensure that no consecutive respondents planned identical journeys. Overall, the methodologies used enabled this task to be completed successfully.

After selecting the test towns and bus stops, the penultimate task involved the designing of the SSBMs. This task was accomplished using the specification developed by Morrison (undated) and through the compilation and processing of geospatial datasets in ArcMap 9.2, from a variety of sources, including a bespoke bus route dataset captured from the OS Meridian 2 digital dataset. Once all required data had been compiled, it was then exported into CorelDraw9 for the final cartographic editing and production of each SSBM.

The final research task involved the testing of SSBMs in the bus stop environment to investigate their effectiveness compared to existing forms of PTI. This task was achieved by asking a sample of the population which bus(es) they could take to get to a particular destination and additional questions pertaining to their travel habits, both at present and in the future.

7.3 Significant Findings of this Research

This research has drawn upon a wide body of existing work and this section summarises the key findings borne out by this current study.

The historical review of developments in UK transport legislation pertaining to the provision of PTI (Chapter 1) suggests that there is still some confusion as to who should be responsible for providing PTI for passengers and there is no specific guidance regarding the various types and designs of PT mapping, and potential strategies for their dissemination. Although the recent 2008 Local Transport Act strengthened Local Authorities' position and influence within the overall bus industry, observations of the quality and completeness of the information provided at a variety of bus stops suggests there is still a long way to go before passengers can enjoy complete, up-to-date impartial information available about all services. There is even more work to do before mapping information becomes a standard feature at bus stops.

This situation is typified at one particular stop in Glasgow, where one operator provided a half-hourly service through the day, operating until around 6pm in the evening. To continue this service through the remainder of the evening, SPT subsidised an hourly service which was provided by a different operator. (To avoid any commercial issues or embarrassment, operator names will remain anonymous here.) Unfortunately, during the testing there was no timetable information available for the daytime service, but there was a timetable available for the evening service which helpfully, if erroneously, informed users to consult the other (non-existent) timetable for journeys during the day.

The Literature Review (Chapter 2) looked at a wide range of issues surrounding PTI. From this, it was evident that high quality information is needed and is highly valued by the passenger, the bus operators and LAs/the Government alike, although it was found that each group had slightly different demands and requirements upon PTI. The key message from the review was that good information is **essential** in instilling confidence in PT, enabling users to complete their journey with minimal effort and encouraging sustained future use of bus services. This was demonstrated by an analysis of the Government's Best Value Performance Indicators which revealed a strong positive correlation between PTI satisfaction levels and the overall satisfaction with PT services.

Nevertheless, it is strongly believed that for too long there has been a bias towards the provision of timetable information. A substantial number of official documents and previous research reports claim to have made improvements in information, when they are actually referring to improvements in *timetable* information. This is unfortunate and perhaps slightly misleading, indicating a clear lack of understanding of the vital role that mapping plays in journey planning.

Although there are only a relatively low number of previous studies into the impacts of mapping information, all results show that for the purposes of planning a PT journey, mapping is by far the preferred form of PTI. Despite this, it has been shown that people struggle to use mapping information effectively, which is a strong argument for designing maps that are more relevant at their point of use, such as the SSBMs and SpiderMaps, although care has to be taken to avoid saturating the market with numerous mapping products.

From the outset of this research, it was always believed that the nature of the SSBM concept would naturally require an automated system in order to make these maps commercially viable. Nevertheless, the methodologies adopted in this study have shown that it is possible to manually design and develop SSBMs for bus stops with a wide range of different attributes, but the time taken in designing each map, particularly where alterations to services required additional revisions, has shown that an automated system will be highly desirable. Although a fully automated system to produce SSBMs from start to finish may take many years to perfect, there were certain tasks such as deciding the route groupings, creation of parallel lines and the placement of text along linear features (roads and rivers) which consumed large amounts of design time. It is felt that automated systems could have significant benefits by addressing these areas first, gradually evolving into a more complete system.

Finally, the results of the user testing have clearly demonstrated the benefits of the SSBM concept over the existing forms of PTI. The findings support the notion that providing users with information which is relevant at the point of use greatly reduces the cognitive workload required when planning and undertaking a journey. It is important to reiterate that SSBMs should not replace existing forms of mapping – there was never any intention to do so – but should be used in conjunction with existing information instead. The results of the user survey also point to the positive impacts that improved information can have upon the overall impression of PT services, and therefore it is believed that such forms of information should be considered as part of a wider PTI strategy in the future.

7.4 Limitations of this Research

As in all research, there are other methods and approaches that could have been adopted, and the methods used in this study still have some outstanding issues that need to be considered. It must be accepted that this study is merely one interpretation of the SSBM concept and of Morrison's specification, and there are some additional limitations that need to be acknowledged and addressed in greater detail.

7.4.1 Sample of Respondents Obtained

Every effort was made to obtain a sample that was representative of the general travelling public which, admittedly, is rather vague in its definition and thus made it difficult to directly specify the desired respondents for the user testing. The experience from this study also supports White's (2005) conclusions: the bus stop environment is not one which is conducive to conducting PTI user surveys. There were occasions where it was difficult to obtain responses from people waiting for a bus, but upon analysing the sample breakdown, the adoption of the alternative bus stop interception technique does appear to have obtained a representative sample of bus users and potential bus users, and has not been to the detriment of the final results.

The key issue to be addressed here is the need to test PTI in the environment in which it is intended to be used. By testing at the bus stop, the SSBMs were being used in their true environment, but a compromise had to be made in obtaining a suitable response rate from the desired range of respondents. It is unfortunate that it was not possible to engage with hardened car users, but the methodology chosen required testing of the SSBMs in the immediate bus stop environment, where it was unlikely that hardened car users would be found.

Whilst the interception approach proved to be an effective method for efficiently conducting the user tests for this study, it may be possible for future research of this nature to be conducted in hall tests, with the proviso that the experimental conditions are controlled in such a way as to mimic the outdoor environment as much as possible, as shown by the review of the cognitive mapping links to journey planning (Section 2.4.1).

There will always be some limitations to any hall tests, which can be mitigated through a careful experimental design. For example, any hall test should use SSBMs which correspond to bus stops in the immediate locality so that respondents who have an existing mental map of the area can still draw upon this existing information, albeit not in the exact environment of the bus stop itself. The orientation of a SSBM relative to the general direction of travel is not as easily resolved within a hall environment, but using a temporary bus stop mock-up correctly orientated with the equivalent real world bus stop may prove to be an acceptable compromise.

Guo (2009) has explored the potential for an ‘immersive video’ technique which utilises a test-suite of large display screens combined with surround sound technologies to give the user a sensory impression of their actual surroundings whilst remaining in the controlled environment of the laboratory. This technique could be adopted in future research involving map user studies to help address the issue of indoor/outdoor environmental discrepancies.

7.4.2 Displaying the Stop-Specific Bus Maps

The PTI user tests were conducted over a short period of time within the four test towns. It would have been beneficial to have the SSBMs displayed alongside existing PTI within the display cases at each bus stop, for a longer period of time than was possible for this study. Although the Literature Review demonstrated, and critiqued, examples of SSBMs from three of Britain’s largest towns, they are still a novel form of information for the majority of areas. Presenting the SSBMs within the overall PTI display would have allowed users to view them in their natural habitat, and thus consider them as part of the overall fabric of the bus stop.

It was noted that on a couple of occasions, respondents were slightly taken aback by the unorthodox nature of the SSBM in front of them. Perhaps having the SSBMs incorporated within the overall display would have made the maps appear to be a standard form of PTI, and could have softened users' reactions when viewing them for the first time. However, for the purpose of this research, it was important to isolate the SSBMs at each stop in order for their performance to be measured with minimal influence from external factors, such as the presence of the other PTI.

Displaying the SSBMs at bus stops for a longer period of time would also allow their actual impacts to be measured, as opposed to the stated preference method that had to be adopted for this study. The impacts of the SSBMs could be monitored and directly quantified through changes in patronage levels over time, increase in reported passenger satisfaction with PTI provision or through variations in passenger movements and travel patterns, as people develop a deeper knowledge about where bus services go in their local area.

7.4.3 Physical Size of the Stop-Specific Bus Map Design

The SSBM design process in this study utilised an A4-sized design for ease of final printing. Given the limited amount of space that is available within bus stop display cases for all the required PTI, it is acknowledged that there will not always be adequate space for an A4-sized SSBM to be displayed. This is particularly evident at bus stops without a shelter, where there is only a flagpole, usually having a maximum of two individual display cases attached to it, within which all the necessary PTI must be displayed. Given this limitation, it is highly unlikely that the amount of available display space would permit an A4-size SSBM to be displayed at these stops and so consideration must be given to SSBMs with smaller dimensions, particularly the width (assuming a portrait orientation).

Reducing the physical size of the SSBMs would have consequent impacts on the general map scale, the overall geographic extent of the forward-portion of the calling services shown, and the amount of extra non-service detail that could be incorporated, particularly on the more complex SSBMs with upwards of 10 services, where it is probable that the only information shown will be that pertaining to the calling services.

The net effect of this reduction in map size would be a need to compromise between the different design elements in order to maintain an acceptable level of legibility. The potential design issues required for producing SSBMs with smaller dimensions also have implications for those maps which are intended to be viewed on electronic handheld mobile devices, discussed later in section 7.5.5.

7.5 Further Research in this Domain

There is great scope for developing this work further, both in terms of how the SSBMs are designed, and how they are subsequently provided to the user.

7.5.1 Detailed Design Analysis and Testing of Stop-Specific Bus Maps

This study has shown that the SSBM *concept* does have some advantages and potential over existing forms of PTI. Two small, post-pilot test improvements were made to the SSBMs in this study, but this was by no means exhaustive, nor was it intended to be so. Therefore, one immediate area of additional research could be an investigation into the various design aspects (for example, font sizes, colours used, line thickness, grouping algorithms, level of back ground detail and so on) associated with the SSBM in greater detail to identify what design features can be improved upon. This would require a more controlled experiment to take place, which would be suited to the controlled laboratory conditions, as discussed in Section 3.2.1.

7.5.2 Automated Design Systems

The manual design of the SSBMs for this study was guided by the specification developed by Morrison (undated). During the design process it was found that the time and resources needed for manually producing the SSBMs were significant issues which would have to be overcome if these maps were to be developed in a cost-effective manner, at the volume required for an individual town to make them a feasible future form of PTI. There are some examples of semi-automated maps already in existence - the Sheffield schematic SSBM example (Figure 2.10) was produced using a specific computer programme and SYPTE are now looking at developing this for the automated production of individual route maps which are geographically correct (R. Mason, 2010, *pers. comm.*).

However, the primary intention of Morrison's specification was to assist with the development of a software system which would then allow for SSBMs to be produced semi-automatically from a GIS or other software with graphical functionality. Therefore, the natural progression of this research would be a further investigation into the development of an automated system to assist with the production of geographically true SSBMs. There is a substantial body of existing research into automated mapping design and systems, with its roots in the digital computer mapping domain of the 1980s and the application of expert systems in the 1990s (Forrest, 1993). The cartographic outputs from such systems are continuously improving and the technologies are becoming more sophisticated, so the application of computer cartography for automated design has become a real commercial possibility.

7.5.3 Learning from Automated Design for Schematic Maps

In existing research, automated design has primarily been associated with the *schematic* representation of networks, where the preservation and emphasis of the network topology is deemed to be more important than representing the true geographic relations within the network data. Given the more diagrammatic, unconstrained nature of schematic representation, and the ease of manipulation of this data compared to information subject to geographic rules and constrained in a spatial reference frame (Cabello and van Kreveld, 2002), it is perhaps unsurprising that previous research has tended to focus on schematic maps, although it must be reiterated that schematics are not the most suitable graphical form of representation for bus networks and SSBMs (Morrison, 1996a).

Nevertheless, alongside a further investigation into the capabilities of existing packages for accommodating specifically graphical manipulation tasks outlined in the specification (for example, altering map projections, applying distortions and perspective or employing 'rubber-sheeting' transformations), it will be important for future research to consider the potential of this existing body of research, exploring how the techniques and findings pertaining to schematic development can be developed and adapted for the automated production of *non-schematic* SSBMs. Whilst a full discussion of the future of this particular research domain is beyond the scope of this study, previous work conducted by Nöllenburg (2005) provides a full discussion and demonstration of what is possible in this area.

An initial starting point for future research in this area could be the experimentation with, and adaptation of, the Schematics desktop extension in ArcGIS which provides a suite of tools "to automatically generate, visualize, and manipulate diagrams from network data or data that has attributes for connectivity" (ESRI, 2006, p.2). The Schematics extension could be suitably applied to generate SSBMs from route network data with the appropriate topological structure, such as an ordered list of links for each route, directional links and other relational characteristics (Rainsford and Mackaness, 2002). As noted above, schematic maps may not be the most suitable form of representation for SSBMs, but the Schematics extension allows the user to produce different types of representation – geographic, geoschematic and schematic (Figure 7.1).

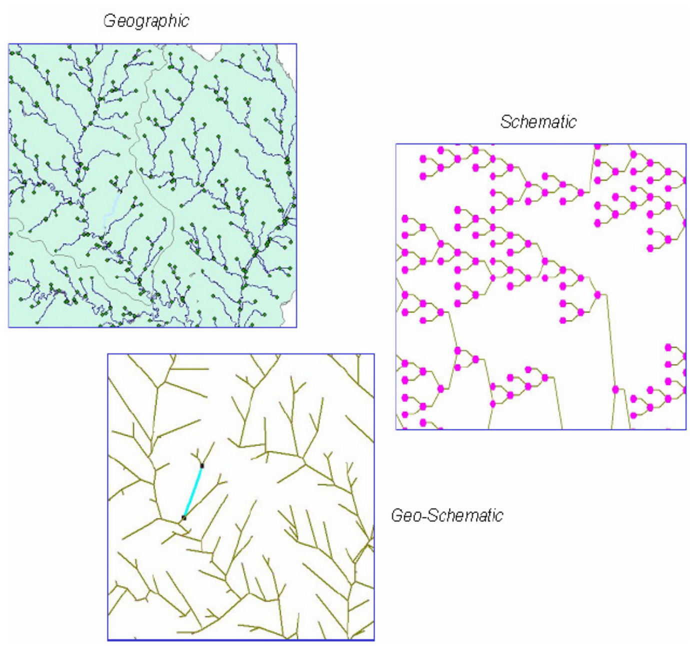


Figure 7.1: Examples of the Various Graphical Outputs from ESRI's Schematics Extension in ArcGIS.

(C) ESRI, 2006

The ESRI definition of a 'schematic' is one which emphasises relationships and connectivity to explain network structure, whereas in transport mapping, the definition of a 'schematic' (used throughout this thesis) relates to a network map in the style of the London Underground map i.e. distorted geometry with lines restricted to 0^o, 45^o and 90^o. Nevertheless, it would be interesting for future research into the SSBM concept to investigate the potential of applying automated geoschematic representation. In addition to ESRI's Schematics extension, there have been a range of techniques and algorithms applied to the simplification of schematic network maps: algorithms for discrete curve evolution (Barkowsky, Latecki and Richter, 2000), the application of graph theory to metro and subway networks (Nöllenburg, 2005) and simulated annealing algorithms (Anand, Ware and Taylor, 2007). Agrawala (2001) developed the LineDrive system which rendered schematic maps (in a hand-drawn fashion) to accompany journey specific textual driving directions, and this could be applied when generating SSBMs. Jenny (2006) conducted some analysis of the level of distortion existing in the London Underground map. In Morrison's specification, there is scope for the use of scale distortion to improve the overall clarity of a SSBM by enabling crowded central areas to be enlarged and peripheral information to be reduced.

7.5.4 Future Visions for Public Transport Information Dissemination

SSBMs are only intended and suitable for use at the relevant bus stop, but there are numerous electronic technologies that could be developed to provide innovative ways of disseminating SSBMs to the travelling public. McQueen, Schuman and Chen (2002) give a detailed proposal and analysis of how travel information systems are set to develop in the 21st Century, in light of today's technological capabilities. Although the primary focus of their work was on information systems for drivers of vehicles, their future visions and functionalities could easily be adapted and applied to information systems for the PT user, including SSBMs.

7.5.5 Online Dissemination of Stop-Specific Bus Maps

For clarification, 'online mapping' in this section refers to maps obtained on a PC/laptop through an internet connection. Whilst technological advances mean there are now many opportunities for the dissemination of mapping information through the *mobile* internet (including mobile versions of standard web pages), there are separate issues surrounding the design and dissemination of geospatial information through mobile technologies. To avoid any confusion, these will be dealt with separately in a later section.

Various internet services allow people to generate bespoke mapping output for their needs with minimum effort. For example, online journey planners (such as Multimap, The AA, and Transport Direct) often include a route map to accompany a set of directions for a particular journey by car or by PT. It was originally argued that the specific purpose of the SSBM concept meant that these maps were of little use unless viewed at the respective bus stop for which the map was originally designed. Therefore, one could ask a question about the practicality and feasibility of disseminating SSBMs via the internet and up until recently, it was personally thought that whilst SSBMs could be disseminated online, there was no real purpose for taking the time and effort to do so.

The only practical purpose that could be associated with providing SSBMs online would be to allow users to download and print them off for reference, either on a display board at home or in an office staffroom, or perhaps if they were undertaking an unfamiliar journey and wanted the SSBM for reference and reassurance at certain points during the journey. This opinion has recently changed (for the better) upon notification of, and experience with 'NextBuses', a new mobile service provided by the Traveline consortium (http://www.traveline.org.uk/nextbus.htm). Although it appears that NextBuses has been designed as a development of the *Txt2Traveline* SMS mobile service, it currently has an internet version, and it is hoped that both versions will continue as they provide an excellent opportunity and purposeful reason for delivering SSBMs over the internet.

Figures 7.2 to 7.4 provide an overview of the output for a query about the next buses from stops around the Department of Geographical and Earth Sciences, University of Glasgow (using the postcode G12 8QQ). After receiving a Google Map 'mashup' showing the bus stop locations (Figure 7.2), the user can select the relevant link for their stop of interest (Figure 7.3) and receive the next departure times (timetabled or in real-time when available) of the buses from that stop (Figure 7.4)

Having personally conducted a number of queries for bus stops in different areas of the UK (all very familiar to the author), the Traveline NextBuses appears to be an excellent service. It does, however, require the user to have some prior knowledge about services in an area, or at least have a suitable Network Map and street plan to hand. Despite investigating every hyperlink provided, the information given in Figure 7.4 is the most detail a user can currently obtain about where services go through this service, as the next level of information is simply a list of departure times from that stop for a specific service.

Traveline's NextBuses service is **not** a journey planner and is provided in conjunction with the existing journey planning services. This means there is no easy and efficient way for users to identify which service(s) they require by only using the NextBuses service. Upon reaching Figure 7.4, the amount of information obtained could still give rise to such questions as ‘Do I need to board the 44 or the 44A?’, ‘Are there differences between the routes followed by each service?’ and, quite possibly, ‘Where is Knightswood?’ This gap in the information provided is an ideal opportunity for SSBMs to be delivered online, by including a hyperlink to the relevant SSBM for the stop in question.

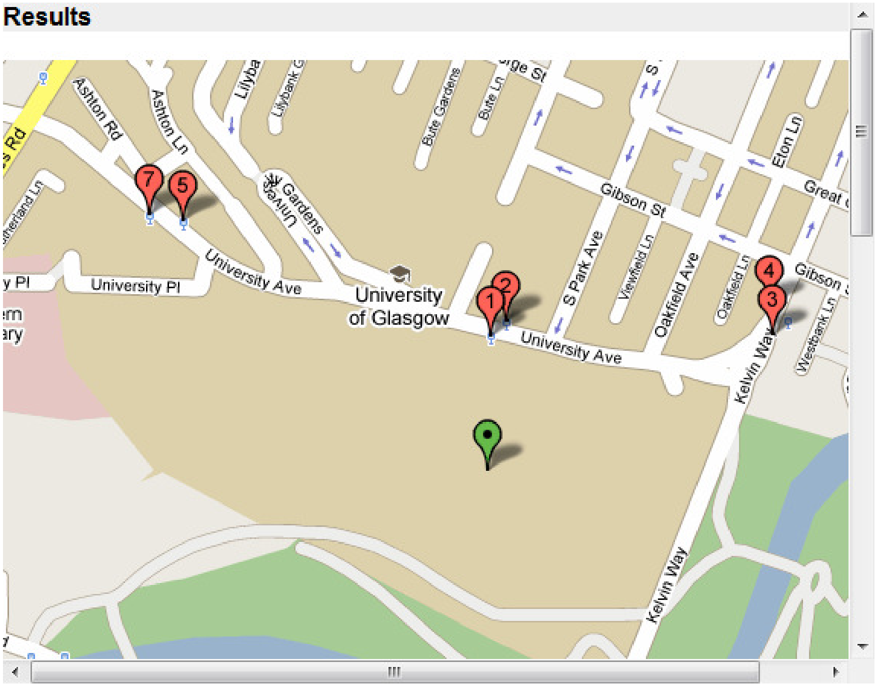


Figure 7.2: NextBuses step 1.

A Google Map ‘mashup’ showing the locations of the nearest bus stops to a given postcode (in this case, G12 8QQ).

80 stops found within 1km of G12 8QQ

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1 University Library (>NW)
on University Avenue, Hillhead (Glasgow) (<500m)
2 University Library (>SE)
on University Avenue, Hillhead (Glasgow) (<500m)
3 Gilmorehill Hall (>SW)
on University Avenue, Hillhead (Glasgow) (<500m)
4 Gilmorehill Hall (>NE)
on University Avenue, Hillhead (Glasgow) (<500m)
5 Boyd Orr Building (>SE)
on University Avenue, Hillhead (Glasgow) (<500m)
6 Kelvin Hall (>SE)
on Argyle Street, Kelvingrove (<500m)
7 Boyd Orr Building (>NW)
on University Avenue, Hillhead (Glasgow) (<500m)
8 Kelvingrove Art Galleries (>SE)
on Argyle Street, Kelvingrove (<500m)

Figure 7.3: NextBuses step 2.

List of the bus stops in Figure 7.2, showing the bus stop name, the general direction of travel of the calling services from each stop and approximate distance from the given postcode.

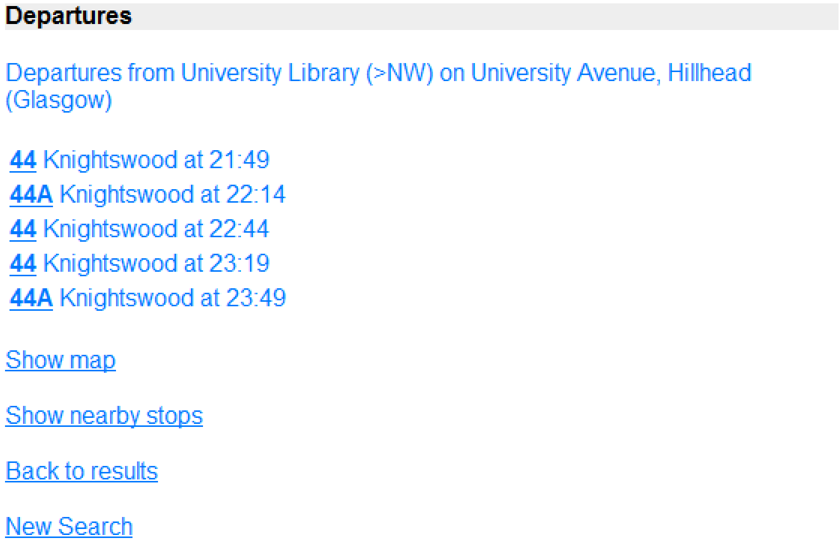

Figure 7.4: NextBuses step 3.

List of destinations and departure times for each of the calling services from a specific bus stop, in this case bus stop 1 in Figure 7.3.

As the departure times are stop-specific, the SSBM would supplement the information already available through the NextBuses service, assisting users to identify which service(s) they are able to board in order to complete their journey. One barrier to this notion is that having an online datastore of SSBMs for every stop in an area might not prove to be the most efficient way of providing such a service, given the data management and maintenance issues required. The research into automated design systems (discussed above) could be further developed to investigate how SSBMs created on-the-fly from a GIS could be incorporated as part of each query to the NextBuses service.

7.5.6 Mobile Dissemination of Stop-Specific Bus Maps

In addition to disseminating SSBMs online, advances in mobile communications and device technologies make the dissemination of SSBMs on handheld electronic devices (mobile phones, smartphones, PDAs etc.) a real possibility (Rizos and Drane, 2004). Traditional SMS text messaging services are now a mainstream PTI application, primarily for obtaining real-time service departure information. Mobile technologies are moving forward at a fast pace and it is now possible for textual information to be supplemented with graphical output, such as the Google map information provided by the aforementioned Traveline NextBuses service.

It is therefore not unreasonable to assume that it may be feasible to provide users with a means of obtaining SSBMs on their mobile devices in addition to the traditional, static paper form of SSBM. Having both forms of SSBM available to the user would be very useful as this means there would be a back-up for each version. The mobile version would be required in situations where the paper SSBM was missing or had been vandalised, or if the lighting conditions were not adequate for reading the display at night, as mobile devices have backlit screens. Conversely, the paper SSBM would provide a back-up for the mobile SSBM should the user not have a suitable mobile device, not have their device to hand or have a flat battery.

There are two main challenges that need to be addressed to achieve this mobile functionality. The first would require revising the existing SSBM specification to produce a design to fit within the confines of a mobile device's display, which has parallels with the limitations of bus stop displays, discussed in Section 7.4.3. There will be a number of issues to overcome, such as would it be possible to fit a *legible* SSBM onto a mobile screen without a substantial level of schematicisation or reduction in map detail, thus losing some of the benefits of the SSBM.

Another design issue to be considered is the variation in screen sizes and pixel resolution of mobile devices, especially considering the possibilities provided by the latest hi-resolution, touchscreen devices such as the Apple iPhone, Nokia N97 or the HTC Touch. The variation in display capacities and general device capabilities will have some influence on exactly what would be possible to display on each individual mobile device, so a system which can quickly adapt and render the graphical output to tailor the SSBM to match individual device specifications might be a key research topic in this area.

Aside from the design and display constraints, a major component of future research would be establishing how to integrate any automated systems for generating SSBMs with the technologies that enable graphical content to be made available through mobile communication protocols, such as GPRS or Bluetooth. As 3G technologies provide adequate download speeds with sufficient data transmission rates to allow graphical information to be obtained on a device reasonably quickly, the main barrier to disseminating graphical content such as SSBMs via mobile networks would appear to be the cost of downloading large file sizes, unless the user has unlimited web browsing as part of their mobile contract. Although the mobile display constraints may demand smaller SSBMs which, ultimately, are of a file size sufficiently small enough to be suitable for mobile dissemination, it may be more feasible for future research to explore the potential of near-range device-to-device communication technologies, such as infra-red or Bluetooth.

One Bluetooth application that could have real potential in future PTI systems is the Hypertag, a range of small electronic devices that can be fitted behind poster displays (such as those at bus stops) which are currently used for marketing and campaign purposes, and in visitor navigation and information systems at tourist attractions. The Hypertag technology would be very useful at bus stops where display space is limited and there is not enough available space for a hardcopy of the SSBM to be displayed alongside the other information. It should be a relatively simple process to implement Hypertags in such a way as to enable users to download SSBMs (and other PT marketing material) directly to their mobile device when waiting at a bus stop.

The most advanced version of the Hypertag can be hard-wired into the Internet to allow its content to be updated remotely, which would be necessary for maintaining the content and currency of the SSBMs, although to minimise the time required to receive the information, it will still be necessary to look at how the size of SSBM files can be kept to a minimum.

7.6 Closing Remarks

At the beginning of this thesis, a number of significant issues surrounding our reliance upon the private car were put forward. Although it cannot be denied that the car is a highly desirable and useful commodity for many people, we have become a very car dependent society. As congestion levels increase, as hydrocarbon reserves become scarcer and as environmental issues and concerns climb ever higher up the political agenda, there is a real cause to move our societal needs away from being over-reliant upon the car and PT can, and indeed should, be the solution to a number of these problems. Whilst PT may not suit everyone or be the most appropriate choice for every journey, there are many people who are willing to switch modes and many journeys for which PT is highly suitable. This research has demonstrated is that if we are going to persuade these people to swap their cars for buses, even for the occasional journey, they need to be aware of the alternative options available to them.

Mapping information is the optimum form of PTI to help people identify which services exist in their area and to where they can travel, but many people are not confident in their ability to use maps. The SSBM concept has shown that existing bus maps can be successfully broken down into their individual components to provide people with information that is relevant at the point of use, and at a level of detail which enables the user to clearly understand what is presented to them. The results of the field tests demonstrate that the SSBM concept has significant advantages over the existing forms of PTI for journey planning, in terms of the percentage of correct answers, the time taken to reach a correct answer and the level of confidence in the user that their chosen service will take them to the intended location. It can therefore be said that the simplified information provided by a SSBM is a vital tool in helping people to understand "where the buses go".

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Table A.1: All Towns with a Population of 75000 – 300000
(Table KS01, 2001 Census)

Census Town Code and Name	Population (2001)
D41309 Bradford	293717
K12202 Cardiff	292150
K60256 Bromley	280305
K60208 Enfield	273203
I91800 Swansea Urban Area	270506
K80400 Southend Urban Area	269415
K60235 Lambeth	267785
D21500 Preston Urban Area	264601
K60214 Brent	263464
D20300 Blackpool Urban Area	261088
K60234 Wandsworth	259881
E83203 Stoke-on-Trent	259252
G90701 Wolverhampton	251462
F90806 Nottingham	249584
K60237 Lewisham	248922
K60229 Newham	243891
N11100 Plymouth	243795
K60236 Southwark	243749
L60400 Aldershot Urban Area	243344
K60213 Hillingdon	242755
K60219 Redbridge	240796
F80300 Derby Urban Area	236738
J60700 Luton/Dunstable	236318
M66602 Southampton	234224
K56801 Reading	232662
K81700 The Medway Towns Urban Area	231659
F80301 Derby	229407
K60231 Havering	223193
K60238 Greenwich	219263
K60216 Waltham Forest	218341
K60215 Haringey	216507
K60232 Hounslow	212341
K60239 Bexley	211802
E16900 Dearne Valley Urban Area	207726
K60206 Harrow	206643
K60225 Hackney	202824
K60223 Camden	198020
I28200 Northampton Urban Area	197199
K60228 Tower Hamlets	196106
G90704 Dudley	194919
G46100 Norwich Urban Area	194839
B81104 Newcastle upon Tyne	189863
I28201 Northampton	189474
K60250 Merton	187908
M61703 Portsmouth	187056
J60702 Luton	185543
D21501 Preston	184836
I27900 Milton Keynes Urban Area	184506
B81900 Sunderland Urban Area	182974
K60226 Westminster	181766
L71400 Crawley Urban Area	180177

Census Town Code and Name	Population (2001)
K60253 Sutton	177796
B81901 Sunderland	177739
K60224 Islington	175797
G46101 Norwich	174047
K60233 Richmond upon Thames	172335
G90702 Walsall	170994
I91801 Swansea	169880
M54502 Bournemouth	167527
D81100 Wigan Urban Area	166840
K60221 Hammersmith and Fulham	165242
K60230 Barking and Dagenham	163944
K80405 Southend-on-Sea	160257
K60222 Kensington and Chelsea	158439
D93400 Warrington Urban Area	158195
F05700 Mansfield Urban Area	158114
K35000 Swindon	155432
D33600 Burnley/Nelson	149796
K60249 Kingston upon Thames	146873
D41320 Huddersfield	146234
M54501 Poole	144800
J41400 Oxford	143016
C35004 Middlesbrough	142691
D20304 Blackpool	142283
K61000 Slough Urban Area	141848
J94500 Ipswich Urban Area	141658
G90707 Oldbury/Smethwick	139855
D90206 Bolton	139403
K11400 Newport Urban Area	139298
E30400 Grimsby/Cleethorpes	138842
J94501 Ipswich	138718
F74100 Telford Urban Area	138241
D50300 York	137505
G90705 West Bromwich	136940
D31200 Blackburn/Darwen	136655
H20700 Peterborough	136292
J25300 Gloucester Urban Area	136203
D90247 Stockport	136082
M83708 Brighton	134293
H01600 Nuneaton Urban Area	132236
I41200 Cambridge Urban Area	131465
E17400 Doncaster Urban Area	127851
M90900 Hastings/Bexhill	126386
K61001 Slough	126276
J25301 Gloucester	123205
K60203 Watford	120960
K90200 Thanet	119144
K56900 High Wycombe Urban Area	118229
I41203 Cambridge/Milton	117717
E17002 Rotherham	117262
K11401 Newport	116143
D84200 Southport/Formby	115882
J62200 St Albans/Hatfield	114710
N20500 Torbay	110366
J30100 Cheltenham/Charlton Kings	110320
M20600 Exeter	106772
M91200 Eastbourne	106562
G90706 Sutton Coldfield	105452

Census Town Code and Name	Population (2001)
D31201 Blackburn	105085
J80800 Colchester	104390
F14900 Lincoln Urban Area	104221
D90221 Oldham	103544
D84106 St. Helens	102629
I31600 Bedford/Kempston	101928
K83800 Basildon/North Benfleet	101492
K60247 Woking/Byfleet	101127
E95100 Chesterfield/Staveley	100879
L71402 Crawley	100547
J71900 Chelmsford	99962
K83801 Basildon	99876
J30101 Cheltenham	98875
K81704 Gillingham	98403
M83702 Worthing	96964
D90211 Rochdale	95796
C71500 Morecambe/Lancaster	95521
G90711 Solihull	94753
I00600 Worcester	94029
L55700 Basingstoke/Basing	93963
D84201 Southport	91404
E70700 Chester Urban Area	90925
L55701 Basingstoke	90171
K21600 Bath	90144
L80900 Maidstone	89684
J71100 Harlow/Sawbridgeworth	88296
E30401 Grimsby	87574
C32300 Darlington	86082
C31300 Hartlepool	86075
F14901 Lincoln	85963
M90902 Hastings	85828
D40100 Harrogate/Knaresborough	85128
I10300 Warwick/Leamington	84945
F71900 Cannock/Great Wyrley	83797
D82302 Birkenhead	83729
D45200 Halifax	83570
K60201 Hemel Hempstead	83118
B81110 South Shields	82854
K13900 Pontypool/Cwmbran	82701
I31601 Bedford	82488
J62201 St Albans	82429
J60800 Stevenage	81482
D81104 Wigan	81203
D93401 Warrington	80661
E70701 Chester	80121
L25300 Weston-Super-Mare Urban Area	80076
C35002 Stockton-on-Tees	80060
G90500 Tamworth Urban Area	79008
B81114 Gateshead	78403
L25301 Weston-Super-Mare	78044
I05400 Redditch/Astwood Bank	77461
K56902 High Wycombe	77178
D41319 Wakefield	76886
K71500 Grays/Tilbury	75635

Table A.2: Towns with a Population of 75000 – 300000, within 100 miles of London

Census Town Code and Name	Population (2001)
K60256 Bromley	280305
K60208 Enfield	273203
K80400 Southend Urban Area	269415
K60235 Lambeth	267785
K60214 Brent	263464
K60234 Wandsworth	259881
K60237 Lewisham	248922
K60229 Newham	243891
K60236 Southwark	243749
L60400 Aldershot Urban Area	243344
K60213 Hillingdon	242755
K60219 Redbridge	240796
J60700 Luton/Dunstable	236318
M66602 Southampton	234224
K56801 Reading	232662
K81700 The Medway Towns Urban Area	231659
K60231 Havering	223193
K60238 Greenwich	219263
K60216 Waltham Forest	218341
K60215 Haringey	216507
K60232 Hounslow	212341
K60239 Bexley	211802
K60206 Harrow	206643
K60225 Hackney	202824
K60223 Camden	198020
I28200 Northampton Urban Area	197199
K60228 Tower Hamlets	196106
G46100 Norwich Urban Area	194839
I28201 Northampton	189474
K60250 Merton	187908
M61703 Portsmouth	187056
J60702 Luton	185543
I27900 Milton Keynes Urban Area	184506
K60226 Westminster	181766
L71400 Crawley Urban Area	180177
K60253 Sutton	177796
K60224 Islington	175797
G46101 Norwich	174047
K60233 Richmond upon Thames	172335
G90702 Walsall	170994
M54502 Bournemouth	167527
K60221 Hammersmith and Fulham	165242
K60230 Barking and Dagenham	163944
K80405 Southend-on-Sea	160257
K60222 Kensington and Chelsea	158439
K35000 Swindon	155432
K60249 Kingston upon Thames	146873
M54501 Poole	144800
J41400 Oxford	143016
K61000 Slough Urban Area	141848

Census Town Code and Name	**Population (2001)**
J94500 Ipswich Urban Area	141658
J94501 Ipswich	138718
H20700 Peterborough	136292
J25300 Gloucester Urban Area	136203
M83708 Brighton	134293
H01600 Nuneaton Urban Area	132236
I41200 Cambridge Urban Area	131465
M90900 Hastings/Bexhill	126386
K61001 Slough	126276
J25301 Gloucester	123205
K60203 Watford	120960
K90200 Thanet	119144
K56900 High Wycombe Urban Area	118229
I41203 Cambridge/Milton	117717
J62200 St Albans/Hatfield	114710
J30100 Cheltenham/Charlton Kings	110320
M91200 Eastbourne	106562
J80800 Colchester	104390
I31600 Bedford/Kempston	101928
K83800 Basildon/North Benfleet	101492
K60247 Woking/Byfleet	101127
L71402 Crawley	100547
J71900 Chelmsford	99962
K83801 Basildon	99876
J30101 Cheltenham	98875
K81704 Gillingham	98403
M83702 Worthing	96964
L55700 Basingstoke/Basing	93963
L55701 Basingstoke	90171
K21600 Bath	90144
L80900 Maidstone	89684
J71100 Harlow/Sawbridgeworth	88296
M90902 Hastings	85828
I10300 Warwick/Leamington	84945
F71900 Cannock/Great Wyrley	83797
K60201 Hemel Hempstead	83118
I31601 Bedford	82488
J62201 St Albans	82429
J60800 Stevenage	81482
I05400 Redditch/Astwood Bank	77461
K56902 High Wycombe	77178
K71500 Grays/Tilbury	75635

Table A.3: Towns with a Population of 75000 – 300000, outwith 100 miles of London

Census Town Code and Name	Population (2001)
D41309 Bradford	293717
K12202 Cardiff	292150
I91800 Swansea Urban Area	270506
D21500 Preston Urban Area	264601
D20300 Blackpool Urban Area	261088
E83203 Stoke-on-Trent	259252
G90701 Wolverhampton	251462
F90806 Nottingham	249584
N11100 Plymouth	243795
F80300 Derby Urban Area	236738
F80301 Derby	229407
E16900 Dearne Valley Urban Area	207726
G90704 Dudley	194919
B81104 Newcastle upon Tyne	189863
D21501 Preston	184836
B81900 Sunderland Urban Area	182974
B81901 Sunderland	177739
I91801 Swansea	169880
D81100 Wigan Urban Area	166840
D93400 Warrington Urban Area	158195
F05700 Mansfield Urban Area	158114
D33600 Burnley/Nelson	149796
D41320 Huddersfield	146234
C35004 Middlesbrough	142691
D20304 Blackpool	142283
G90707 Oldbury/Smethwick	139855
D90206 Bolton	139403
K11400 Newport Urban Area	139298
E30400 Grimsby/Cleethorpes	138842
F74100 Telford Urban Area	138241
D50300 York	137505
G90705 West Bromwich	136940
D31200 Blackburn/Darwen	136655
D90247 Stockport	136082
E17400 Doncaster Urban Area	127851
E17002 Rotherham	117262
K11401 Newport	116143
D84200 Southport/Formby	115882
N20500 Torbay	110366
M20600 Exeter	106772
G90706 Sutton Coldfield	105452
D31201 Blackburn	105085
F14900 Lincoln Urban Area	104221
D90221 Oldham	103544
D84106 St. Helens	102629
E95100 Chesterfield/Staveley	100879
D90211 Rochdale	95796
C71500 Morecambe/Lancaster	95521
G90711 Solihull	94753
I00600 Worcester	94029

Census Town Code and Name	**Population (2001)**
D84201 Southport	91404
E70700 Chester Urban Area	90925
E30401 Grimsby	87574
C32300 Darlington	86082
C31300 Hartlepool	86075
F14901 Lincoln	85963
D40100 Harrogate/Knaresborough	85128
D82302 Birkenhead	83729
D45200 Halifax	83570
B81110 South Shields	82854
K13900 Pontypool/Cwmbran	82701
D81104 Wigan	81203
D93401 Warrington	80661
E70701 Chester	80121
L25300 Weston-Super-Mare Urban Area	80076
C35002 Stockton-on-Tees	80060
G90500 Tamworth Urban Area	79008
B81114 Gateshead	78403
L25301 Weston-Super-Mare	78044
D41319 Wakefield	76886

Table A.4: Towns with a Population of 75000 – 300000, within 100 miles of London, but not within a PTE/ITA or M25 Boundary

Census Town Name	Population (2001)	Sample ID Number
Aldershot (Urban Area)	243344	00
Basildon/North Benfleet	101492	01
Basingstoke/Basing	93963	02
Bath	90144	03
Bedford/Kempston	101928	04
Bournemouth	167527	05
Brighton	134293	06
Cambridge (Urban Area)	131465	07
Cannock/Great Wyrley	83797	08
Chelmsford	99962	09
Cheltenham/Charlton Kings	110320	10
Colchester	104390	11
Crawley (Urban Area)	180177	12
Eastbourne	106562	13
Gloucester (Urban Area)	136203	14
Grays/Tilbury	75635	15
Harlow/Sawbridgeworth	88296	16
Hastings/Bexhill	126386	17
Hemel Hempstead	83118	18
High Wycombe (Urban Area)	118229	19
Ipswich (Urban Area)	141658	20
Luton/Dunstable	236318	21
Maidstone	89684	22
Medway Towns (Urban Area)	231659	23
Milton Keynes (Urban Area)	184506	24
Northampton (Urban Area)	197199	25
Norwich (Urban Area)	194839	26
Nuneaton (Urban Area)	132236	27
Oxford	143016	28
Peterborough	136292	29
Poole	144800	30
Portsmouth	187056	31
Reading	232662	32
Redditch/Astwood Bank	77461	33
Slough (Urban Area)	141848	34
Southampton	234224	35
Southend (Urban Area)	269415	36
St Albans/Hatfield	114710	37
Stevenage	81482	38
Swindon	155432	39
Thanet	119144	40
Warwick/Leamington	84945	41
Woking/Byfleet	101127	42
Worthing	96964	43

Table A.5: Towns with a Population of 75000 – 300000, outwith 100 miles of London, but not within a PTE/ITA Boundary

Census Town Name	Population (2001)	Sample ID Number
Blackburn/Darwen	136655	00
Blackpool (Urban Area)	261088	01
Burnley/Nelson	149796	02
Cardiff	292150	03
Chester (Urban Area)	90925	04
Chesterfield/Staveley	100879	05
Darlington	86082	06
Derby (Urban Area)	236738	07
Doncaster (Urban Area)	127851	08
Exeter	106772	09
Grimsby/Cleethorpes	138842	10
Harrogate/Knaresborough	85128	11
Hartlepool	86075	12
Lincoln (Urban Area)	104221	13
Mansfield (Urban Area)	158114	14
Middlesbrough	142691	15
Morecambe/Lancaster	95521	16
Newport (Urban Area)	139298	17
Nottingham	249584	18
Plymouth	243795	19
Pontypool/Cwmbran	82701	20
Preston (Urban Area)	264601	21
Southport	91404	22
Stockton-on-Tees	80060	23
Stoke-on-Trent	259252	24
Swansea (Urban Area)	270506	25
Tamworth (Urban Area)	79008	26
Telford (Urban Area)	138241	27
Torbay	110366	28
Warrington (Urban Area)	158195	29
Weston-Super-Mare (UrbanArea)	80076	30
Worcester	94029	31
York	137505	32

B.1 Random Sampling from each Sample Stratum

A random number table was used to generate a sequence of two-digit numbers. The starting place for the first sampling stratum (towns within 100 miles of London) was selected by going the number of letters in the author's first name (6) along the top row and then down by the number of letters in the author's surname (5), generating the following sequence: 47 74 **43** 68 55 83 **07** 66 **19** 75 96 86 57 49 76 **41**

The numbers in bold correspond to valid sample numbers, these locations are: **43** Worthing; **07** Cambridge (Urban Area); **19** High Wycombe; **41** Warwick/Leamington Spa

For the second sampling stratum (towns outwith 100 miles of London), the starting place was selected using the same process but reversing the author's names (i.e. along 5, down 6) to ensure a different set of random numbers was generated. This gave the following sequence: 54 73 99 **23 30 32** 60 **07**

The numbers in bold correspond to valid sample numbers, these locations are: **23** Stockton-on-Tees; **30** Weston-super-Mare; **32** York; **07** Derby.

The PT services available in each of the randomly sampled locations were then assessed to identify if any location would be suitable for testing purposes. It must be noted that the inherent flexibility of PT services in the UK means that it is likely that the situation described for each location will probably not exactly match the current PT services that now exist in each area.

B.2 Post-sample Screening: Towns within 100 miles of London.

Location 1: Worthing

Worthing (Figure B.1) is located on the south coast of England, approximately 49 miles from Central London and about 10 miles west of Brighton. It has a population of 96,964 (2001 Census) and is one of a number of towns of a similar size situated along the Brighton-Portsmouth coastal corridor.

Figure B.1: Location Map of Worthing

Buses in Worthing

The main bus operator in the area is Stagecoach, who run eight local services from Worthing to surrounding areas; the Worthing 'Pulse', a Town Centre service; and the 'Coastliner' service which runs along the South Coast linking Worthing with Brighton, Portsmouth and the other main towns in the area. Stagecoach also provides a single daily shopping service to/from the local supermarkets.

Brighton and Hove Buses also serve Worthing but only in the evening Monday to Saturday (four journeys). They also provide a single daily shopping service to/from the Holmbush Shopping Centre. Compass Bus travel are an independent operator who run services across the local area and are based in Worthing, but they only have four services that actually serve the Worthing area. Metro Bus operates a two-hourly service linking Worthing with Horsham and Crawley.

Total Number of Regular Services: approximately 15.

Rail Services in Worthing

Worthing has frequent rail services along the South Coast mainline to/from destinations such as Brighton, London, Gatwick Airport, Portsmouth and Southampton. Worthing itself is served by three railway stations, Worthing, East Worthing and West Worthing, as well as other stations at Durrington-on-Sea and Goring-by-Sea.

Decision: **Not to be Used**. Worthing has a limited number of regular bus services plus good competition from rail services, both on a local and more regional level. Worthing has a population close to 100,000 but there are many other towns in close proximity with a similar population and it was felt that a location which was more 'free-standing' in its nature was desirable.

Location 2: Cambridge (Urban Area)

Cambridge (Urban Area) (Figure B.2) is located about 50 miles north of Central London, with a population of 131,465 (2001 Census; Cambridge itself has a population of 117,717, a significant population centre in its own right). There are no other main towns within the immediate vicinity of Cambridge; other centres of population in the region include Ely, Newmarket and Huntingdon, with Peterborough about 30 miles to the North West.

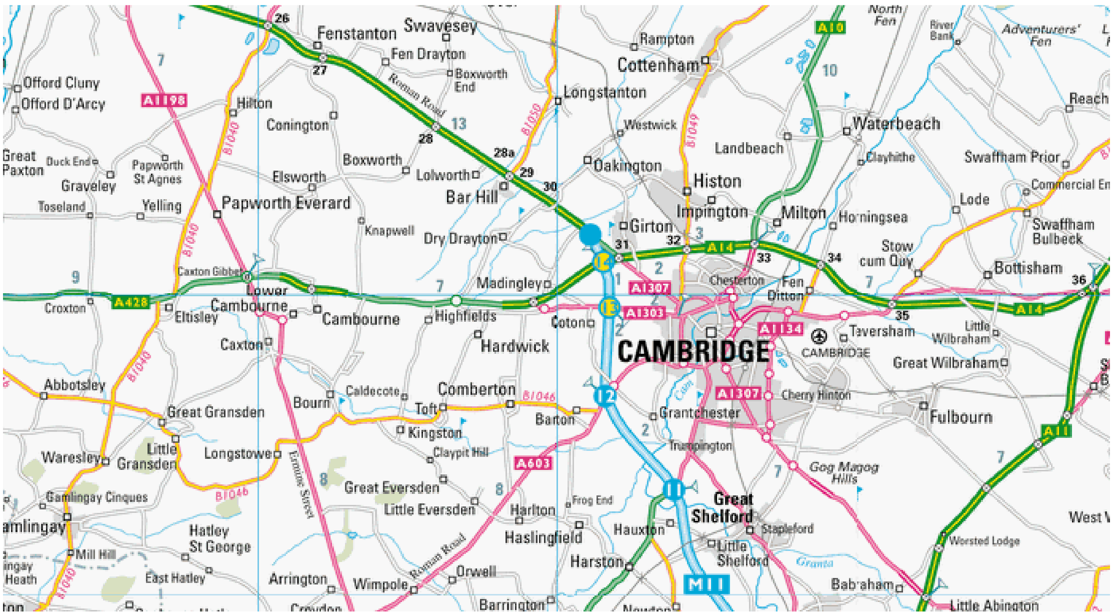

Figure B.2: Location Map of Cambridge (Urban Area)

Buses in Cambridge

The main bus operator in Cambridge is Stagecoach (Cambridge) who operate a variety of local town services (the 'Citi' network), local services to surrounding towns/villages and express coach services to destinations such as Bedford, Peterborough and Oxford.

Huntingdon and District Buses provide regular services between Cambridge and Huntingdon throughout the day plus a number of additional limited, evening or weekend only services between the two locations. Local services are also provided by Go Whippet, an independent operator, between Cambridge, Huntingdon and other surrounding towns.

Total Number of Regular Services: approximately 35.

Rail Services in Cambridge

Cambridge has one mainline railway station with a mixture of rail services. Express services and an hourly stopping service operate to/from London King's Cross and stopping services also operate to/from London Liverpool Street. Regional services operate to/from Kings Lynn, Norfolk, Suffolk, Stansted Airport and Birmingham New Street but overall, rail services to/from Cambridge can not be defined as local.

Decision: **Use**. Cambridge has a good number of bus routes, both intra-town and inter-urban services, with little (if any) competition from rail services, at least at the local level, so it can be defined as primarily a bus-based city. It is a free-standing urban area with a significant population but also has a major tourist attraction in Cambridge University, and so it can be assumed that there will be plenty of infrequent bus users for whom a SSBM would be extremely useful.

B.3 Post-sample Screening: Towns Outwith 100 miles of London

Location 1: Stockton-on-Tees

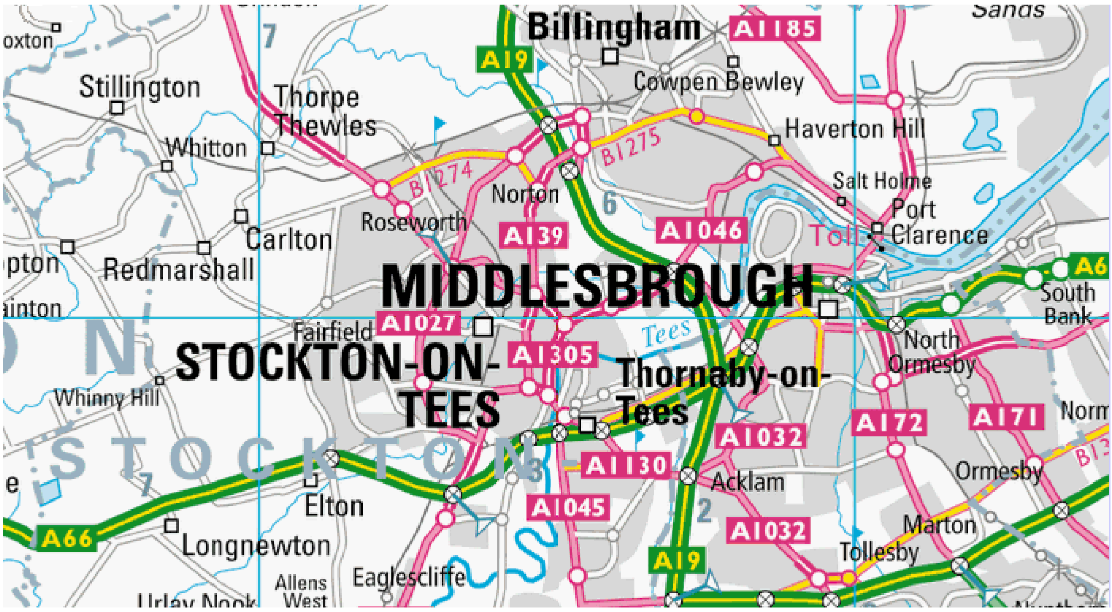

Figure B.3: Location Map of Stockton-on-Tees

Stockton-on-Tees (Figure B.3) is located in the North East of England, about 220 miles from Central London. It has a population of 80,060 (one of the smallest populations in the sample frame) and is very close to Middlesbrough (population: 142,691).

Buses in Stockton-on-Tees

Current bus services are provided by Arriva and Stagecoach plus the council-run Boroughbus network. A number of smaller operators provide additional services in the area. However, at the time of the selection process, bus services in the Tees Valley area (consisting of Stockton-on-Tees, Middlesbrough, Hartlepool, Darlington and Redcar & Cleveland Borough Councils) have been under review, with preliminary results recommending a hierarchical bus network with 'super-core' services supplemented with secondary and tertiary networks. These recommendations are currently being investigated and assessed by the various parties which may result in major changes occurring to the bus network. Due to this potential instability (although admittedly, all British bus networks are subject to instability due to the six-week period of notice required to alter a bus service), it was decided that it would not be suitable to try and collate all the required data and conduct research surveys when services were likely to undergo significant changes in the short term future.

Stockton has one railway station, with an hourly service to/from Hexham-Newcastle-Sunderland-Billingham-Stockton-Middlesbrough. It can therefore be said that Stockton is primarily a bus-based town.

Decision: **Not to be Used**. The 2005 review of the entire Tees Valley bus network has been conducted and recommendations are being implemented. Due to the time restrictions of this study, it was decided that conducting surveys at this time when significant changes were likely, requiring significant work to recollect data and revise maps, would be a difficult task to achieve. Also, Stockton is a town in its own right, but its close proximity to Middlesbrough means that it would be hard to determine which bus services would be the most appropriate to represent in the database of services.

Location 2: Weston-super-Mare (Urban Area)

Weston-super-Mare (WSM) (Figure B.4) is located in the West by the Bristol Channel, approximately 123 miles from Central London, and about 18 miles South West of Bristol. It has a population of 80,076 (Urban Area; WSM itself has a population of 78,044) which, like Stockton, is one of the smaller populations in the sample frame.

Figure B.4: Location Map of Weston-Super-Mare

Buses in Weston-Super-Mare

The majority of buses in WSM are provided by Badgerline, part of First Group (Somerset and Avon) with a handful of small operators providing a very limited range of additional services that run once or twice a week. The Badgerline services consist of around ten local town services and around ten regional services including express routes to Bristol, and routes to surrounding towns such as Cheddar, Axbridge and Bridgwater.

Total Number of Regular Services: approximately 20.

Rail Service in Weston-Super-Mare

WSM has three rail stations at Weston-super-Mare, Weston Milton and Worle. There are a mixture of services, which can be summarised as an hourly local stopping service to/from Bristol (calling at all three stations) plus stopping regional services to destinations such as Gloucester, with regular express services to/from Bristol, the South West, London, Birmingham and the North East. The small number of local stations will probably mean that travel within WSM is primarily bus-based, with the main rail competition being focussed on the Bristol market.

Decision: **Not to be Used**. WSM is too small a town, the bus market was limited in the number of operators (only First Group have any significant presence), and the number and geographical coverage of the intra-town routes didn't lend themselves to the SSBM concept – a well designed Network Map would probably suit in this instance.

Location 3: York

York (Figure B.5) is located approximately 174 miles north of Central London and has a population of 137,505 (2001 Census). It is a free-standing city, close to the West Yorkshire Urban Area (Leeds/Bradford/Wakefield).

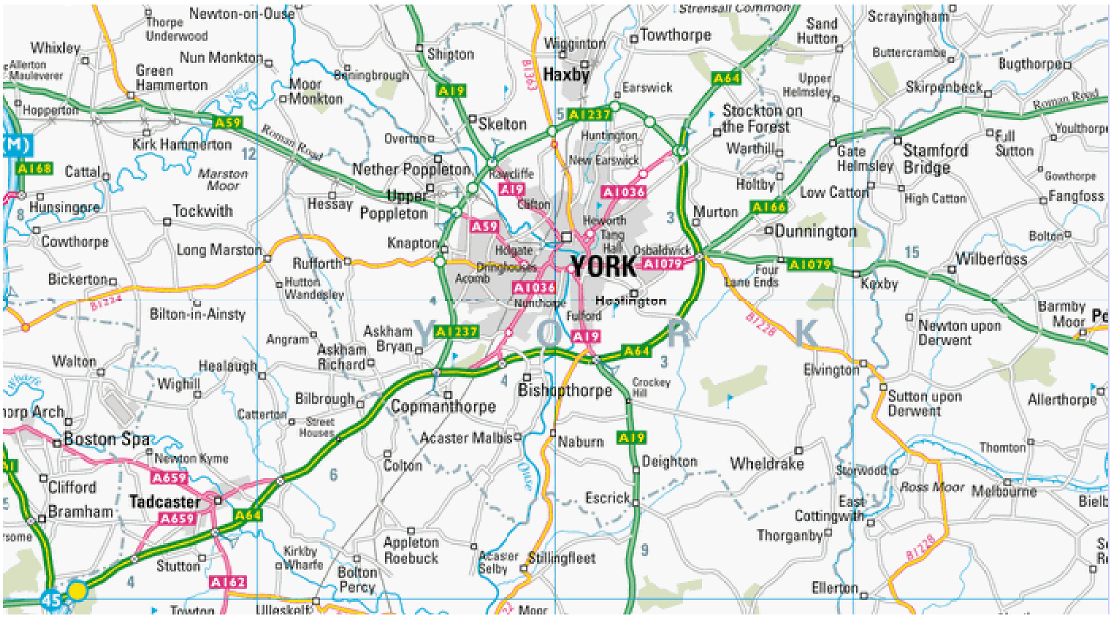

Figure B.5: Location Map of York

Buses in York

York is served by a number of operators, including two national companies in Arriva (Yorkshire North) and First Group (York), of which First has the greatest presence.

First operate the York 'Overground' services, based on the same concept as found in Glasgow of having a core network of high-frequency routes serving main corridors which are supplemented by secondary, less-frequent routes. There are nine high-frequency services, including 'service 4' which is operated by futuristic 'ftr' vehicles, and four additional standard services in the 'Overground' network, plus a further five services which operate at lesser frequencies.

Arriva operate seven services to/from York, at differing frequencies, to Selby, Ripon and Wetherby. The East Yorkshire Motor Service Company operates a number of services to destinations in East Yorkshire, including Hull, Bridlington and Pocklington. Yorkshire Coastliner operate three express bus services at a half-hourly interval linking Leeds-York-Malton-Whitby/Scarborough/Bridlington. A number of smaller, independent operators also operate some services to/from York.

Total Number of Regular Services: approximately 40

Rail Services in York

York has one mainline railway station with a variety of services and destinations across the UK. There is another smaller station in the area, Poppleton, which services the villages of Upper Poppleton and Nether Poppleton, with an hourly service to/from Leeds via Harrogate, but overall there are no services which can be deemed as being 'local'. Stopping services go to/from Leeds (via Harrogate), Hull, Scarborough and Sheffield whilst regional and express services operate to a variety destinations across all of Britain. However, intra-town PT services in York can clearly be defined as primarily bus-based.

Decision: **Use**. As with Cambridge, York has a suitable number of bus routes, both intra-town and inter-urban services, with little (if any) competition from rail services, so it can be defined as primarily a bus-based city. It is a free-standing urban area with a significant population.

This appendix provides an overview of how the Contour tool was implemented to create parallel lines for the SSBMs. For clarity, a simplified, fictional set of services has been used here, service 1 being depicted by the purple line, service 2 by the orange line, service 3 by the green line, service 4 by the blue line and service 5 by the red line. Although it is quite an involved process, this method proved to be very efficient once fully mastered, especially over long sections of common route or roads with numerous turns or high sinuosity.

Step 1 – Once the data had been imported into CD9, the individual layers for each bus service were overlaid and a visual inspection carried out to identify the extent of the common section(s) of route. In Figure C.1 (below), the common section is formed of the links A-B-C-D.

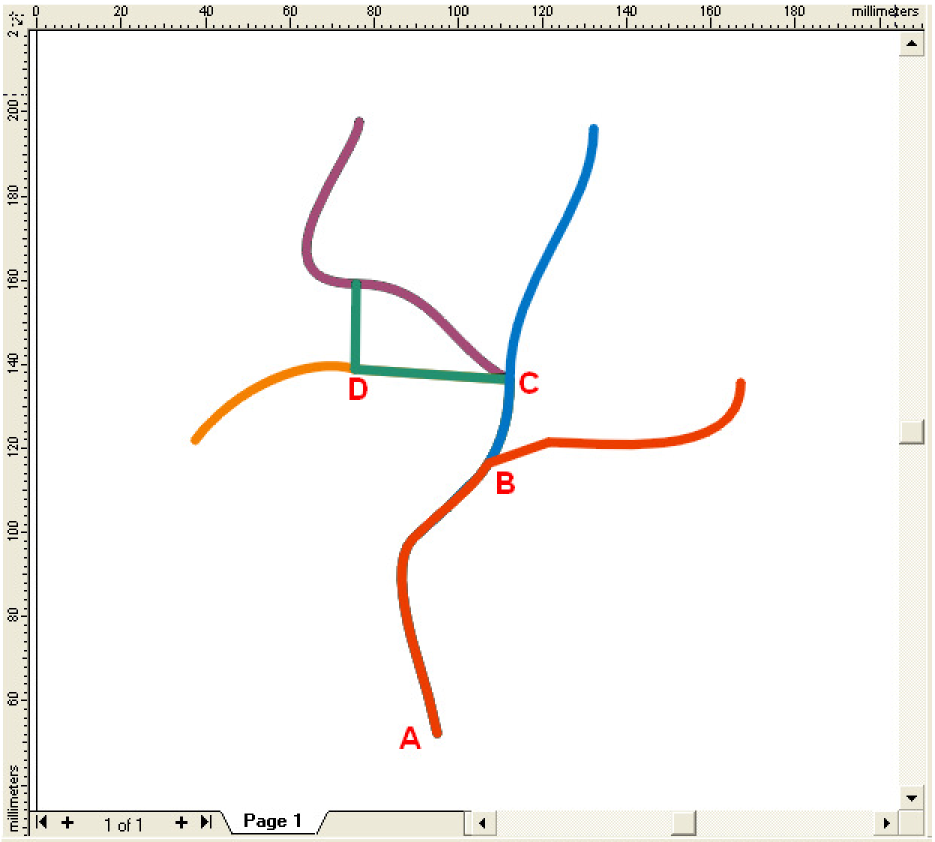

Figure C.1: Initial visual inspection of extent of route data and identification of common section(s) of route which require paralleling

Step 2 – Once the common section(s) had been identified, a new layer called 'Parallel' was created (Figure C.2a), upon which a single continuous polyline was drawn along the centreline of the common section(s) (the thin black line in Figure C.2b) with 'Snap to Objects' activated to ensure each node along the common section was captured.

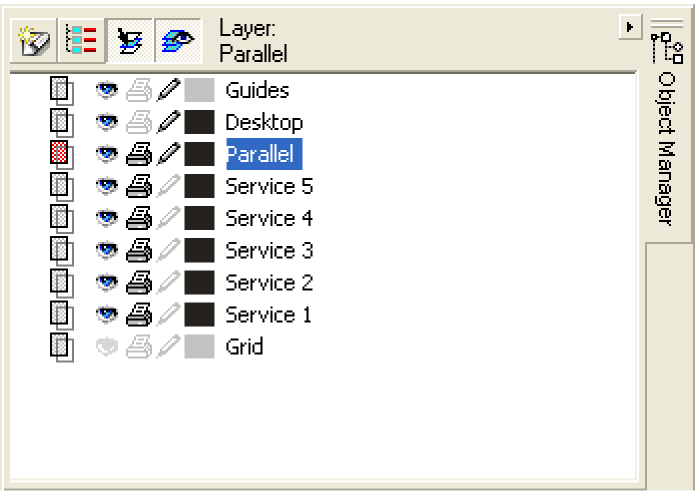

Figure C.2a (left): Creation of new dedicated layer to receive a base polyline from which parallel lines are created

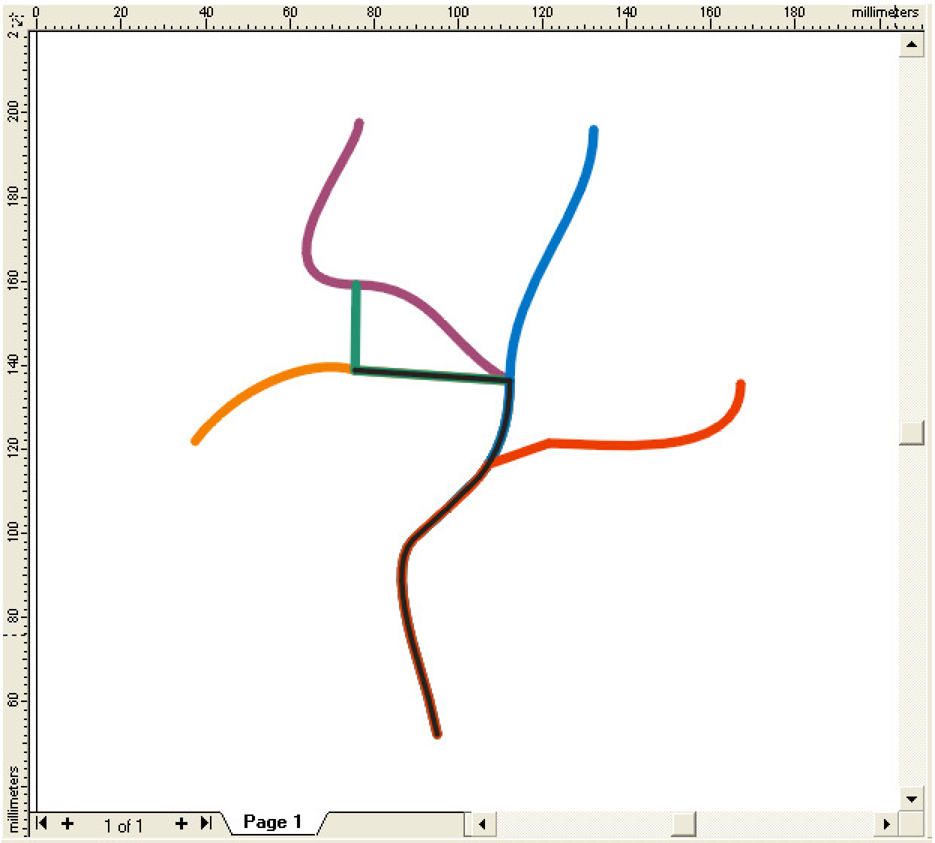

Figure C.2b: Placement of base polyline along the common section of route

Step 3 – After the new polyline had been drawn upon the 'Parallel' layer, the Contour tool was then used to create multiple parallel lines about the existing line (Figure C.3). The Contour spacing was set to 99% of the line width outlined in the specification (for this study the line width was 2mm, therefore the Contour spacing was 1.98mm) to allow for the final lines to nest neatly with each other, eliminating significant expanses of white space between the lines at corners.

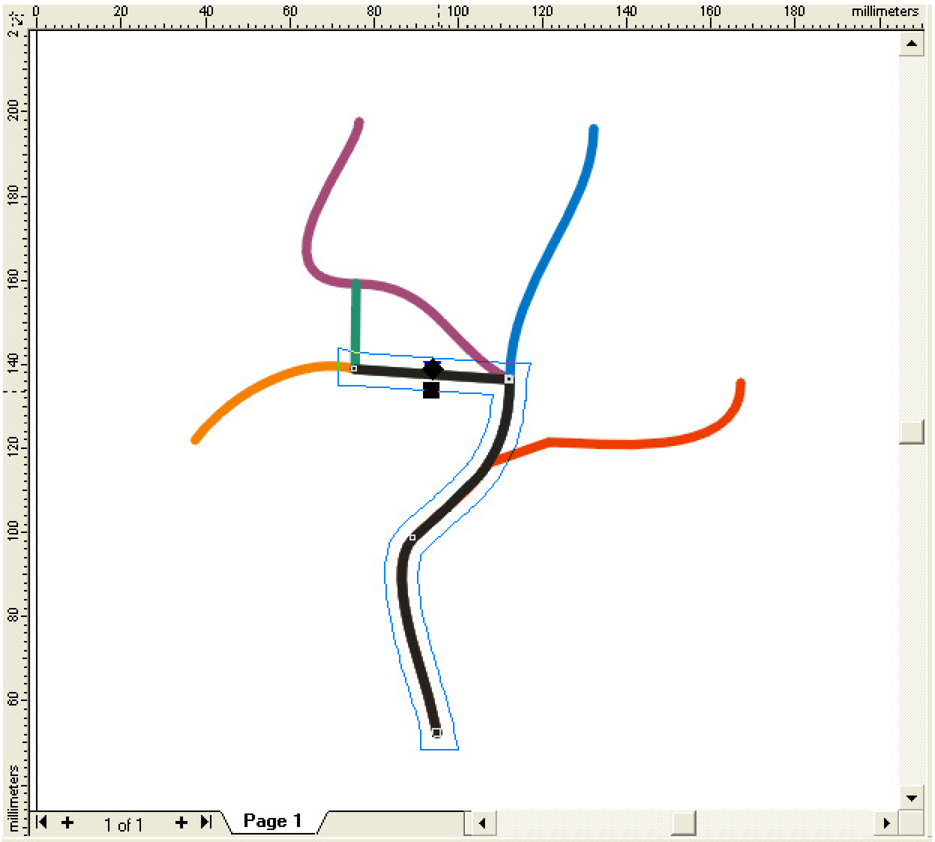

Figure C.3: Using the Contour tool to create initial set of parallel lines

Step 4 – After the Contour tool had been applied successfully, the resulting set of contours had to be separated into single objects (Figure C.4) to allow them to be split apart which would enable the individual parallel line sections to be assigned to the correct layer representing each bus service.

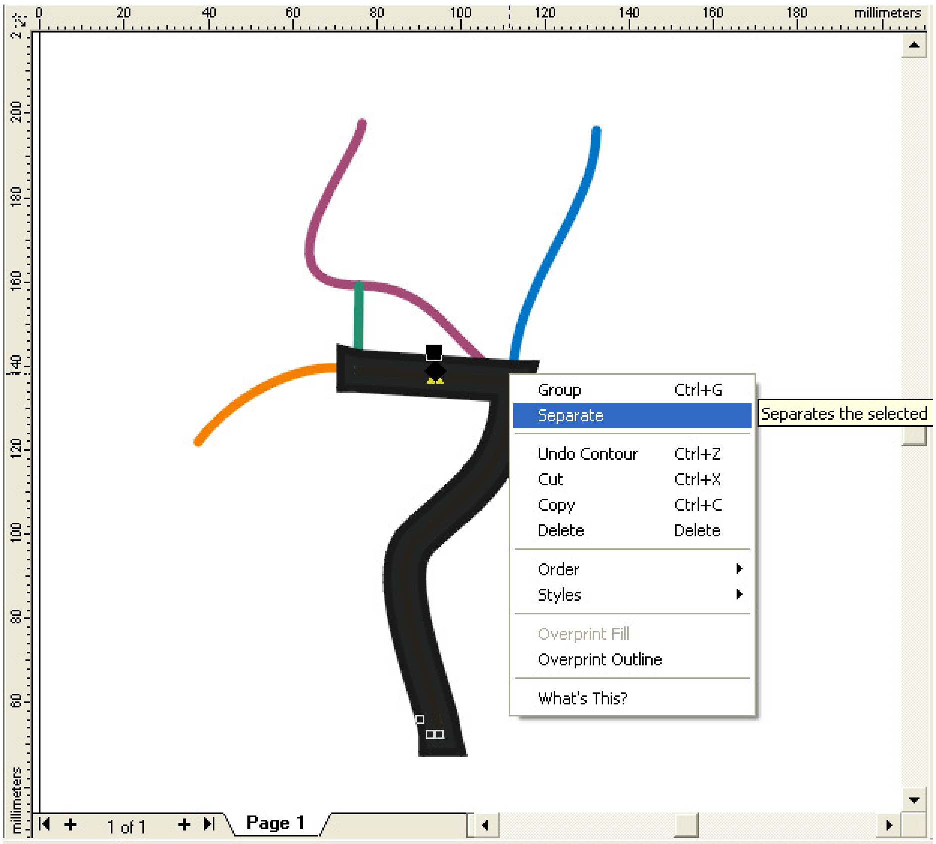

Figure C.4: Separation of parallel lines into individual graphical entities

Step 5 – The output of the Contour tool was such that the ends of the line received a 'cap' which was not required on the SSBMs. The separated contour lines were split apart (Figure C.5) at the relevant nodes and these caps deleted to give the required number of individual parallel lines.

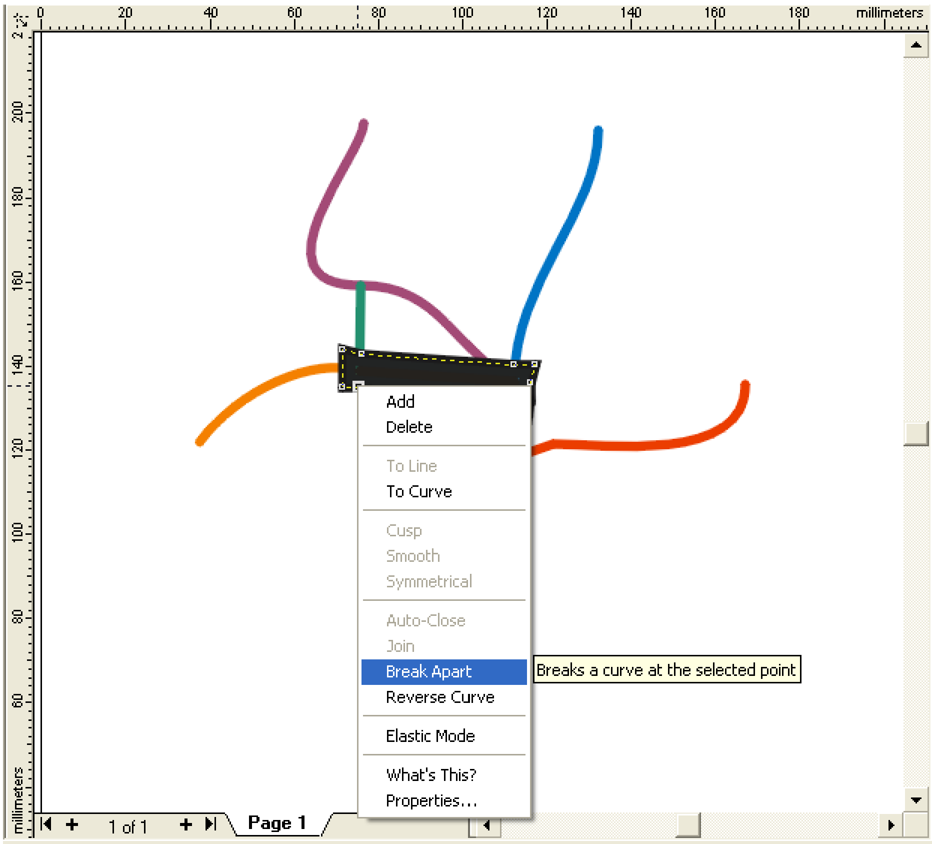

Figure C.5: Splitting of individual parallel lines to remove end caps

Step 6 – Each parallel line was cut and pasted from the 'Parallel' layer into their respective bus service layers, and then the colour for each individual bus service was applied to the new lines. As Figure C.6 shows, the output thus far is highly satisfactory and of greater quality than the output of other systems, as discussed in the main body of the thesis (see Figure 4.3).

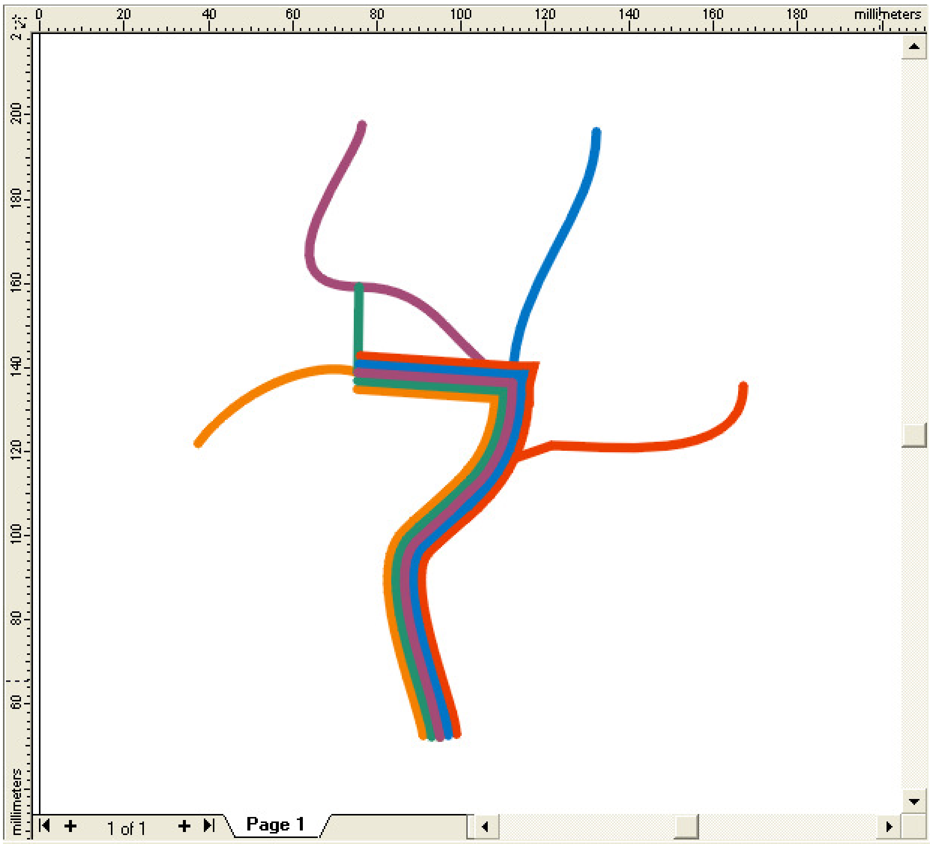

Figure C.6: Assigning individual parallel lines to the respective layers

Step 7 – Finally, each layer had to be edited to trim the sections of route that were now surplus to requirement for each service. Existing lines were broken apart and new nodes were manually inserted (Figure C.7) at the appropriate locations to allow the old and new content to be snapped together into a single continuous line. At certain locations, a degree of cartographic licence had to be applied in order to align sections of route without the final output looking too jagged.

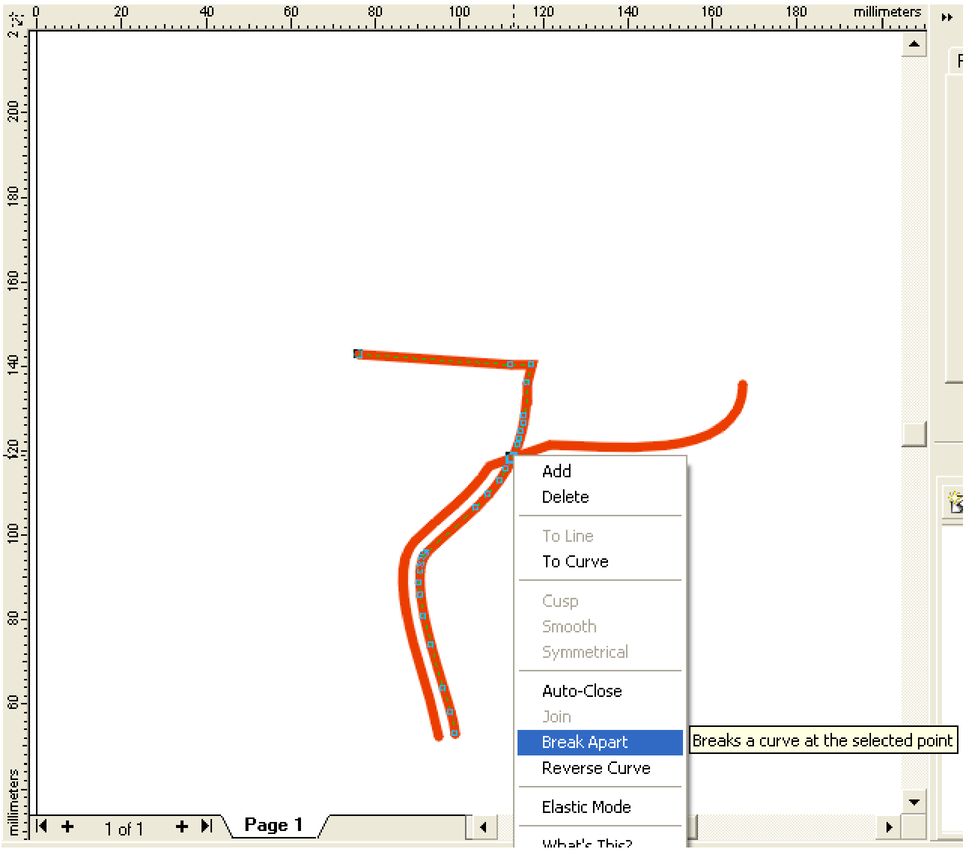

Figure C.7: Editing of individual layers to merge existing route data with the new data created during the paralleling process

Step 8 – This process was carried out for all individual services until the necessary sections were paralleled (Figure C.8). If there were additional parallel sections at points further along the routes, Steps 2 to 7 were repeated.

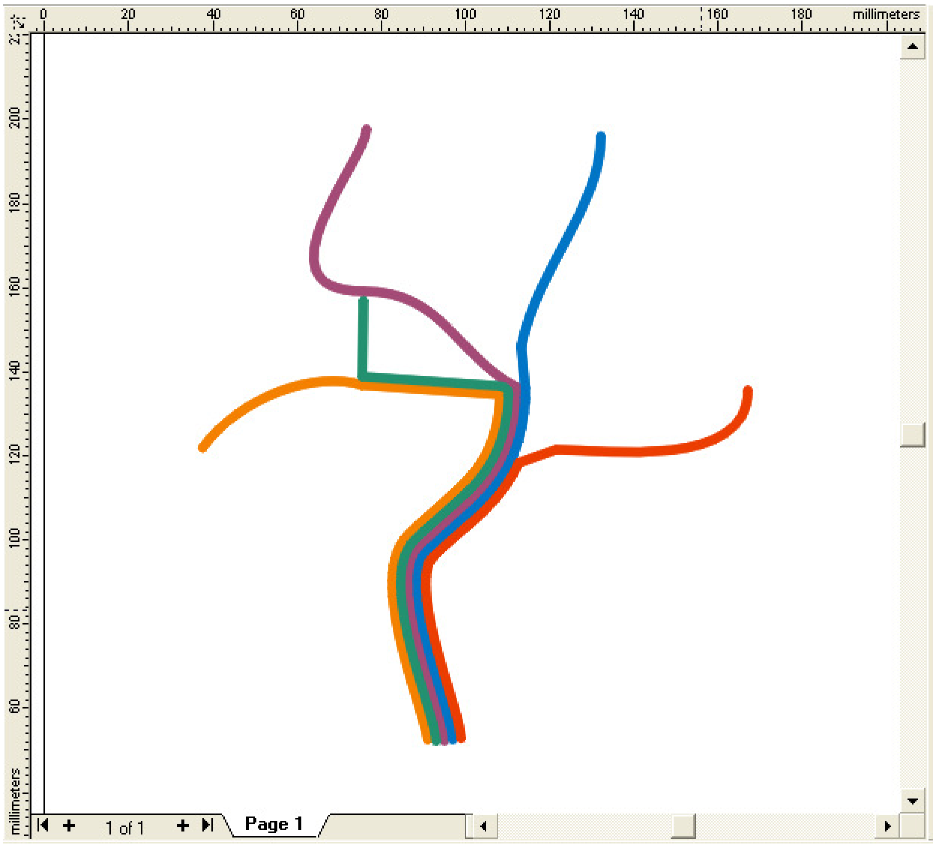

Figure C.8: Final output of the whole paralleling process, showing the neat nesting of the individual parallel lines with one another

The pilot questionnaire and revised final questionnaire can be found in this appendix, along with the answer matrix sheet, developed to assist with the recording of multiple responses in the field, whilst minimising the amount of paper having to be carried between test bus stops.

Date ____________ Respondent No. _____

Loc^{n}. _________________ Start Time _______ End Time _______

SSBM Questionnaire v1 (Pilot)

Good <morning/afternoon>. We are currently conducting research at the University of Glasgow into Public Transport Information and in particular, a new type of bus map. This map is designed to make planning a bus journey quicker and easier. I would like to ask you to plan a bus journey followed by a few questions. If your bus arrives during the survey, you are free to terminate the survey and board your bus. The survey will only take a few minutes and your answers will remain entirely confidential and anonymous.

<u>1. Journey Planning Exercise.</u>

*I would like to ask you to plan a bus journey, originating from this stop, using <insert method>. I must stress that this is not a test of **your** personal capability! We are only interested in assessing how easy the general public find different information sources to obtain an answer to a query.*

I will read out a destination to you. Using <insert method>, please tell me the number of the route which you would board at this stop, and the name of the company operating this route, in order to reach the given destination. [If you think there is more than one route, please state the number of all the routes you could board, and their operator's name.]

To allow us to compare different information sources, I will time how long it takes you to find an answer to the query.

(Check that subject understands overall procedure and is happy with exercise.)

[If using NM, hand to subject. If using TT or SS, indicate their location at the stop to subject. Read out a destination from card and start watch as soon as destination is read out. No help is to be given to subjects from this point.]

Date _____________ Respondent No. _____
Loc[n]. __________________ Start Time ________ End Time ________

2. How did you find using <*insert method*> to plan the journey?

5	*4*	*3*	*2*	*1*
Very Easy	*Slightly Easy*	*Neither Easy nor Difficult*	*Slightly Difficult*	*Very Difficult*

3. How confident were you that you had found the optimum route when using <*insert method*> to plan the journey?

5	*4*	*3*	*2*	*1*
Very	→	→	→	*Not at All*

Demographic Questions

4. Age: Under 18 18 – 24 25 – 34 35 – 49 50 – 64 65 or over

5. Gender: M F

Travel Habits

6. Do you have a current Drivers' Licence? Y N

7. Do you have regular access to a car, either as a Driver or a Passenger? Y N
(If Y, go to Q8; if N, go to Q9)

8. How often do you travel by car (on average/in general)?

5+ times per week	3-4 times per week	1-2 times per week	1-2 times per month	< 1 time per month

9. How often do you travel by (local) bus (on average/in general)?

5+ times per week	3-4 times per week	1-2 times per week	1-2 times per month	< 1 time per month

10. When travelling by bus, do you have a particular journey that you make on a ***regular*** basis (by regular we mean to the same destination, using the same route(s))?
Y N *(If Y, go to Q11; If N, go to Q12)*

11. What is the main trip purpose of this ***regular*** journey?

Work Education Shopping Leisure/Social Other

12. What percentage/proportion of your total bus use does this ***regular*** journey take up?

All	Most	Some	Few	None
100%	75%	50%	25%	0%

Date ____________ Respondent No. _____

Loc^{n}. _________________ Start Time _______ End Time _______

Planning a Journey

13. When travelling by bus in <*area*>, what sources of information (if any) (a) are you aware of and (b) have you consulted?

Information Source	*(a) Aware Of*	*(b) Have Consulted*
Timetable (at-stop)		
Timetable (in Leaflet/Booklet)		
Real Time Departure Display		
Bus Map (at-stop)		
Bus Map (in Leaflet/Booklet)		
Phone helpline (e.g. Traveline)		
Web Journey Planner (e.g. Traveline)		
Fares and Ticketing Offers		
Bus Stop Flag/Sign		
Ask Bus Driver		

14. When planning and undertaking a <*insert type*> bus journey, what information (if any) would you like to be available/able to consult?

Journey Type → *↓ Info Source*	*(a) Familiar, Irregular*	*(b) Unfamiliar, New*
Timetable (at-stop)		
Timetable (in Leaflet/Booklet)		
Real Time Departure Display		
Bus Map (at-stop)		
Bus Map (in Leaflet/Booklet)		
Phone helpline (e.g. Traveline)		
Web Journey Planner		
Fares and Ticketing Offers		
Bus Stop Flag/Sign		
Ask Bus Driver		

Date ____________ Respondent No. _____
Loc^{n}. __________________ Start Time _______ End Time _______

15. How do you rate the bus information (in general) in your local area?

(Ask about each of the four aspects, listed below)

- Clear (Understandable)
- Concise (Can find answers quickly)
- Current (Up-to-Date)
- Overall

Rating → *↓ Feature*	*Very Good (5)*	*Good (4)*	*OK (3)*	*Poor (2)*	*Very Poor (1)*
Clear					
Concise					
Current					
Overall					

16. Do you have any suggestions as to how the design of <*insert method*> could be improved?

17. Do you have any other general comments or suggestions about Public Transport Information that you would like to make?

Many thanks for taking the time to take part in this survey.
It is much appreciated.

Gareth Evans, University of Glasgow

Date ____________ Respondent No. _____

Loc^{n}. _________________ Start Time _______ End Time _______

SSBM Questionnaire v2

Good <morning/afternoon>. We are currently conducting research at the University of Glasgow into Public Transport Information and in particular, a new design of bus map. This new map is intended to make planning a bus journey quicker and easier.

I would like to ask you a few questions and ask you to plan two bus journeys. The survey will only take a few minutes and your answers will remain entirely confidential and anonymous.

Journey Planning Exercise

1. *I would now like to ask you to plan two bus journeys, originating from this stop, using <insert methods>. I must stress that this is not a test of* **your** *personal capability! We are only interested in assessing how easy the general public find different information sources to obtain an answer to a query.*

I will read out a destination to you. Using <insert method>, please tell me the number of a service which you could board at this stop, and the name of the company operating this service, in order to reach the given destination. This process will then be repeated for a second journey.

To allow us to compare different information sources, I will time how long it takes you to find an answer to the query.

[Check that subject understands overall procedure and is happy to undertake the exercise.]

[If using NM, hand to subject. If using TT or SS, indicate the position of the information at the stop to subject. Read out a destination from card and start the stopwatch as soon as destination is read out. ***No help is to be given to subjects from this point****.]*

Using Public Transport Information

2. How did you find using <*insert method*> to plan the journey?

Journey 1

5	4	3	2	1	0
Very Easy	*Slightly Easy*	*Neither Easy nor Difficult*	*Slightly Difficult*	*Very Difficult*	*DK/NA*

Journey 2

5	4	3	2	1	0
Very Easy	*Slightly Easy*	*Neither Easy nor Difficult*	*Slightly Difficult*	*Very Difficult*	*DK/NA*

3. How confident were you that you had found the 'optimum' route when using <*insert method*> to plan the journey?

Journey 1

5	4	3	2	1	0
Very	→	→	→	*Not at All*	*DK/NA*

Journey 2

5	4	3	2	1	0
Very	→	→	→	*Not at All*	*DK/NA*

Travel Habits

4. Do you have a current Drivers' Licence? **Y** **N**

5. Do you have regular access to a car, either as a Driver or a Passenger? **Y** **N**

6. How often do you travel by bus in <*area*> *[prompt: on average]*?

5+ times per week	3-4 times per week	1-2 times per week	1-2 times per month	< 1 time per month	Never

7. Of either of the journeys you were asked to plan at the start of the survey, are either of these a journey you make on a regular basis? *[If Y go to Q9, if N go to Q8].*

Y (1 2 Both) **N**

8. When travelling by bus, do you have a particular journey that you make on a ***regular*** basis *[prompt: regular = same destination, using the same route(s)]*?

Y **N**

Potential of SSBMs for Increasing Journeys

[If SS was not used for one of the planned journeys, show SS for the current stop to the respondent.]

9. If SS maps were displayed at all stops in <*area*>, would you consider making more journeys by bus?

5	*4*	*3*	*2*	*1*	*0*
Yes	→	→	→	*No*	*DK/NA*

Improvements to Public Transport Information

10. Do you have any suggestions as to how the design of these SS maps could be improved?

11. Do you have any other general comments or suggestions about Public Transport that you would like to make?

Demographic Questions

12. Age: 18 – 24 25 – 34 35 – 49 50 – 64 65 or over

13. Gender: **M** **F**

Many thanks for taking the time to take part in this survey - it is much appreciated.

Gareth Evans, University of Glasgow

Location	
Stop	

Date	
Time	

Journey Planning Exercise, Q1

	Journey 1					Journey 2				
	PTI	Dest.	Answer	Time	Cat.	PTI	Dest.	Answer	Time	Cat.
Respondent 1	*1*	*1*				*2*	*4*			
Respondent 2	*2*	*2*				*3*	*1*			
Respondent 3	*3*	*3*				*1*	*2*			
Respondent 4	*1*	*4*				*2*	*3*			
Respondent 5	*2*	*1*				*3*	*4*			
Respondent 6	*3*	*2*				*1*	*1*			
Respondent 7	*1*	*3*				*2*	*2*			
Respondent 8	*2*	*4*				*3*	*3*			
Respondent 9	*3*	*1*				*1*	*4*			
Respondent 10	*1*	*2*				*2*	*1*			
Respondent 11	*2*	*3*				*3*	*2*			
Respondent 12	*3*	*4*				*1*	*3*			
Respondent 13	*1*	*1*				*2*	*4*			
Respondent 14	*2*	*2*				*3*	*1*			
Respondent 15	*3*	*3*				*1*	*2*			
Respondent 16	*1*	*4*				*2*	*3*			
Respondent 17	*2*	*1*				*3*	*4*			
Respondent 18	*3*	*2*				*1*	*1*			
Respondent 19	*1*	*3*				*2*	*2*			
Respondent 20	*2*	*4*				*3*	*3*			
Respondent 21	*3*	*1*				*1*	*4*			
Respondent 22	*1*	*2*				*2*	*1*			
Respondent 23	*2*	*3*				*3*	*2*			
Respondent 24	*3*	*4*				*1*	*3*			

Using PTI, Q2 - Ease of Use

	Journey 1						Journey 2					
	Very Easy	*Slightly Easy*	*Neither E or D*	*Slightly Difficult*	*Very Difficult*	*DK/ NA*	*Very Easy*	*Slightly Easy*	*Neither E or D*	*Slightly Difficult*	*Very Difficult*	*DK/ NA*
Respondent 1	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 2	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 3	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 4	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 5	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 6	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 7	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 8	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 9	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 10	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 11	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 12	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 13	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 14	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 15	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 16	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 17	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 18	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 19	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 20	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 21	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 22	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 23	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 24	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***

Using PTI, Q3 - Optimum Route

	Journey 1						Journey 2					
	Very	*>>>*	*>>>*	*>>>*	*Not at all*	*DK/NA*	*Very*	*>>>*	*>>>*	*>>>*	*Not at all*	*DK/NA*
Respondent 1	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 2	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 3	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 4	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 5	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 6	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 7	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 8	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 9	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 10	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 11	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 12	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 13	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 14	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 15	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 16	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 17	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 18	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 19	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 20	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 21	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 22	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 23	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
Respondent 24	***5***	***4***	***3***	***2***	***1***	***0***	***5***	***4***	***3***	***2***	***1***	***0***
	Very	*>>>*	*>>>*	*>>>*	*Not at all*	*DK/NA*	*Very*	*>>>*	*>>>*	*>>>*	*Not at all*	*DK/NA*

Travel Habits, Q4-Q6

	Q4 Drivers License?		Q5 Regular Car?	
Respondent 1	***Y***	***N***	***Y***	***N***
Respondent 2	***Y***	***N***	***Y***	***N***
Respondent 3	***Y***	***N***	***Y***	***N***
Respondent 4	***Y***	***N***	***Y***	***N***
Respondent 5	***Y***	***N***	***Y***	***N***
Respondent 6	***Y***	***N***	***Y***	***N***
Respondent 7	***Y***	***N***	***Y***	***N***
Respondent 8	***Y***	***N***	***Y***	***N***
Respondent 9	***Y***	***N***	***Y***	***N***
Respondent 10	***Y***	***N***	***Y***	***N***
Respondent 11	***Y***	***N***	***Y***	***N***
Respondent 12	***Y***	***N***	***Y***	***N***
Respondent 13	***Y***	***N***	***Y***	***N***
Respondent 14	***Y***	***N***	***Y***	***N***
Respondent 15	***Y***	***N***	***Y***	***N***
Respondent 16	***Y***	***N***	***Y***	***N***
Respondent 17	***Y***	***N***	***Y***	***N***
Respondent 18	***Y***	***N***	***Y***	***N***
Respondent 19	***Y***	***N***	***Y***	***N***
Respondent 20	***Y***	***N***	***Y***	***N***
Respondent 21	***Y***	***N***	***Y***	***N***
Respondent 22	***Y***	***N***	***Y***	***N***
Respondent 23	***Y***	***N***	***Y***	***N***
Respondent 24	***Y***	***N***	***Y***	***N***

Q6 Frequency of Bus Use					
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***
5+/wk	***3-4/wk***	***1-2/wk***	***1-2/mth***	***<1/mth***	***Never***

Travel Habits, Q7-Q8

	Q7 Regular Journey in Q1?				Q8 Other Regular Journey?		Notes/Comments - Q7/Q8
Respondent 1	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 2	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 3	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 4	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 5	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 6	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 7	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 8	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 9	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 10	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 11	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 12	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 13	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 14	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 15	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 16	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 17	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 18	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 19	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 20	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 21	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 22	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 23	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
Respondent 24	***Y1***	***Y2***	***Yboth***	***N***	***Y***	***N***	
	GO TO Q9			*Q8 >*			

SSBM Potential, Q9

	Potential to Increase Use?						
	Very	*>>>*	*>>>*	*>>>*	*Not at all*	*DK/NA*	Notes/Comments - Q9
Respondent 1	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 2	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 3	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 4	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 5	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 6	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 7	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 8	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 9	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 10	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 11	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 12	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 13	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 14	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 15	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 16	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 17	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 18	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 19	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 20	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 21	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 22	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 23	***5***	***4***	***3***	***2***	***1***	***0***	
Respondent 24	***5***	***4***	***3***	***2***	***1***	***0***	
	Very	*>>>*	*>>>*	*>>>*	*Not at all*	*DK/NA*	

Other Comments, Q10

Respondent 1	
Respondent 2	
Respondent 3	
Respondent 4	
Respondent 5	
Respondent 6	
Respondent 7	
Respondent 8	
Respondent 9	
Respondent 10	
Respondent 11	
Respondent 12	
Respondent 13	
Respondent 14	
Respondent 15	
Respondent 16	
Respondent 17	
Respondent 18	
Respondent 19	
Respondent 20	
Respondent 21	
Respondent 22	
Respondent 23	
Respondent 24	

Other Comments, Q11

Respondent 1	
Respondent 2	
Respondent 3	
Respondent 4	
Respondent 5	
Respondent 6	
Respondent 7	
Respondent 8	
Respondent 9	
Respondent 10	
Respondent 11	
Respondent 12	
Respondent 13	
Respondent 14	
Respondent 15	
Respondent 16	
Respondent 17	
Respondent 18	
Respondent 19	
Respondent 20	
Respondent 21	
Respondent 22	
Respondent 23	
Respondent 24	

Demographics, Q12-Q13

	Q12 Age of Respondent					Q13 Gender	
Respondent 1	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 2	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 3	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 4	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 5	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 6	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 7	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 8	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 9	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 10	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 11	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 12	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 13	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 14	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 15	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 16	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 17	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 18	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 19	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 20	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 21	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 22	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 23	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***
Respondent 24	***18-24***	***25-34***	***35-49***	***50-64***	***65+***	***M***	***F***