Beyond Problem Identification: Valuing methods in a ‘system of usability practice’

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I, Dominic Furniss, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

"People were using levers long before they investigated the principles on which levers work. Having established the principles, they can now use levers more effectively […] What is recent is the systematic, and therefore scientific, study of these things. It may not always yield better answers than the intuitive wisdom of the specially gifted – but then, achievement in any applied science is to raise average standards of performance, not necessarily the standards of the outstanding individual. It also provides an essential means of testing the intuitive answers – too often for comfort, these turn out to be wrong."

Klein, L. (2005, p. 1-2). Working Across the Gap: The practice of social science in organizations. Karnac: London.

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To Mum, Dad, and Joe. More than all the stuff you can shovel. LH.

Abstract

Historically, usability evaluation methods (UEMs) have been evaluated on their capability for problem identification. However, the relevance of this approach has been questioned for applied usability work. To investigate alternative explanations of what is important for method use a grounded theory of usability practitioners was developed (9 interviews from the website domain and 13 in the safety-critical domain). The analysis proceeded in bottom-up and top-down stages. The bottom-up stages produced insight from the data in an exploratory and inductive manner. This highlighted the importance of contextual factors and the need for system descriptions: UEM adoption and adaptation cannot be fully understood devoid of context. The top-down stages used Distributed Cognition and Resilience Engineering conceptual frameworks as leverage for exploring the data in a deductive manner. These were chosen for their functional descriptions of systems. To illustrate the importance of context we describe three models: 1) where previous research has highlighted the downstream utility of UEMs we expand the metaphor to consider the landscape through which the stream flows, where the landscape represents the project's context; 2) where information propagation and transformation in a project is influenced by social, information flow, artefact, physical and evolutionary factors; and 3) where the functional couplings between parts of the system of usability practice can be monitored and managed to positively resonate with each other, thereby improving the performance of the system overall. The concept of 'Positive Resonance' is introduced to describe how practitioners adapt to the context to maximise their impact under constrained resources. The functional couplings are described in a functional resonance model of HCI practice. This model is validated by interviewees and other practitioners outside of the study. This research shows that problem identification is limited for valuing UEMs. Instead, functional couplings of UEMs should be considered to improve system performance, which influence UEM adoption and adaptation in practice.

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Part I

Introduction and Literature Review

This part of the thesis covers the background, motivation, approach to the study, and outlines the contribution and the structure of the thesis. The literature review shows different areas of knowledge concerning HCI practice. We see that the current literature regarding opportunities and barriers for method use in usability practice is limited. There is a need for a more realistic explanation, which applies to modern Human Factors (HF)/usability practice and is grounded in context. There is also a need for a more holistic explanation of usability practice to house the current, seemingly disparate parts of research in HF/usability practice under one roof, thereby making it more cohesive.

Chapter 1: Introduction

Research shows that many usability evaluation methods (UEMs) are produced but few make the successful transition from academia to practice (Bellotti, 1988; O'Neill, 1998). Worse still, critics suggest that much of the literature on UEMs is irrelevant to practitioners (Wixon, 2003). This suggests that there is a gap between UEM research and UEM practice. This thesis offers novel conceptions for understanding UEM use in practice. It highlights the importance of contextual dependencies that are rarely addressed. This account has emerged from analysis grounded in practitioners' perspectives.

1.1 General Overview

Human-Computer Interaction (HCI) has long promoted principles that have put an early focus on users and their tasks; empirical measurement; and iterative design (Gould & Lewis, 1983) to make tools and devices more user-friendly and improve the likely success of products. HCI research has sought to make practical contributions through the development of guidelines, design tools and methods, novel interactions, and theory. It is clear that there is success here, as systematic approaches for providing user feedback have developed over 25 years, which have adapted to fit business and development environments (Jeffries & Wixon, 2008, p. xii).

However, research has shown that the successful transfer of usability evaluation methods (UEMs) from research to practice leaves much to be desired (Bellotti, 1988; O'Neill, 1998). In short, a large number of methods are produced by academia with most failing to impact on industry. Some have argued the case that HCI research should take a more user-centred approach when designing guidance and support for HCI practice itself (Rosson, Kellogg, & Maass, 1988). More specifically, we do not currently know enough about the practitioners, and their practice contexts, which we are designing for (Bellotti, Buckingham Shum, MacLean, & Hammond, 1995). This thesis contributes to this literature by investigating the opportunities and barriers for HCI methods in practice, from practitioners' perspectives. A better grounded understanding of methods in practice is liable to meet Wixon's (2003) challenge to make usability research literature more relevant to usability practitioners.

1.2 Setting the scene

We introduce two arguments to set the context and the motivation for the focus of this inquiry. The first (Section 1.2.1) refers to research that has primarily focused on the understanding of practice for the endeavour of improving the transfer of knowledge from research to practice: this work is mainly concerned with the transfer of methods. The second line of argument (Section 1.2.2) refers to the growing body of knowledge that looks at issues that go beyond method use in practice. This second argument makes the case that research into usability practice is moving outward from technical issues to understanding such issues as communication and organisational factors for their own sake: i.e. in being motivated to improve usability practice, researchers look at methods, improving communication, understanding how craft skills are developed and applied, and how usability practitioners integrate with other professionals.

1.2.1 Argument 1: Understanding practice better to improve the transfer of tools, methods and knowledge from research to practice

Bellotti (1988) and O'Neill (1998) report work that demonstrates that HCI transfer, from research to practice, has difficulties in the fact that practitioners do not use the many methods developed by research. To improve this transfer, researchers (e.g. Hammond, Jørgensen, MacLean, Barnard, & Long, 1983; Rosson et al., 1988; Bellotti et al., 1995) believe that we need to have a better understanding of who we are designing for, what tasks they should support and in what context. This is somewhat self-reflexive in that it is usability advice for usability research: we should not proceed with designs of tools and methods when we do not have enough information about the user group, their tasks and the context of use. The literature (reviewed in Chapter 2) shows that our knowledge of usability practice is composed of four areas with different content and different levels of validity. We argue that the research community would benefit from a documented and formalised description of usability practice grounded in practitioners' perspectives.

The need for a more grounded understanding of usability practice also resonates with Wixon's (2003) criticism that much of the usability research literature is irrelevant to practitioners. He outlines three premises which he believes is embedded in much of the literature on UEM evaluation:

1. Number of problems detected is the most appropriate criterion for evaluating a method.
2. Methods can be evaluated in relative isolation from the practical goals of the method and the context in which the method is used.
3. A quasi-scientific framework is the most effective approach to resolve disputes about the best method.

He goes on to state: "All three of these premises render most of this literature irrelevant to applied usability work, by which I mean the application of usability work to the development of products in real commercial enterprises." Wixon (2003) concludes that case studies should provide a vehicle for sharing lessons and knowledge between practitioners. In this work we investigate opportunities and barriers for method from practitioners' perspectives, but instead of a case study approach we develop rich qualitative accounts which abstract across cases. This forces more generalisable accounts that can be scrutinised and developed.

1.2.2 Argument 2: Moving outward from technical issues to understanding wider aspects of usability practice for its own sake

This thesis explores usability work from practitioners' perspectives which was initially motivated to contribute to the corpus of literature focused on the issue of tool, method and knowledge transfer (Section 1.2.1 Argument 1). Here, researchers have looked to better understand practitioners to build better informed tools (e.g. Rosson et al. 1988), inform methods or processes (e.g. Bellotti, 1988; O'Neill, 1998), or identify obstacles in method transfer (e.g. Bellotti, 1988; Buckingham Shum & Hammond, 1994; Bellotti et al., 1995). However, whilst remaining faithful to the motivation to develop better accounts of what happens in industrial practice this work has a wider focus that moves away from tools and methods, and more towards a better understanding of activities and issues in practice *per se*.

To support this wider perspective we use Grudin's (1990) observation that there has been an "outward movement of the computer's interface to its external environment, from hardware to software to increasingly high-level cognitive capabilities and finally to social processes" and claim that a similar outward movement is happening in research for usability practice. This outward movement is captured in Table 1.1. We do not make the strong claim that Table 1.1 refers to the only steps or the right steps of this outward movement, but the weaker claim that this outward trend exists. Also, we do not wish to infer that any level of research is superior to another; in fact we stress their complementary nature in supporting applied usability practice.

Table 1.1: The outward movement of research for usability practice.

Level	Focus in usability practice	Example work
1	Technical development of methods	Card, Moran, and Newell (1983) in developing GOMS
2	Transfer of methods to practice	Blandford, Buckingham Shum, and Young (1998) in training developers in a novel evaluation technique
3	Use of methods in practice	Nørgaard and Hornbæk (2006) in studying think-aloud in practice
4	Wider issues in practice	Hornbæk and Frøkjær (2005) in studying the communication of problems and redesign proposals

1.2.3 Summary

The first argument presented above remains a valid motivation for this study in its own right; however, it is strongly complemented by the second argument which has been conceived through ongoing literature reviews and theoretical developments in the thesis. Method choice is embedded in a rich context of factors, and is hard to understand outside this. The addition of this second line of reasoning is in recognition of the many factors that influence the effectiveness and efficiency of usability practice. This includes those factors fundamental to method choice, and those that are extraneous to it. The reason for presenting these complementary arguments separately is to maintain the rationale for understanding method use in practice, but also to recognise that research has an important role in developing understandings of what wider factors are important to the successful functioning of usability services.

1.3 Research approach

The research approach adopted in this thesis resides in the interpretivist and constructivist traditions. Interpretivism engages with how people interpret the world, and how we as researchers interpret their interpretations. Constructivism engages with how people create meaning of their world, and posits that scientists create meanings of the world rather than discover meaning from direct access to an objective reality. Both traditions agree that there are multiple perspectives that make sense from different world views. Research in this thesis develops qualitative grounded accounts of practitioner perspectives gathered through interviews. A Grounded Theory approach (Strauss & Corbin, 1998) was followed which is discussed extensively in Chapter 3.

This approach contrasts with contributions in the positivistic tradition which are derived from prediction, measurement and testing of an objective world.

This research approach has led to the form and content of the contributions of this thesis, which are markedly different from the studies of defect identification of methods (e.g. Cockton & Woolrych, 2002). To illustrate this difference we draw analogy between our work and the two worldviews for studying the psychology of information technology by Clegg (1994). Clegg (1994) contrasted two worldviews:

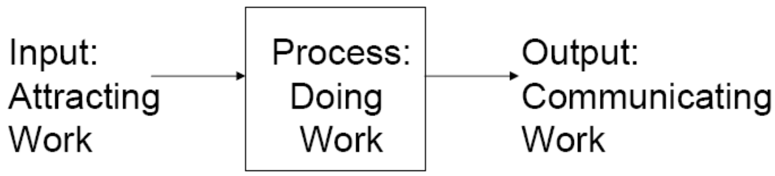
- The first was a world of individual, rational, planful behaviour that is primarily studied in the laboratory, where cognition is in the head and there is a focus on the short term.
- The second was a world of social, interpretive, subjective, emergent and situated behaviour that is studied in context, where cognition is also distributed in the world and where there is a focus on the long term.

The first world view corresponds more to the defect identification studies of methods and the premises that Wixon (2003) claims underlies much of the research on UEMs. The second worldview is much more in line with the research approach of this thesis.

1.4 Scope of the thesis

This thesis explores three (assumed) important elements of usability practice, which includes the before and after of 'usability work': 1) attracting work, 2) doing the work itself, and then 3) communicating work. Fig. 1.1 illustrates the relationship between these three elements in an input/output style diagram. These three elements may not be appropriate for all usability work, but they add structure to the data gathering and analysis stages of the project. Importantly, this widens the focus of the study beyond just the practice of methods.

Figure 1.1: Three important elements of usability practice



The before and after elements of usability work will influence the work itself. This also provides important insight into how usability practice integrates with design and business processes, which is essential for the transfer of value in industry.

The interviewees who took part in the research were responsible for consultancy or in-house usability work. This involved different levels of design and evaluation in different projects and organisations. The work does not include seeking the perspectives of clients and other important players in the development process. Such work could create a quite different account. Further detail of the method used and the type of questions asked are presented in Chapter 3.

Two domains were focused on: website design and safety-critical system development. The former looked at mainstream usability, i.e. a focus of website design, but also included work on kiosks, mobile phones, and software when they occurred in the discussion of work. The latter looked at work contributing to safety-critical systems which involved the risk of injury or loss of life should an accident occur. The rationale for comparing these two contrasting domains was not only to broaden the sample base but also to enhance potential insights by comparing and contrasting them.

1.5 Thesis summary and research contributions

We need to understand the contextual dependencies of UEM choice in practice, in terms of the performance of the overall system. To achieve this, we develop new understanding through the development of concepts and theory. Wixon (2003) recommends a case study approach to disseminating lessons in UEM choice and use. Although this has merits in contextual description, it also has drawbacks in abstraction. Our approach uses rich qualitative analysis that abstracts across contexts. This abstraction is more amenable to scientific scrutiny and development.

The main contribution to knowledge of this thesis is that an ecological understanding of methods should be understood from a systems-thinking perspective, i.e. we should think about how methods are affected by, and affect, wider factors in the system. More specifically the adoption and adaptation of methods is simultaneously coupled to the technical substance of the project; issues concerning the communication of results, issues and advice to stakeholders; client resources, budgets, and structures; project structures; the capabilities and experience of the practitioners involved; the rapport, relationships and reputations; and the need to provide auditable documentation where appropriate. This new perspective moves away from thinking about methods purely as they are prescribed and solely in terms of the capability for problem identification and argues that methods should be understood in a wider system of Human Factors (HF)/usability practice performance.

We realise the need for a systemic explanation through inductive analysis (Chapter 4) and develop this description (Chapter 6). The systemic description is enriched using Distributed Cognition (Chapter 9) and Resilience Engineering (Chapter 11). These conceptions provide new ways of understanding the adoption and adaptation of UEM's in practice. Including:

- Concepts such as:
  - Usability, like a plug and play technology, adapting to projects and clients; and
  - the loose coupling between method prescriptions and practice;
- The idea of a contextual landscape through which the project flows.
- The distributed cognition description of UEM practice which accounts for the computational effect of the social factors, information flows, artefacts and tools, the physical space in design and the evolution of practices.
- The Resilience Engineering conceptual leverage of UEM practice which accounts for how the practitioner makes choices which fit well with the internal and external demands of the system so that performance can be maximised under constrained resources. The final functional network shows how method adoption and adaptation needs to positively resonate with other functions in a system of HF/usability practice to maximise the impact on system performance.

Section 1.6 shows how this was realised and developed in the structure of the thesis in more detail. The final contributions are discussed in-depth in Chapter 13.

1.6 Structure of the thesis

The parts and chapters of the thesis are described below. Table 1.2 shows their structure and relationship. The literature review of HCI practice in Chapter 2 provides foundation for the website study described in Chapter 4. Other literature orientation chapters are included directly prior to their respective analyses.

Table 1.2: The structure of the thesis.

Parts	Chapters
I Introduction & Literature Review	1 Introduction
	2 Literature review on HCI practice
	3 Qualitative research and the Grounded Theory approach
II Bottom-up: Listening to the data	4 Grounded Theory of HCI practice in the website domain
	5 Safety-critical system development literature review
	6 Grounded Theory of safety-critical system development domain
	7 Diversity in interviews, between interviews and between domains
III Top-down: Application of theoretical frameworks as leverage	8 Distributed Cognition literature review
	9 Distributed Cognition analysis
	10 Resilience Engineering literature review
	11 Resilience Engineering analysis
	12 Validation
IV Conclusion	13 Conclusion of thesis

1.6.1 Summary of the thesis parts

Part I covers the background, motivation, approach to the study, and outlines the contribution and the structure of the thesis. The literature review shows different areas of knowledge concerning HCI practice. We see that the current literature regarding opportunities and barriers for method use in usability practice is limited. There is a need for a more realistic explanation, which applies to modern Human Factors (HF)/usability practice and is grounded in context. There is also a need for a more holistic explanation of usability practice to house the current, seemingly disparate parts of research in HF/usability practice under one roof, thereby making it more cohesive. For example, although the importance of relationships (Redish et al., 2002), communicating redesign proposals (Hornbæk & Frøkjær, 2005), and method use (Blandford et al. 1998) are relevant for the performance of usability practice they are not integrated well.

Part II accounts for the Grounded Theory (GT) analyses of the data from a bottom-up perspective. Here we apply GT to website and safety domains, and explore different treatments and representations for the data. We see that a system perspective of HF/usability practice is needed to explain the opportunities and barriers for method uptake in industry (Chapter 4). The treatments of the qualitative analyses are developed, which culminates in rhetoric about understanding the downstream, upstream and the landscape of usability projects (Chapter 6). These stand for the downstream influence of the method, how it is affected by things upstream in the project, and the contextual landscape through which the project flows. It is argued that method adoption and adaptation can be understood within this.

Part III accounts for the top-down application of established theoretical frameworks to the data. This top-down approach was undertaken to see what analytic leverage could be gained from the concepts and structure of that have been developed in these frameworks, i.e. they would provide a different lens for 'seeing the data' through. Two frameworks are applied in turn: the first is Distributed Cognition (DC) and the second is Resilience Engineering (RE). The DC leverage gives us a complex computational view of the system, and the RE leverage gives us a functional view of the system. Both views show that methods affect and are affected by wider factors in the HF/usability system. In the DC analysis we develop an explanation of the computational effect of the social factors, information flows, artefacts and tools, the physical space in design and the evolution of practices (Chapter 9). For example, methods affect the transformation of data and the flow of information is affected by language, relationships and reporting formats, which impact on HF/usability performance. In the RE analysis we develop an explanation of how functional parts of the system affect each other in non-linear ways (Chapter 11). For example, method selection will not only be affected by the problem, and time and budget constraints but also the HF/usability practitioner's history, tool availability, client preferences and other nuances of the context. Here the practitioner must make choices which 'positively resonate' with the internal and external demands of the system so that performance can be maximised under constrained resources. A functional network of HF/usability practice is then developed in the form of a FRAM analysis.

Part IV concludes the thesis by reflecting on its contributions, and suggestions for future work.

1.6.2 Summary of the thesis chapters

Chapter 1: Introduction

This provides an outline of the thesis including setting the scene, the research approach, the contributions and the structure of the thesis.

Chapter 2: Literature Review on HCI Practice

This provides a summary four separate sections to acknowledge different sources of HCI knowledge which vary in their validity, consistency and content. These four areas are organised under the letters 'PITC' and include: Prescriptive HCI, Interviewing

Practitioners, Testing research in practice, and Case studies of HCI practice. The chapter concludes that there is a need for research to build theory of HCI practice directly from practitioners' perspectives.

Chapter 3: Qualitative Research and the Grounded Theory Approach

This sets the methodological context in which this research has been conducted. It starts broadly by providing an overview of different research paradigms, then contrasts quantitative and qualitative methods, and introduces grounded theory as the chosen method for the study.

Chapter 4: Grounded Theory of HCI Practice in the Website Domain

This was a grounded analysis of usability practice in professional website design (although work in this area drifted into other technologies because of the diversity and blurring of interface work, e.g. kiosks and mobile phones). Eight practitioners were interviewed and a descriptive theory was developed from this data. The theory was organised into four sections which emerged as important areas for practice: methods and processes; relationships; communication and coordination; and psychology and expertise. It was concluded that some sort of system level view would be useful to conceive usability practice through. A ninth practitioner was opportunistically interviewed from this domain but was too late to be included in the analysis, their data was integrated from Chapter 7 onwards.

Chapter 5: Safety-Critical System Development Domain Literature Review

This literature review is an orientating chapter to introduce the reader to issues within the safety-critical system development domain.

Chapter 6: Grounded Theory of Safety-Critical System Development Domain

Like Chapter 4, this chapter details a grounded theory of human factors practitioners in safety-critical system development. Thirteen practitioners were interviewed and three different treatments of the data were explored. The rationale behind this exploration was to reflect on the usefulness of these different treatments in terms of their leverage for analysis, representation and communication of the data. It concludes by giving an account of how the downstream metaphor of usability practice can be extended to include upstream influence and the role of the landscape. This provides rhetoric for the influence of context on method use in practice, as it offers a story of the different factors that influence their choice and use.

Chapter 7: Diversity in Interviewees, between Interviews and between Domains

This chapter focuses on apparent tensions and conflicts within interviews, between interviews and between domains. This allows the opportunity for the analyst to break from the conceptual story that has been developing in Chapters 4 and 6. Apparent surface differences in this chapter allow reflection at a deeper level. Four interesting loose ends are identified which fall outside of the scope of qualitative analyses in Chapter 4 and 6; these are: different classes of HF/usability problem, tacit contributions, the role of emotion in HF/usability work, and similarities with academia. These could be explored further in future research.

Chapter 8: Distributed Cognition Literature Review

This literature review is an orientating chapter to introduce the reader to issues, themes and studies within the Distributed Cognition literature. This provides a foundation for the subsequent analysis in the next chapter.

Chapter 9: Distributed Cognition analysis

This analysis provides a theoretical bridge from the Distributed Cognition literature and the data gathered in the website and safety domains. Distributed Cognition is used as leverage to explore the data. The analysis proceeds by combining Marr's three levels of cognitive description (1982, cited in Hutchins, 1995a, p. 50), the Resource Model (Wright, Fields, & Harrison, 2000) and DiCoT (Blandford & Furniss, 2005). This provides the framework for the analysis which gives insight into the socio-cultural nature of HF/usability practice and factors influencing the computation of the system.

Chapter 10: Resilience Engineering Literature Review

This literature review provides a similar role to that of Chapter 8 except it orientates the reader to literature on Resilience Engineering. It provides a foundation for the analysis in the next chapter.

Chapter 11: Resilience Engineering analysis

This analysis provides a theoretical bridge from the Resilience Engineering literature and the data gathered in the website and safety domains. Resilience Engineering is used as leverage to explore the data. The analysis proceeds by recognising links with themes in Resilience Engineering; by introducing the reader to positive resonance in HF/usability practice through discussion of different accident models; and performs a FRAM (Functional Resonance Accident Model) analysis of HF/usability practice which maps out the functional couplings in this system (Hollnagel, 2004). Recommendations for fine tuning the positive resonance of HF/usability practice, and how this impacts on method use is discussed at the end of the chapter.

Chapter 12: Validation

This chapter discusses the validation of the thesis.

Chapter 13: Conclusion of Thesis

This chapter concludes the thesis by reflecting on its contributions, and making suggestions for future work.

1.7 Conclusion

This chapter provides the reader with a summary of what the thesis is about. However, whereas it represents the start of the thesis it does not represent the start of the research. The reader is reminded that in terms of chronology the research direction, depth of understanding, and conclusions of this work were not present at its start. This point is emphasised because the outset of the research was open and responsive to practitioner concerns (in a true grounded theory fashion), and the need for a system perspective only became apparent in Chapter 4, which is developed in Chapter 6 onwards. It is from this informed position, which is far removed from the start of the research, that this introduction provides an outline of the thesis including setting the scene, the research approach, the contributions and the structure of the thesis.

Methods, theories and systems play a large role in this thesis. At an abstract level all of these have some connection as they specify some sort of conceptual network. Methods can provide a set of loose activities or processes to be performed. Theories provide a conceptual network that give a perspective and understanding of the world, these are generated to conceptualise some phenomena or context, and do not have to be predictive. Systems specify elements, and the relationships between these elements, that share some common purpose.

Chapter 2: Literature review on HCI practice

Generally, knowledge of HCI practice does not come from any one particular source but is an amalgamation of different sources. This will vary depending on an individual's experience, social network and role. In reviewing the literature four categories have been identified that contribute to understanding HCI practice. These are presented under the letters 'PITC', which acts as a mnemonic device.

- (P) Prescriptive HCI
- (I) Interviewing practitioners
- (T) Testing research in practice
- (C) Case studies of HCI practice

These are not completely independent but provide clarity by giving a framework that identifies the sources of different HCI practice knowledge. By linking the sources of knowledge with their content we can better identify: 1) limitations in areas of HCI practice knowledge, in terms of validity, consistency, explanatory development or documentation; and 2) what sources of HCI practice knowledge we might wish to develop to progress this area of research.

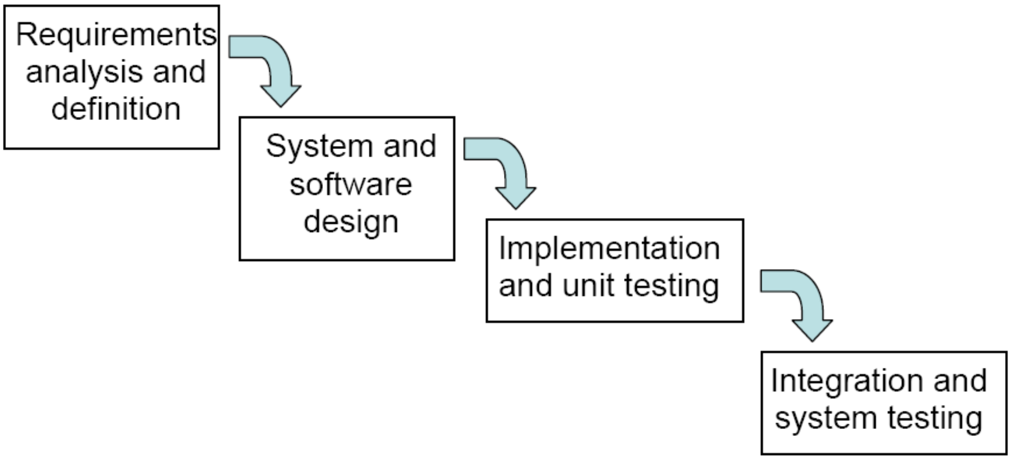
2.1 Prescriptive HCI

This area of HCI practice knowledge is based less on what HCI practice actually does but rather what it ought to be doing. These sorts of messages are common in text books (e.g. Preece et al., 1994), and can be considered clean, idealised and simplified versions of approaches. They are easier to communicate than the case studies discussed in Section 2.4 which show some of the real world complexities that occur. This prescriptive area is what Rosson et al. (1988) refer to when researchers describe how HCI should take place and not how it does take place.

There is a thin line between people giving advice on what they should be doing and those giving advice on how to do it (e.g. Cooper, 1999). The latter generally originates from experienced HCI practitioners sharing knowledge and tactics of how they work. The former is generally closer to espousing principles which appear as common sense but are harder to implement with the details of practice. Examples of such principles are an early focus on users and tasks, empirical measurement, and iterative design (Gould & Lewis, 1983).

Lifecycle models provide a good example of how prescriptions are harder to follow in practice and do not tell the whole story. One of the most commonly referred to software engineering lifecycle models is the ‘waterfall model’. This is a stepwise process which has management benefits; the sort of benefits one might claim have eased the software crisis recognised by Freidman and Cornford (1989), e.g. by increasing the control of budget, time and resources. However, it can itself have different instantiations depending on how linear the model is. The strictest model would not allow any re-visiting of a previous step in the process (see Figure 2.1), whereas looser models might allow re-visiting in one or more places illustrated by the feedback arrows (see Figure 2.2).

Figure 2.1: A simplified version of the waterfall model of software development (Sommerville, 1992 cited in Preece et al., 1994)



Even with the feedback arrows the waterfall model suggests a largely linear process. Alternatives to this more linear conception of the development process have been introduced (Hix & Hartson, 1993) and some empirical observation supports the argument that development may not be best conceptualised in a linear way (Bellotti, 1988). One example of such a non-linear conceptualisation is the star lifecycle developed by Hix and Hartson (1993) (see Figure 2.3). Preece et al. (1994, p. 47) point out that its two most predominant features are: 1) that the central and most focal point of the star is evaluation, which is viewed as being relevant at all stages in the lifecycle; and 2) the star lifecycle is ‘intended to be equally supportive of both top-down and bottom-up development, plus inside-out and outside-in development’. The star model was derived following extensive analysis of actual HCI design practice, highlighting the roles of prototyping and evaluation (Preece et al., 1994 p. 380).

Figure 2.2: A simplified version waterfall model with 'some' feedback arrows for illustrative purposes

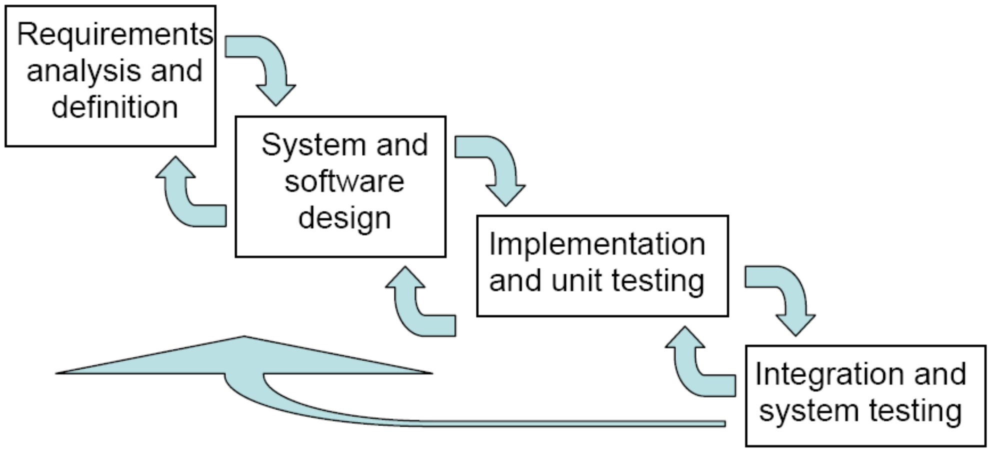
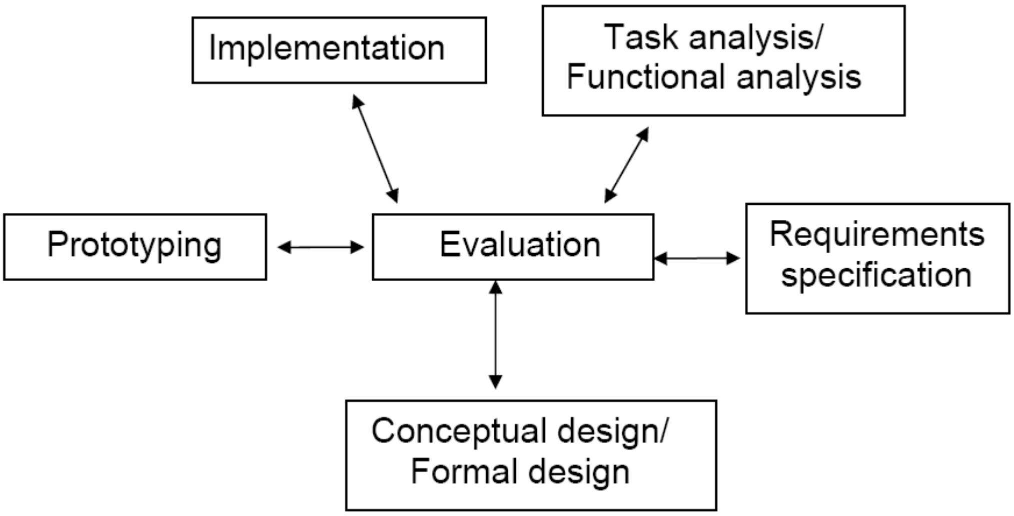


Figure 2.3: The star life cycle (adapted from Hix and Hartson, 1993; cited in Preece et al., 1994 p. 49)



Even with these variations of development processes there are still those who would say that they fail to reflect real practice. For example, O'Neill (1998, p.46) writes:

> "Terrins-Rudge and Jørgensen (1993) studied ten system development projects, through participant-observation, structured interviews, questionnaires and video analysis. They found that the most common approach to system development was one of 'muddling through'. Formal or structured methods were not employed, developers preferring selectively and opportunistically to use individual parts of such methods in the course of muddling through." (O'Neill, 1998, p.46)

Along similar lines Blandford, Keith, and Fields (2006) observe that the whole process is much more organic and opportunistic than that assumed in prescriptions of design processes.

2.2 Interviewing practitioners

A second area of contribution seeks to gain a better understanding of design practice through direct unobtrusive observations, e.g. by surveying, by interviewing and by observing. This area relies less on changing circumstances and testing (see Section 2.3: Testing research in practice) and more on investigating the way things actually work.

We use the term ‘design’ loosely to include HCI and software development projects which is in accordance with the literature in this chapter. Most of the references in this section are dated as more modern equivalents of this quality are rare (e.g. an exception is Nørgaard and Hornbæk, 2006).

Hammond et al. (1983) interviewed five designers to determine how individual designers make decisions, the processes they use, the knowledge and tools they employ, and their perceived relationship with other groups of people. They state three reasons why this form of research is beneficial: 1) appreciating the nature of design will aid research direction and intervention; 2) modifications to design practice may allow research to be used more effectively; and 3) design practice is liable to provide researchers with insight into how HCI is practiced (Hammond et al., 1983, p. 40). They organise their conclusions under three headings:

View of the Design Process

Designers favoured the more logical system arguments and favoured a ‘clean’ internal system above user goals. Designers appeared to consider ‘compatibility’ with the new design in three respects: 1) with previous products; 2) with existing aspects of the system; and 3) with possible future extensions.

Designers’ ‘Theories’ of Users

Designers make many decisions on the basis of implicit or explicit beliefs of users’ psychological capabilities. Three major types of theories were recognised that can be viewed in a hierarchy of granularity: 1) very general statements about user behaviours and preferences, e.g. users always do something differently; 2) more specific statements about learning and knowledge representation, e.g. learning a new system; and 3) even more specific statements on particular user processes, e.g. menu selection.

View of Human Factors

Although designers wanted help with initial task analysis, with specifying the interface image, and with user issues, successful interactions with Human Factors people were met with difficulties. It was observed that Human Factors input was often too fine grained and so was received unfavourably. This had knock on effects as advice that was perceived as poor by the designer led to the Human Factors experts' authority being undermined.

This research is dated in some respects, given that the design of interactive systems has changed over 25 years, if not in process and attitude then in the sorts of technologies and issues encountered. However, their general observations may remain to some extent. A question that immediately springs to mind is to what extent they remain, and whether these observations differ across design practice contexts and cultures. We speculate that these observations may be dependent on the context, culture and people involved. This tract of thought is not discouraged as the study only focuses on five people from the same company. Hammond et al. (1983, p. 44) recognise that they have not engaged with the organizational context in which individual design decisions are embedded and so their study lacks insights at this higher level of granularity, insights that might have a strong influence at the individual level. We emphasise this limitation as Bellotti et al. (1995) recognise cultural context as being important to understanding design practice, and this level of granularity has a strong presence in Section 2.3.5 where real practitioners share advice with each other through case studies.

Rosson et al. (1988) and Rosson, Maass and Kellogg (1986) report a study which involved interviewing 22 designers, 17 of which were from IBM. The interviews focused on particular projects they worked on. Like Hammond et al. (1983) they had recognised areas of focus for the interview and structured them to explore these issues. They recognised two very different types of projects: phased projects which had specific steps and stages in the design, and incremental projects where the whole design evolves and grows as they go along. They found that business projects were generally of the phased variety, and research projects were of the incremental sort. This was attributed to stricter time and budget management issues in the business projects because clients had paid for and were expecting the results. Interestingly they did not find an association between early user testing and the type of project. It was expected that incremental projects would have more early user testing as they have some version of their system available but it was found that late testing took place here and some phased projects sought early user feedback through prototypes (Rosson et al., 1988, p. 1291).

In both cases it was thought that early user testing was seen as an evaluative step rather than a source to generate ideas. It was also observed that larger group sizes generally adopted the business approach, perhaps because they need more structure to organise the different parts of the group, but this conclusion may be confounded if the majority of larger groups they interviewed worked on business projects anyway.

Rosson et al. (1988) and Rosson et al. (1986) also found discrepancies in designers' views of the system: some believed that the system and the interface were inseparable, and others thought that they could be separated but that the design of the interface should come first. The importance of this distinction may not seem immediately obvious; one view is that as long as the user and their issues are given priority the distinction should not matter. However, the fact that the distinction exists for designers is the important issue:

> "If our goal is to support the design of user interfaces, we must begin with an appreciation of how designers conceptualize the user interface. Researchers must not assume or force distinctions on designers that are inappropriate or confusing in practice" (Rosson et al., 1988, p. 1294).

They conclude that most 'work on design aids has been founded on traditional design methodologies such as stepwise refinement, rather than on analysis of the strategies actually used by designers' (Rosson et al. p. 1294).

Like Hammond et al. (1983) and Rosson et al. (1988), Bellotti (1988) takes a structured interview approach to investigate whether specific HCI task analysis techniques are used in practice and to evaluate the suitability of practice environments for the application of HCI task analysis techniques. Like those before her, the overall motivation of such research is to develop a better understanding of practice so theoreticians can better provide for them. Unlike those before, Bellotti (1988) intentionally samples designers from different commercial interface design projects to provide more power to her generalisations. However, the 8 projects studied by Bellotti (1988) were of the traditional interface variety, e.g. a stock management system and an educational graphics package for children. Bellotti (1988) calls these 'commercial system interface design'. They do not cover the broader spectrum of commercial HCI practice nowadays, e.g. website design, mobile phone design and safety-critical system design. The findings of Bellotti's (1988) paper are organised under three sections:

Variations in the Design Environment

Dimensions are recognised along which design environments vary, e.g. autonomy from client, size of design team and access to task and user information. Recognising these separate dimensions seems beneficial because they help characterise a context, but the fact that they are not integrated in a wider explanation of design practice theory, but remain relatively detached, means they remain a list of components with limited explanatory power.

Categories of Design and Development Activity

Five categories of development activity were recognised and described: 1) commitment to requirements specification; 2) conceptual specification; 3) generation of a working prototype; 4) testing; and 5) finalisation. Bellotti observes that these activities are distinguished by their goal and can be done in any order, which contrasts with some prescriptive processes of doing design as described in Section 2.1.

Commercial Design Problems

Bellotti (1988) lists 12 design problems faced in industry. These problems are given extra description and are related to one another where appropriate. We have included this list below, with a brief note to indicate their meaning:

1. Poor Communication – Where this occurs it is usually between designer and client, which can lead to discrepancies in goals, and poor data for the designers to work on.
2. Uncertainty about requirements – It seemed common that an explicit requirements specification was difficult to provide, so the designers had to discover gaps and potentials themselves. This meant more work for the designers and the potential for misunderstandings between the designer and client.
3. Exclusion of users – For example, in one case a systems expert provided user information instead of direct involvement of users. This information turned out to be poor and so design decisions were deficient.
4. Expanding task outline – This occurs where people propose more ideas for inclusion in the design as it develops. This can occur as people realise the potential of the design and want it to do more, which can cause problems for the designers.
5. Designers' unfamiliarity with task domain – This has the potential to increase communication problems.
6. Lack of HCI guidelines and standards meant that the acceptability of solutions was left to designers.

7. Familiar solution application – If under pressure designers would take shortcuts by fitting solutions from similar, previously encountered problems rather than thinking about the current problem as a separate entity.
8. Technological constraints can cause designers problems as trade-offs have to be made.
9. Written software constraints – This occurred where proposed changes to the design are too costly in terms of the effort required to change the code of the software.
10. Over-casual evaluation – This led to a degradation of the data being used for the design, a more extreme case involved a designer pretending to be a naïve user.
11. Lack of performance metrics – It was thought this would contribute to less meaningful evaluation on performance, and so degrade design decisions.
12. Market pressures – Budget and timescale pressures pose significant restrictions on a thorough investigation and considered action, meaning practical decisions have to be made on what can be done rather than what would ideally be done.

Bellotti (1988) has started to map the different issues and components that can be used to describe practice but this by no means exhausts this line of research. There has been little in the way of follow up work since 1988. This is important as her work can be considered dated in four respects:

- In commercial practice: HCI/Usability industry has grown and evolved.
- In examples used: e-commerce and interactive systems are more widespread and pose different challenges nowadays.
- In available HCI techniques: new methods are now available, including formal and informal methods.
- In the qualitative tools used to do the investigation.

Bellotti (1988) made important steps towards developing explanatory theory of methods in practice by recognising many of the components, issues and variables in design practice, but has less in the way of linking these ideas together with theory. With the growth and diversification of the usability industry a modern day study would also need to be explicit about what parts of the industry it focused on.

O'Neill (1998) bridges the gap between this section and Section 2.3. His work is included here as it follows well from Bellotti (1988) and has a large preliminary study on HCI practice before engaging in a slightly more obtrusive research style (similar to those discussed in Section 2.3). O'Neill (1998) recognises that there might be advantages in trying to combine task analysis techniques with the more informal technique of participatory design. His thesis then moves on to building theory around this methodological combination through action research.

O'Neill bases his work on two premises: the first is that modern interactive systems must be built with a clear focus throughout the development process on supporting users' tasks (Gould & Lewis, 1985); the second is that there should be as few layers of mediation as possible between users, developers and the emerging artefacts. Although the first premise is now received wisdom amongst the HCI community the reality of achieving this is questionable – the alternative to implementing this rich perspective is to try to improve what we actually have. The second premise speaks of reducing mediation layers, but it should perhaps be the improvement of these mediations which should be our primary concern rather than the outright elimination of them. It is worth remembering that layers consist of both people and representations, and that these layers can help. People from different communities do not find it easy to communicate with each other so these layers have legitimate reason to exist. Cooper (1999) argues for exactly this: the role of an interaction designer is to understand the user and develop a blueprint for developers to work to. The rationale is that users do not know what they really want or the potential of what they could get, and developers are too technology focused to communicate with users or understand their needs at an interaction level. For Cooper this mediating role is essential.

Bellotti (1988) and O'Neill (1998) were both focused on developing the understanding of: 1) how certain HCI techniques were being used by industry at that time; and 2) how the application of these techniques could be better understood in practical contexts. At the heart of these issues is the desire to make both theoretical and practical contributions to HCI. The more general problem that lies behind both theses is the division between academic research and industry practice. This is captured, in part, by the development of tools, methods and advice by academia to enrich the process and product of HCI, and the relative independence of industry and poor uptake of these research contributions to which Bellotti (1988) and O'Neill (1998) both refer. One of the unknowns to which both authors contribute is the development of an understanding of how industry practice actually operates. It is hoped, that researchers can be better informed about the practice and constraints of industry so there is a better chance of theoretical contributions translating into practical contributions.

Following the motivation for understanding the use of methods in practical contexts Bansler and Bødker (1993) interviewed 9 designers in three Danish companies about their use of the Structured Analysis method. They observed: that design practice did not fit much of the normative literature; that defining the design problem can be the crux of the matter and cannot be taken as given; that designers do not have time to experiment with methods; that designers 'back rationalize' to justify what they have done after the occurrence; that experienced designers do not follow rules but pick and choose elements of the method; and that methods and processes are subordinate to the developing understanding of the designer.

More recently, Nørgaard and Hornbæk (2006) provide an observational study of think-aloud testing in usability practice. Their observations suggest that think-aloud studies are too focused on known problems, favour issues of usability rather than utility, include expectations rather than the actual experience in the study, and are shaped by practical realities and laboratory-style procedures. They recommend more work on fast paced analysis, more systematic analysis, and analysis which includes issues regarding the utility of systems.

The general message from the papers discussed in this section is that we need to understand design practice better so we can inform future research hoping to impact on HCI practice. The lack of understanding and the academic reward system for building new theories may have contributed to what O'Neill (1998, p. 65) refers to as "the largely undisturbed arsenal of system development methods." In support of this he also states: "there have been so many attempts at prescribing formal or structured methods of engineering software that most developers have heard of only a small proportion of them" (O'Neill, 1998, p. 62). With the ultimate aim of an applied discipline, such as HCI, being the improvement of practice (O'Neill, 1998, p. 297) the papers in this section suggest that more work should be done to find out about the complexities of practice. Given that there are so few studies and the ones there are can be considered reasonably dated, it would appear that this area of research can not only be updated, but developed.

2.3 Testing research in practice

Quite often, testing in practice will be carried out to see whether developed academic methods and prescriptions can easily transfer to industry contexts which have not previously used them. Examples include training practitioners in novel methods and influencing their design procedures. This type of research not only tells us about the specific method that is being transferred, but also, importantly, teaches us about industry practice. From instances where methods and techniques have met difficulties in practice we can infer that the researchers involved were not in a position to predict the performance of their method. In a similar sense to which Newman and Lamming (1995) advocate simulation in design, as a design's success in a real context cannot always be predicted to the nth degree, these researchers can be considered as testing their methods in practice. As stated previously, these tests teach us about the method as well as the users and contexts in which they are to be used.

Buckingham Shum and Hammond (1994) recognize 'gulfs' that have a significant effect on whether HCI modelling techniques transfer to practice. Before discussing their conclusions it is worth noting their motivation for investigating this area as it is highly pertinent to the current thesis. They recognize that the HCI community is generating a large quantity of modelling techniques; that any impact of these techniques on practice will rely on their intelligibility, utility and usability; and that the potential success of these techniques can be increased if model developers sensitize themselves to the needs and resources of their target design communities. Put another way, we can better provide for industry practice if we understand it better. This is the implicit, overarching gulf that their research is trying to address. The explicit gulfs that their research recognizes as being potential barriers to modelling uptake include:

- Prerequisite gulf: This refers to the prerequisite understanding of the approach: i.e. it should be sufficiently understood and trusted. If there is not sufficient understanding then the approach may not be used efficiently and effectively.
- Cost gulf: This refers to the demands placed on designer in using the approach. If the cost of using the method is too high (e.g. it takes too long to complete) then the value of it may be compromised. So, the expertise of the person using the approach will affect the cost.
- Payback gulf: This refers to the potential benefits that the approach will give to the design process.
- Consultancy gulf: This refers to the value to the recipient, e.g. are the results of the modelling useful, that is, intelligible, relevant and applicable.

These gulfs to method uptake are important but are not comprehensive. Buckingham Shum and Hammond (1994) also importantly point out the influence of 'organisational gulfs' which are more associated with the context, culture and practice, rather than the individual or the cost-benefit trade-off in using a particular technique. This aspect of their paper is not the main focus of their contribution. A more thorough investigation would have to be undertaken to explain the role of organisational gulfs.

Bellotti et al. (1995) describe the transfer of modelling to practice as a component of the AMODEUS project which sought to develop semi-formal and formal methods to be of use in design and by practitioners. The paper's purpose is to 'demonstrate' the value that theoretical modelling techniques can bring to design which it achieves to some extent. However, due to the loaded aim to 'demonstrate', and the level of expertise and effort that went into making the practice a successful one, questions are raised about the objectivity and fairness of the conclusions. For example, it is questionable whether a business would invest the time, cost and expertise levels that were present in this research project. The paper raises and describes important insights relevant to the understanding of design practice and its needs:

- It is recognized that the communication of tools, methods and results is as important as the technical merit of the tool itself. This opens up a new dimension and value in tool use which goes beyond normal problem finding.
- It is recognized that we should use HCI principles to develop HCI practice by understanding our users more: e.g. we should not produce a new methodology without understanding the HCI practitioners who might use it, what they might use it for, and what context they may use it in.
- Bellotti et al. (1995) recognized that some claims they make may appear 'obvious' but that instantiating them is rather more complex.

Bellotti et al. (1995) also recognise the strong influence of design cultures on the receptiveness to HCI modelling techniques. This recognition may have become apparent in working with people with quite different cultural backgrounds, which would also emphasise communication issues as people from different backgrounds clashed. This relates to Winograd and Flores' (1986) 'breakdowns', which is taken from Heidegger: i.e. when there is a disruption in our normal understanding and we consciously notice and reflect on what has caused this. Whether or not this is the case in this instance, it seems sensible to suggest that the more implicit understandings possessed by one culture may only become apparent when contrasted with another culture with different assumptions. Hence this thesis compares two different design cultures to enhance the potential insights for both (these are website design and safety-critical system development).

Blandford et al. (1998) explore issues to do with getting practitioners to use the PUM (Programmmable User Modelling) technique. The motivation of this work originated in the observation that many techniques fail to transfer to practice, and so training practitioners to use a specific technique might indicate reasons why this might be. The paper makes it apparent that the interaction between craft skill, modelling, notation and design insight is a complex one. The level of expertise a practitioner has will influence how strictly they use the method and when it can be relaxed; it will affect the level of insight and where this happens in the modelling process; and it will affect the ease of use of the notation, consequently affecting the cost of investment and the benefit received. This complex set of interacting issues is made more difficult to study when we acknowledge that people’s understanding of a method is not static; and that the value of using any method is often domain dependent. Both of these issues make observations and generalisations of expertise in method use for analysis difficult. A detailed explanation of method use by practitioners at this level of granularity is liable to invoke these complicated issues which centre around the concealed dynamic craft skill level of the people involved. Also, the assumption that people either use or do not use particular methods, in a binary fashion, is a naïve one. There are many cognitive complexities lying under the surface that will govern how a method is used and the insights gained from it.

Hyde (2001) who developed a novel usability evaluation method, EMU (Evaluating Mutli-modal Usability), found expertise a great stumbling block when trying to evaluate the method validly. Rather than being a weakness of the research this has highlighted issues to do with expertise. This conforms to the claim made in the opening paragraph of this section, that the process of experimenting and applying this research in real settings develops our understanding about these settings. Blandford et al. (1998) found that practitioners gained insights into the design problem sometimes before they started any explicit analysis; Hyde (2001) found that people gained insights into the design problem which were outside the scope of the particular method they were using. Again, this highlights that there is a lot going on, concealed in people’s heads, which reveals itself on close inspection.

Blandford et al. (2006) sought to see how Claims Analysis might be used in practice. In their particular context it was found that there was resistance to using the technique in a formal way, and so the adoption of it was not as smooth as some of its proponents claim. They claim that the method was too structured, inflexible and academic for the design scenarios under study and report that the whole process is much more organic and opportunistic than that assumed in descriptions of design processes. Whether this was a conflict of culture (Bellotti et al. 1995) or whether it is a more general concern about the particular method and design context, it remains clear that what designers do, what cultures they work in and how they actually use different methods (if they do) is not well documented and understood.

Progress has been made in this area, as the references discussed in this section demonstrate, but there is more work to be done in gaining a better idea of what is happening in practice at different levels of granularity and focus. Themes which seem of particular importance are the understanding of expertise in method use, how design culture affects practice and method use, and communicating insights and recommendations. If we want to increase the potential for HCI input in practice then it appears that we should not only focus on method use and problem finding but also on communication involved in the wider design process and understanding what is important to the different groups of people involved in this process.

2.4 Case studies of HCI practice

Case studies are one way that practitioners can share experiences of what they do, of best practice and advice on what not to do. However, we can not assume that these case studies contain the 'warts and all' detail of the situation if the author wants to maintain favour with their current or previous employer. Despite this limitation case studies can provide a wealth of insights from people's experience over many years of working. We refer to two books that document case studies which show insights in practice. Both Wiklund (1994) and Winograd (1996) provide collections of essays from practitioners that describe what they do and share insights they have gleaned. Although these case studies have been well collated in these two books it is questionable how far these insights integrate with common knowledge and academic theories. A large difference here is that case studies provide one-off insights from a personal point of view, whereas the development of academic theories encourages building on works that have preceded it, hence there is much more longevity and continuity in the academic arena. There is also a different status between case studies and academic theories as the latter is the product of academic procedure and scrutiny, and the former involves the sharing of personal knowledge. Here the difference essentially lies in academic acceptance and authority. However, this distinction does seem to get fuzzy as these personal accounts could easily be construed as data points for a qualitative study, and some audiences might prefer accounts from practitioners who work in context rather than more abstract academic accounts. Although these differences should be appreciated, we should benefit from insights from both.

In contrasting the two collections Wiklund (1994) focuses more on establishing and managing usability practices within large organisations; and Winograd (1996) focuses on what software design is and what it might be. Although there is a practical focus in both books, Winograd (1996) sides more with progressing knowledge about design, whereas Wiklund (1994) offers more advice on establishing and managing a usability practice. This difference is probably influenced by the editors' backgrounds, the contributors, and the overall aim of the books. Winograd (1996) quotes Norman (1993, p. xii) in helping to explain that a collection of case studies may be able to offer the 'design knowledge cauldron' which academia cannot:

> "University-based research can be clever, profound, and deep, but surprisingly often it has little or no impact either upon scientific knowledge or upon society at large. What matters is precision, rigour, and reproducibility, even if the result bears little relevance to the phenomena under study." (Norman, 1993, p. xii, cited in Winograd, 1996, p. 234)

This criticism of contextual relevance appears to be of the same variety which would arise between proponents of quantitative and qualitative scientific traditions; the former having more rigour and reproducibility but less relevance to the situation at hand. The exemplar comparison between both traditions is between laboratory and field studies. Some would argue that the very fact of neutralising and controlling variables in a laboratory, to improve rigour and repeatability, dismisses the interesting variances of real world phenomena. The response can often be to defend the generalisability of such results, with the implication that qualitative methods have difficulty going beyond the particular cases they have encountered in the field. Without digressing into methodological issues in this chapter too much, the question of how usability methods are used in different contexts favours the qualitative tradition. Returning to the case studies at hand we can see that they help inform an early qualitative analysis as they are qualitative, first hand reports, of the context in which these people work – the very context we are interested in finding out more about.

In keeping with the academic and real world divide, and the role of complexity and context, it seems fitting to describe Norman's (1996) contribution in Winograd's collection: Norman, a well respected HCI academic, moved into industry to try and implement academic practice in the real world; however, once involved in industrial design he found that there was no real place for idealised academic solutions, and that the solutions were often just a best fit once all the complex real world rationale had been taken into account. This relates to insights shared by other contributors in Wiklund's collection. Usability practitioners should engage with the design 'in the trenches' rather than in an 'ivory tower,' so they can understand the issues, and engage with the real problems and trade-offs at hand rather than offer abstract advice (e.g. Logan, 1994, p. 80). It is also important to speak the developers' language including terms they use for the application domain (Wichansky & Mohageg, 1994, p. 254) and make sure that people are working together rather than in competition (Salasoo, White, Dayton, Burkhart, & Root, 1994, p. 512).

Kapor (1996) – which is a reprint from a 1991 paper – makes the case for the role of a 'software designer' who is responsible for the overall design of the software, but who is distinct from programmers who engineer software and produce code, and user interface designers who are sometimes detached from the back-end of the software. There is recognition amongst those trying to understand design that it is a complex and messy thing. Kelley and Hartfield (1996) explain that it is the designer's job to try and understand the mess: although they cannot tell you how it is done they just do it. Schön and Bennet (1996) provides some conceptual leverage to understand how designers work. In this transcribed interview Schön describes how designers have a reflective conversation with the design materials, where the design situation 'backtalks' to the designer developing their understanding of the context, and where this backtalk can be a real revelation to how users perceive and use new designs. Adding to this reflective perspective of design Schrage (1996) talks about different cultures of prototyping that lead to their different use in design – from cultures where a lot of value, effort and thought is placed on using prototypes early on and which are developed through the design process to other cultures where it is just an evaluative step at the end. Relating the development of design ideas to rock climbing Gal (1996) describes 'footholds' in design, whereby a designer reaches a stage where they can take stock of what they have done, reflect and decide where to go next. This ability of tasking stock of a design is described by Schön (1996) as the designer's ability to 'taste', whereby they can discriminate the quality of a design in many different ways. From Crampton-Smith and Tabor (1996) we might also infer that different types of designers will have different types of taste and different methods for tasting. Crampton-Smith and Tabor (1996) draw distinction between artist-designers and engineer-designers, where the former traditionally has a more decorative emphasis and the latter acts in a more predictive design space. They make the case that the skills of the artist-designers have an increasing role to play in interaction design as they engage with human experience and subjective responses which are intrinsically ambiguous.

Wiklund's (1994) collection of case studies are mainly to do with political management and getting usability established in the organisational setting. These insights, which are not the 'usual' subject of usability design research, are nevertheless essential for affecting design outcomes, getting usability heard and therefore its overall success. Affecting design in an organisation is a social process and so politics has to be managed, ideas marketed and people persuaded in the long and short term.

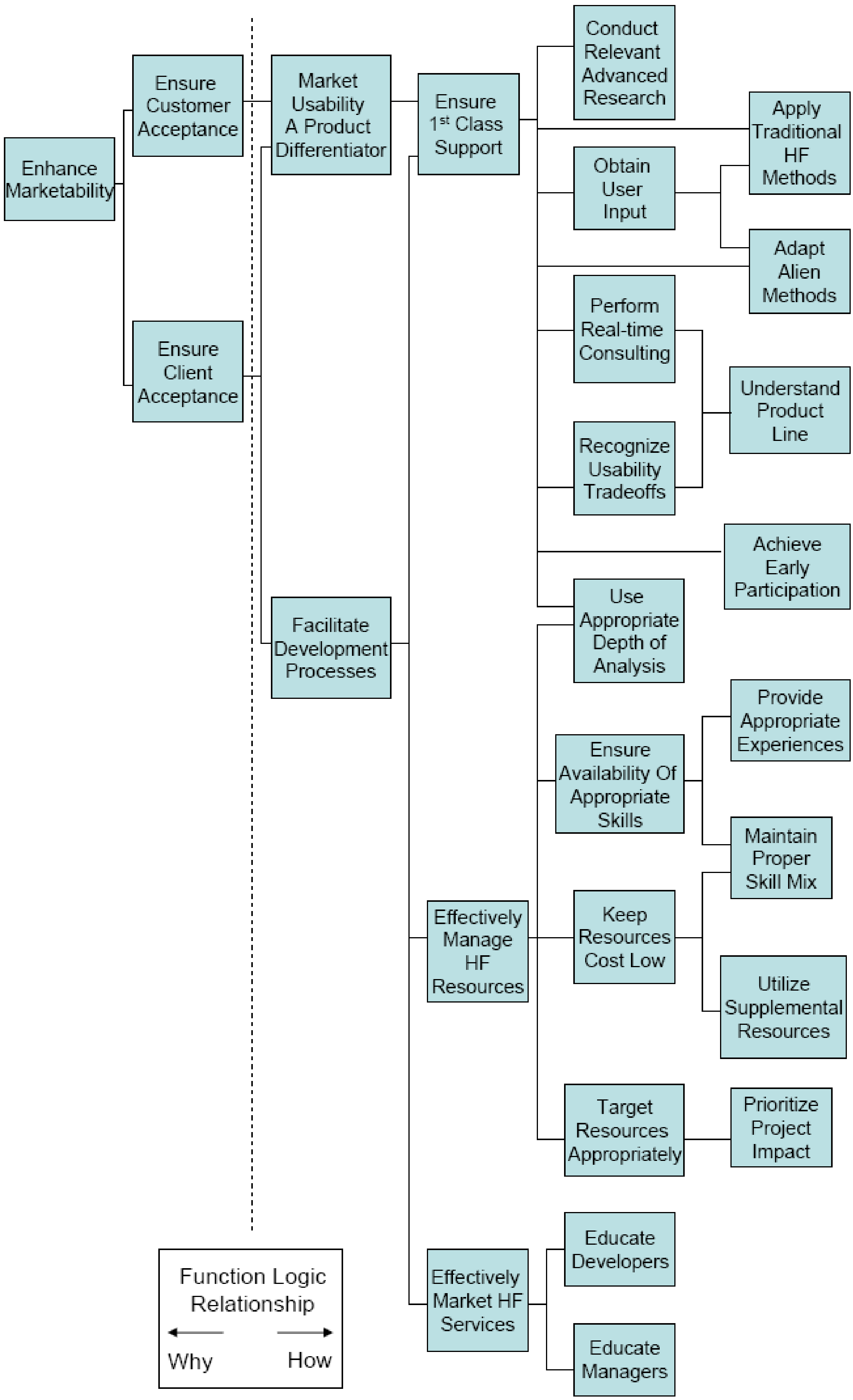
Caplan (1994) provides a framework for a corporate usability program (see Figure 2.4) under which different components are recognised as important for enhancing the marketability of the usability program. The figure can be read from left to right, as higher level goals for ensuring the marketability of usability are broken down into smaller more manageable activities. Each of these components is described in detail, but we only give a highlight here for the sake of brevity; the component titles are highlighted in bold (p. 28-30):

- **Conduct relevant advanced research.** People are often unable to experiment with state of the art in a project cycle, these should be researched outside the design cycle where possible.
- **Apply traditional human factors methods.** "Theoretically, a method should be chosen that gives a high level of confidence in its outcome. Practically, availability of time and money often dictate the method chosen".
- **Adapt alien methods.** Use methods from another discipline if required.
- **Perform real-time consulting.** Because so many usability problems are found during development it makes it impractical to study every one. "A good usability program has experienced people who can make reasoned, on-the-spot judgements about usability issues".

- **Recognize usability trade-offs.** “Inevitably on a project, there are times when the best solution can be achieved only at the cost of added development effort, increased unit manufacturing or life-cycle cost, or a potential reduction in product reliability. Continually ignoring these considerations in the name of usability is not practical and jeopardizes the Human Factors engineer’s rapport with the client. On the other hand, software developers, hardware designers, and the like sometimes magnify the obstacles to implementing usability features because they do not want to put forth extra effort”.
- **Achieve early participation.** “Typically, early involvement will occur for a couple of product lines where repeat business over the years has evolved into a close relationship with clients here. Companies having a prescribed corporate development process that drives all projects provide an opportunity for consistent early Human Factors involvement by formally including usability considerations in the first phases. Also, early involvement is likely at companies where senior executives have final product approval and usability is one of their criteria. This gives added importance and awareness of the Human Factors function to product developers”.
- **Use appropriate depth of analysis.** Practitioners should balance how much actual research is done in line with the issue’s importance and the time and money available. It is detrimental to give the impression that HCI is always unnecessarily “researchy” and time-consuming.
- **Prioritize project impact.** Where resources are tight the projects that will benefit the most from usability input should be prioritised.

This sort of framework provides a very useful and accessible source of reference to those factors that impact on the marketability of a usability practice. One advantage of this work is its visual representation which relates these components under a common framework (see Figure 2.4). This visual summary makes the components more intelligible and accessible than would be achieved in prose alone.

Figure 2.4: Diagram for a corporate usability program (adapted from Caplan, 1994, p. 27)



Being persuasive is one of the biggest themes that runs through the case studies in Wiklund (1994). This includes maintaining credibility, communicating well and fitting in with the existing systems, people, and practices. Examples of persuasive practice include: Logan (1994, p. 79) reports that his team treat presentations to management like a commercial and deliver two or three key ‘info-bytes’ which are easily internalised. These ‘info-bytes’ are repeated over time until executives start using them in discussion and reasoning themselves – creating a change and a certain level of acceptance. Wixon and Comstock (1994, p. 188) advise on using a convincing method rather than the ‘right’ method. In terms of communicating with clients Wichansky and Mohageg (1994, p. 254) recommend adopting the vocabulary of the application domain and talk the developers language. Wilson, Loring, Conte and Stanley (1994, p. 424) stress the importance of overcoming geographical distances and having face to face communication to try to build the personal relationships that are so important for trust and confidence which might influence the acceptance of design recommendations.

The transfer of usability problems and recommendations is a predominant issue for the practitioners in Wiklund’s collection. Rosenberg and Friedland (1994, p.270) recommend that problems be categorised by severity and priority to allow people to prioritise and rationalise what action to take. Their usability problems gained a large advantage as they were handled within the established software debugging system of the company and not treated as a separate entity. This ‘piggybacking’ tactic is recognised as a more general strategy to achieve influence and acceptance by Rideout and Lundell (1994, p. 223). Other practitioners really promote the beneficial effects of getting clients to watch usability tests first hand or via video recordings (e.g. Wichansky and Mohageg, 1994, p. 265;). Dieli, Dye, McClintock and Simpson (1994, p. 335) recognise that ‘a picture is worth a thousand words’ and explicitly seek to collect video data as a persuasive tool as well as a data source for analysis. Both Purvis, Czerwinski and Weiler (1994, p. 142) and Lund (1994, p. 485) explicitly state that watching a video of a user struggling is more persuasive than statistics and logical argument. It is not clear exactly what value these visualisations have, which allegedly have such a large effect on the client, but Butler and Ehrlich (1994, p. 320) suggest the answer is in the non-verbal cues that cannot be captured in a verbal report. A strong example of this is reported by James (1994, p. 360) who describes a programmer who at first believed usability testing was a hoax; however, after observing the tests he was completely supportive of the findings. The programmer in question subsequently retracted the program he thought was so good for further development before release.

Another big lesson involves fitting with corporate culture, which can be heavily aided by managerial support. Indeed, Rosenburg and Friedland (1994, p. 290) recognise that to "build truly usable products efficiently the usability engineering process has to blend directly into the corporate culture". Butler and Ehrlich (1994, p. 318) recognise that the addition of a new process or influence in the design process can disrupt established responsibilities and power relationships e.g. control of the interface can move from developers to HCI practitioners. These changes need the support of management to help them through. This important influence therefore is likely to have serious consequences for those studies that try to validate methods in real design teams such as those described in Section 2.3. For example, if management fully support the adoption of a new UEM it will increase the potential for it to be seen to be applicable to practice; however, this may be more to do with management than the method itself.

The case studies referred to in this section provide excellent examples of the useful insights and practical knowledge that can originate from this area. They touch on real life problems, strategies and contexts, which can too easily be overlooked or disregarded in a focused academic study. What is interesting is the change in emphasis from what academics think is important to research, to what practitioners think it is important to tell each other. From a brief analysis of the content of this section compared to Section 2.3 (Testing Research in Practice) there is a different level of focus which changes from finding usability issues to getting usability issues heard, and from analysis to being persuasive. There is also a shift from the prescriptive authors described in Section 2.1 (Prescriptive HCI), in that the sharing of knowledge is more open amongst colleagues rather than a tool for preaching. Despite the advantages of this body of knowledge it does have limitations in that the validity of the claims and insights are academically questionable as they are personal reports. Also, the insights are relatively dispersed and do not currently have obvious links to academic theory development which would promote their longevity, robustness, improve their recognition and hopefully lead to better understanding. This would serve academia and practice better.

2.5 Conclusion

The purpose of this chapter has been to give an introduction to the research topic and structure to the background knowledge and research that supports it. This background knowledge has been categorised by method and type of data. The motivation behind this categorisation is to help show that HCI practice knowledge has a diverse composition; i.e. it is composed of prescriptive knowledge, studies of interviews and observations, studies involved with testing in practice and case studies. From this position we can be more explicit about the make-up of this knowledge so we can reflect on what personal knowledge we have, why we have this view, how rigorous this might be, and identify ways of improving it.

Overall, we can see that HCI knowledge has a variety of influences and these are likely to be different for different people. If our goal is to better provide for practice through improved understanding we need to concentrate on what is actually happening in practice rather than prescribe methods and theories that do not fit (Section 2.1), we need to find out what is going on and not introduce artificial changes to practice (Section 2.3), and we need to take note of what is important to practitioners (Section 2.4). This project will concentrate on developing the knowledge base of Section 2.2 as we want to find out about practice without introducing different measures or trying to make changes.

In terms of content, limitations were recognised with the literature in Section 2.2. Modern HCI now has more methods, and is involved in a wider variety of systems development, and industry has evolved to accommodate different types of consultancies and in-house usability experts. It is not clear how far things might have changed from the studies referred to in this section. Their generalisations are expected to hold, but a survey of any industry practice will be influenced by its area of focus and the time it was carried out. Two modern HCI domains are studied to exploit creative tensions they may provide (these are website design and safety-critical system development). The research approach is described in detail in the next chapter.

Chapter 3: Qualitative research and the grounded theory approach

3.1 Introduction

This chapter introduces the method of inquiry of this thesis. However, it goes further to add coherence to the thesis by establishing the paradigm of the research. In hierarchical terms the chapter starts at a high abstract level by establishing the philosophical assumptions behind the approach (Section 3.2). It then goes down a level to develop an understanding of what can be expected from a qualitative project such as this (Section 3.3). Focusing down further it explains why grounded theory was selected as a research method and how it was conducted (Section 3.4).

3.2 Appreciating Different Research Paradigms

Research is generally thought of as a search for information or an answer to puzzling questions (Boyle, 1997, p. 12). Science has rigorous standards for carrying out research so that we can be fairly sure that we are progressing towards some 'truth' and that spurious conclusions do not distract us from this path. Science is most closely associated with research in the natural sciences where things can be objectively measured and tested. However, there are many areas of research where the characteristics of the object of study change: e.g. studying the boiling point of water is very different from cultural perceptions of 'love'. When the object of study changes in such a dramatic way so do the rules of the game: assumptions about reality (ontology), assumptions about what can be known (epistemology), the methods of investigation (methodology), as well as the subsequent claims of validity.

A common categorisation people use to discuss different methodological approaches is the distinction between quantitative and qualitative methodologies. Quantitative methodologies typically relate to the positivist paradigm whereby hypotheses are tested through controlling conditions and measurement of an objective world. Qualitative methodologies are typically employed to investigate the more subjective worlds, e.g. people's beliefs, understanding and meanings, which relate to interpretivist and constructivist paradigms. These different approaches normally reside in different academic disciplines, e.g. physics and sociology. Tensions can exist where different approaches are housed within the same discipline as the proponents of the approaches question the method, generality and validity of the other approach (Strauss & Corbin, 1998, p. 28). Limitations can be identified in each; for example, quantitative studies are criticised as their focus is intentionally decontextualised as variables are controlled, nullified and manipulated. In contrast this naturally occurring contextual variance is exactly what is valued by qualitative researchers but they are criticised for their insights not being generalisable: i.e. conclusions are so attached to a specific context that generalisations cannot be made. There is also the issue of interpretation in qualitative studies as subjective biases are much more liable to influence insights, but qualitative proponents would defend the rigour of their analysis and retort that subjective biases will influence the questions quantitative proponents ask. Interpretation is entirely consistent with interpretivist and constructivist philosophical positions. It is worth recognising the limitations but also noting that there is no one right way to adopt; both approaches are valid and should be used according to their suitability to the research question. We should not be asking what is the best method in any absolute sense, but instead what can we learn from each perspective (Eisner, 2003; Mackay & Fayard, 1997).

This thesis takes a pragmatist view: i.e. a research perspective should be suited to the research question. As the focus of this research is on the knowledge and perceptions of usability practitioners, i.e. how they perceive their work and what they do, we gravitate toward the subjective and exploratory side of research and more qualitative approaches, which we explore in more detail in the next section.

3.3 Qualitative Research: Further detail, challenges and method selection

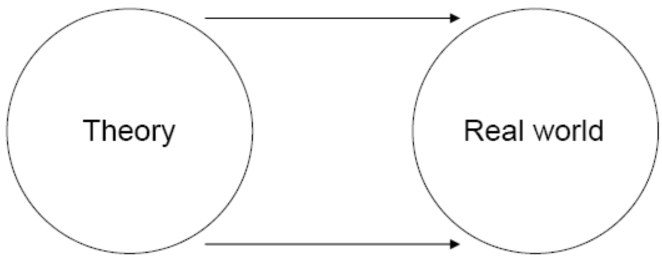
This section looks to elucidate our understanding of qualitative research further so we are in a better position to appreciate it, do it and judge its merits, processes and product. This section is divided into two: the first looks at the outcomes or products of interpretivist studies and the second looks at specific challenges that qualitative studies face. Both of which give us a better idea of what to expect of a qualitative study.

3.3.1 The products of interpretivist research

This section juxtaposes interpretivist with positivistic research to show fundamental differences in their approaches.

Research methods in the positivist tradition are associated with hypothesis testing. In these cases the hypothesis to be tested is created before any empirical data gathering starts and is couched in current knowledge, wisdom and theorising which often amounts to an incremental step of an existing theory; data is collected to test whether the new theory fits the world (Morse, 1997, p. 166). This relationship between theory and the real world can be seen in Figure 3.1. Due to the nature of the relatively detached theorising in the 'conjecture then test' procedure, and the fact that the relationships have to be construed in such a way to be measurable and testable, some argue that such theory is divorced from reality as it is too simplistic, intolerant of ambiguity and has convenient yet arbitrary boundaries (Morse, 1997, p. 168).

Figure 3.1: Research methods in the positivist tradition where theory is tested for fit against the real world (reproduced from Morse, 1997, p. 169)

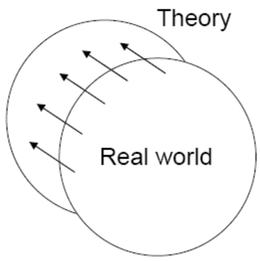


Research methods in the interpretivist tradition often have a very different relationship between theory and the real world, which is illustrated in Figure 3.2. These studies have a close relationship with the empirical world whereby inferences are made in an inductive manner and theory is developed and confirmed in the data gathering process.

> "These theories are rich in description, and the theoretical boundaries have been derived from the context and not from the researcher's arbitrary goals for delimiting the scope" (Morse, 1997, p. 168).

As theory is developed more directly from the 'real world' it has more potential to be innovative compared to positivistic theories that are an incremental step from current theory (Morse, 1997, p. 169). It reflects the important aspects of reality rather than incremental theory progression per se.

Figure 3.2: Research methods in the interpretivist tradition where theory is derived from the real world (reproduced from Morse, 1997, p. 169)



Theory testing is top-down in the sense that some assertions exist about the world and an experiment tests whether these assertions are true. In contrast, this study starts with taking an exploratory approach as the goal is to recognise, describe and explain what patterns there are in the world from a bottom-up perspective. This allows one to be responsive to the research situation as it is and to take more of a direct approach to finding out what is really going on (Dick, 2005). Table 3.1 provides a summary of some of the important differences between positivistic and interpretivist approaches.

Table 3.1: Summary of important differences between positivist and interpretivist derived theory (adapted from Morse, 1997, p. 167).

Characteristic	Positivist approach	Interpretivist approach
Derivation of theory	Hypotheses are invented or created from literature and then tested to achieve incremental progress	Theory is developed from empirical data after a research focus has been identified
Relationship of theory to empirical world	Conjectural and inferential Hypothetical Operational definitions may be vague Boundaries arbitrary	Represents empirical world Organises reality Rich description Boundaries appropriate
Relationship of new theory to existing theory	Foundation in existing theory Incremental modification	May be innovative Linked to associated theory

Interpretivist research can offer concepts and theories for understanding real world phenomena. Research of this nature might introduce and develop understanding of a single concept, describe a situation in a new way, or it might create concepts and explicate relationships between these concepts to form theory. Morse (1997, p. 173) recognises that the product of qualitative studies range from the more descriptive to the more abstract. The former remains close to the details of the situation, whilst the latter subsumes multiple cases under conceptual relationships.

This section elucidates our understanding of what can be expected from an interpretivist study. We have seen how interpretivist studies develop theory inductively, which remain close to the real world. Depending on the conceptual depth of analysis interpretivist studies can produce different types of theory from the very descriptive to the very conceptual where theories contain multiple abstract concepts and linkages between them. By exploring challenges that qualitative studies face in the interpretivist tradition we will have a better idea of what principles one should adopt to overcome such challenges.

3.3.2 Challenges of qualitative methodology

By looking at the nature and challenges that qualitative research faces we will gain a better understanding of what can be expected from such a study. Borman, LeCompte and Goetz (1986) describe and reflect on nine 'charges' for qualitative research which we discuss:

1) Qualitative research is too subjective, and
2) Qualitative research is too value laden

The first two charges discussed by Borman et al. (1986) relate to the influence of the researcher on the research. Due to the role of the researcher in making sense of the qualitative data the researcher can be considered the research tool (Wolcott, 1975). The problem implicit in these charges is why we should accept someone's personal account of a situation over someone else's. Borman et al. (1986) believe that the qualitative researcher must be honest, introspective and adopt a 'disciplined subjectivity' (Erickson, 1973), which should be evident in their research report. Triangulation can also give credence to findings, i.e. that similar data and conclusions are supported from different sources, methods, people and perspectives (e.g. Mackay & Fayard, 1997).

3) Qualitative research is not replicable, and
4) Qualitative research is not generalisable

One of the main tenets of the experimental paradigm is the fact that experiments can be repeated. This has a direct impact on how generalisable results are. Experiments are normally tightly controlled, under specific conditions, and as long as these are replicated the results should also be consistent with the original study. If, however, they are 'one-offs' as qualitative studies are charged with here, then we can assume that they do not generalise out of the specific contexts of study. This issue arises as qualitative studies look for the contextual influences that exist in reality and do not try to control and decontextualise variables. There are two responses to this charge, the first is to dissolve it by saying that it is not the concern of qualitative studies to be repeatable as they engage with the rich contextual environment of each situation, but we lose power in generalisability. The second, more preferable response, is to limit the stringency of repeatability, i.e. to say that the exact results may not be repeated but that the results should be traceable in the study and that should someone repeat it then they may get different but not contradictory conclusions.

Generalisability is often assumed to mean more people across different contexts, but it can be understood in wider terms. Johnson (1997) introduces us to horizontal and vertical generalisation:

> "Whereas quantitative studies typically rely on procedures such as standardised measurement and random sampling to ensure the "horizontal generalisation" of their findings across research settings, many qualitative researchers aspire instead to the theory-building work of "vertical generalisation", i.e. an endeavour to link the particular to the abstract and to the work of others (Johnson, 1997)" (Yardley, 2000, p. 219-220).

Here, vertical generalisation offers support for abstract conceptual theory through its relation to similar work and it offers insights across contexts, e.g. product designers, software designers, graphic designers, and architects are likely to have strong similarities in their work at some abstract level.

5) Qualitative research has no validity, and
6) Qualitative research is not empirical
Borman et al. (1986, p. 51) believe that the empirical merit of qualitative research is actually superior to quantitative studies. This is because it pays closer attention to the natural state of affairs and does not abstract description to categories amenable to mathematical analysis, or manipulate natural conditions for testing. Borman et al. (1986, p. 50) also state that careful qualitative researchers try to maintain emic rather than etic meanings. Emic meanings are orientated around the terms and meanings used by the participants in context, and etic meanings are orientated around terms that the researcher brings to the situation. By focusing on and testing participant concepts rather than researcher concepts we come closer to understanding our participants' perspectives.

7) Qualitative research does not prove anything, and
8) Qualitative research produces trivial conclusions
It is not in the remit of qualitative research to prove facts but instead to develop insightful, plausible conceptual theory that aids our understanding about a particular area, to this end Glaser (1978, p. 93) writes:

> "The goal of grounded theory is to generate a conceptual theory that accounts for a pattern of behaviour which is relevant and problematic for those involved. The goal is not voluminous description or clever verification." (Glaser, 1978, p. 93)

In terms of producing trivial conclusions Borman et al. (1986, p. 49) believe that the answer to this charge is simply to do good research; they state:

> "In our opinion, simple, flat description that does not create linkages with substantial conceptual and theoretical literature is not good ethnography; neither is research that does not examine the socio-historical context for explanations of what is going on."

By developing linkages with substantial and theoretical literature the researcher also adds credence to results as it is nested in the work of others, i.e. this is a form of theoretical triangulation. In this thesis it is evident most strongly through the use of Distributed Cognition and Resilience Engineering literatures to develop the analysis.

9) Qualitative research is neither rigorous nor systematic, hence is unscientific

Borman at al. (1986, p. 52) recommend that enough scientific documentation is included in research reports so reviewers and readers can judge the products fairly. This would include specifying "what they did, how they did it, who was involved and for what length of time." They also believe that the non-linear processes that are often perceived as ill-thought-through ad hoc operations are actually one of the greatest strengths of qualitative research, whereby researchers can respond to incoming data in a bottom-up manner giving greater potential to understanding what is actually going on in the field.

This section has discussed methodological issues with specific relation to the challenges that are faced by qualitative research. From these, guiding principles for qualitative projects can be extracted, which we aim to follow in this thesis:

- Documentation: It is important that enough documentation of the thoughts, moves and processes of the analysis are available to consumers of the research so that they can judge the work. This documentation will also have to be coherent and accessible enough for consumers of the research to follow.
- Qualitative researcher must be honest, introspective and adopt a 'disciplined subjectivity': Due to the nature of qualitative studies the analyst will almost inevitably affect the results. From an interpretive and constructivist stance this is a natural part of the process. However, it is important to be aware of this so one can be self-reflexive and explicit in reporting where a personal perspective is influencing their analysis.

- Triangulation: Triangulation has been referred to in providing credence to theory and in developing theory to the level of explanatory theory. Using different samples, methods, perspectives and contexts is good practice.
- Vertical generalisation: Although descriptive theory has a place in research it is thought good practice to abstract and make conceptual moves. In this way the work becomes more generalisable and can be related to the work of others and existing theory. This is believed to have more conceptual depth and be more interesting in that the potential power of the explanation increases.
- Develop conceptual understanding not proving facts: Deep qualitative research looks to expand our conceptual understanding of an area. It is not to prove facts although facts will be important to abstract from.
- The goal of qualitative studies is to create conceptual structures that 'fit' the real world and add value to our understanding, to find insightful patterns in the apparent chaos.

Yardley (2000), and Yardley and Marks (2004), identify four guiding principles that can be applied to all research; these reinforce and enhance the principles above:

- Sensitivity to context

The foundation of this principle is to be sensitive of the theoretical literature in which the research is embedded, to be sensitive to what the data is saying rather than trying to fit it to a theory, and to be aware of the different assumptions, values and viewpoints of those involved in the research (Yardley & Marks, 2004, p. 18). Glaser and Holton (2004) warn against being too bound up in previous theory as they believe that this stifles the innovative potential of grounded theory. A pragmatic view suggests a balance between the two which is not without tension, i.e. to balance the need to ground the research focus in the literature but not so grounded in the literature as to be short-sighted by current thinking and unresponsive to the raw data.

- Commitment and rigour

This relates to the quality of the research, the skill and competence in applying the method and the depth and breadth of analysis developed (Yardley & Marks, 2004, p. 18). In large part this comes down to the competence, skill and effort of the researcher; it is down to their efforts and insights to go beyond flat commonsense description and beyond what is already known to add value.

- Transparency and coherence

This relates to the need for extensive documentation previously mentioned. It is important for research consumers to follow arguments and judge whether conclusions are legitimately grounded in the data. Yardley and Marks (2004, p. 18) also mention a meta-level of reflexive transparency in relation to constructivist positions whereby documentation goes beyond data and conclusions to include an awareness of the researcher's influence on how things have turned out. The quality of research also depends on its internal coherence so the philosophical perspective, methodology, data gathering, analysis and conclusions work together in a valid and consistent manner.

- Impact and importance

Yardley and Marks (2004, p. 18) describe three different levels of impact and importance for research:
1) Abstract value: "opening up new ways of looking at an issue, which may in turn suggest new understanding and further useful lines of research."
2) Socio-cultural value: "providing evidence relevant to arguments about what policy is preferable or what factors are responsible for various outcomes."
3) Practical value: "research may have practical value for a range of different people and purposes, from providing health care professionals with information about the mechanisms that mediate illness, prevention and cure, to providing sections of the community with means of voicing their viewpoint and achieving greater insight into and control over their situation."
There seems no reason why a piece of research cannot impact on more than one of these levels.

3.4 Method Selection: Grounded Theory

There are many different methods to choose from in qualitative research which have different applicability and purpose. Grounded theory (Strauss & Corbin, 1998) was selected here as the study aims to investigate practice from a practitioner's perspectives in an exploratory manner. It is a non-intrusive technique which "aims to develop theory from data rather than to gather data in order to test a theory or hypothesis" (Goede & de Villiers, 2003). The grounded theory process first involves gathering data to be analysed which can be recordings, images and text; then breaking down this data into components by coding; and then these codes are related to one another to reveal patterns. These patterns are the beginning of a theory which has been built up through the data.

Alternative qualitative techniques include: content analysis, thematic analysis, action research, and questionnaires. Content and thematic analysis (Joffe & Yardley, 2004) rely on analysing the frequencies of codes and do not engage in the deep iterative conceptual development that grounded theory affords. Action research (Ballinger, Yardley, & Payne, 2004) is more intrusive in that the researcher partakes in the work, which would mean that access may be difficult and it would be harder to get a broad sample. Questionnaires again do not provide the conceptual depth or the exploratory flexibility to go out and develop theory whilst talking to participants. Grounded theory was an appropriate choice for theoretical as well as practical reasons. We now discuss the Glaser and Strauss controversy as an introduction to perceptions of how the grounded theory method should be performed.

3.4.1 The Glaser and Strauss controversy

Glaser and Strauss are attributed with the 'discovery' of grounded theory but developed divergent opinions of how the method should be performed. Heath and Cowley (2004, p. 142) state that Glaser (1978, 1992) is recognised as remaining faithful to 'classic grounded theory' whilst Strauss and Corbin (1998) moved away, adding structure by creating analytic tools and providing detailed procedural advice to novices. Heath and Cowley (2004, p. 142) say that Glaser (1992) claimed the Straussian developments were no longer grounded theory but 'full conceptual description' because of the rigidity of their process and the encouragement of detailed description rather than conceptual emergence.

The crux of the controversy lies in rigid guidance and the difference between rich description and conceptual theory. Glaser and Holton (2004) strongly believe that grounded theory is different to normal qualitative methods in that it does not aim to provide detailed description of phenomena, or incrementally advance theory, but instead develop original and insightful conceptual theory. This conceptual theory has to emerge from the data and not be restricted or forced by the literature, frameworks or tools. They believe that to add such structure is to detract from the true essence of grounded theory, moving away from bottom-up theory development, and so erode it at its roots.

The Glaserian approach, which is dubbed ‘classic grounded theory’, is described by Glaser and Holton (2004) who try and establish its differences from normal qualitative research, some differences of which are shared with the Straussian approach. The dichotomy between classic grounded theory and qualitative methods described by Glaser and Holton (2004) is summarised in Table 3.2.

Table 3.2: Dichotomy between classic grounded theory and qualitative methods (inspired by Glaser and Holton (2004)).

Qualitative data analysis	Classic grounded theory
Research is linear as the study is developed from the literature, data is gathered, then analysed and conclusions drawn.	Research is non-linear as theory develops alongside data gathering, including ability to change sampling with theory development.
The analysis often takes the form of counting, sifting and sorting led by a preconceived theoretical basis.	The analysis uses memos to foster iterative thinking about conceptual developments and emerging theory without a preconceived framework.
The goal is accurate fact finding and rich description of an area of study, so details and structures are known.	The goal is ‘multivariate conceptual theory’ that aids understanding of an area of study.
This accounts for and describes variability in the phenomena.	The use of abstract concepts in theory means that variability is subsumed.
The analyst is generally seen as a source of bias that should be controlled for.	The analyst needs to take time, allow the theory to emerge and use their creativity and insight to bring the theory together.

The dichotomy between classic grounded theory and qualitative methods projected by Glaser and Holton (2004) adds a richness to the picture of why Glaser objects to Straussian developments. Analytic techniques and guidance was the focus of Strauss and Corbin’s (1998) grounded theory developments. Glaser would hold that theory development should come from the data and not be shaped by any framework, including the paradigm model and conditional matrix which are analytic tools developed in the Straussian approach. In fact, it would appear that the paradigm model and conditional matrix take the analyst down the path of rich description (akin to the goal of qualitative data analysis). For example, the paradigm model as used by Webb (2001) provides him with a rich conceptual structure to frame his data analysis on:

CAUSAL CONDITIONS [A] → PHENOMENON [B] → CONTEXT [C] → ACTION / INTERACTION STRATEGIES [D] → CONSEQUENCES [E]; INTERVENING CONDITIONS [F]

By using this paradigm model he builds up a rich description of software development from the Straussian side of the grounded theory divide. The paradigm model is used to guide the analysis by specifying what to concentrate on in developing the description. From the Glaserian perspective this adds top-down structure to what should be bottom-up development. Kendall (1999, p. 756) states that he agrees "with Glaser (1992) that axial coding via the paradigm model is inconsistent with the work necessary to generate useful and dense theory." It is important to note that the two approaches are not just different but actually conflicting: i.e. it is thought by focusing on anything but the emerging theory from the data will cause distraction and would not amount to classic grounded theory.

Turning to pragmatic concerns, the qualitative data analysis paradigm that Glaser and Holton (2004) describe is much more amenable to research environments than the idealised position of grounded theory they advocate. For example, investing many hours' data gathering and analysing will almost necessitate a thorough grounding in the literature to make sure that the area is a sensible and potentially fruitful one to look at. Other pragmatic issues might also get in the way of an idealised grounded theory such as having a lot of data in one go and not doing that gathering and analysis iteratively. Glaser (1999, p. 836) recognises that people will adopt and adapt parts of grounded theory. Whether people adopt and adapt grounded theory for practical reasons we should make efforts to recognise where we are deviating from the original prescription and what consequences this has. Table 3.3 shows that classic grounded theory can vary with alternative approaches across different dimensions. When doing an analysis the study may vary at different places on these dimensions; i.e. some on the left, some on the right, and some somewhere in between.

The dimensions in Table 3.3 characterise some of the different ways of doing grounded analyses. It is up to the researcher to have that disciplined reflexive subjectivity and be clear about how they choose to carry out the study, with an acknowledgement of how these choices will influence the results.

Table 3.3: Classic grounded theory can differ with alternative approaches across different dimensions

Dimension	Classic Grounded Theory	Alternative Grounded Theory
Literature review before analysis	Very little or none	Extensive
Literature involvement during analysis	Very little or none	Extensive
Analytic tool use (e.g. Paradigm Model)	No – purely data driven	The focus of analysis
Data sampling	Constant review and iterative data gathering and analysis	All data collected in one go before any analysis

In this section we have described the Glaser and Strauss controversy. It is recognised that the two approaches can suit different people better, might suit contexts or questions better, and that the analyst will have to explore and find their own style of working (Heath & Cowley, 2004; Kendall, 1999). This is not a free licence to do anything but a challenge to the analyst to be aware, reflexive and clear about the methodological choices they choose and their consequences. Here, we move further from the fine grained methodological procedure and instead put faith in the researcher's ability to do good work, be insightful, reflexive and open. Thorne (1997, p. 119) reflects on Leininger's ((1994, 1968) work which

> "effectively orients us to a kind of evaluation that extends beyond adherence to a set of external standards for methodology and toward a more grounded appreciation for the nature of the knowledge toward which the methods are applied." (Thorne, 1997, p. 119)

This appreciation must be related back to the goal of grounded theory which is unlike that of quantitative testing. For example, Schofield (1990, p. 71) writes that qualitative research should not aim to produce a set of results which another careful researcher could repeat but to produce a coherent and illuminating description consistent with the situation under study.

3.5 Practicalities of Grounded Theory

This section describes elements of grounded theory used in this project, both its theory and practice. The elements are presented in a rough sequential order but in practice the whole process is highly iterative. The elements covered are: sampling, interviews, transcribing, open coding, axial coding, selective coding, memos and diagramming, the constant comparative method, theoretical saturation, and the supporting software used.

3.5.1 Sampling

Sampling is the process of selecting data gathering points in a study. It is important to think about the sampling process of any study as it will have subsequent effects on the data and hence the conclusions. In quantitative studies one looks to test a sample of a population that is representative of that population, so that one can generalise conclusions to the wider population. The rationale for selecting a particular sample is made before the experiment and, assuming a statistical test is used, the number of participants sampled will provide sufficient statistical power to generalise from.

Qualitative studies, like grounded theory, do not rely on numbers of participants but instead selecting appropriate participants for the development of theory as it emerges. Theoretical sampling is sampling on the basis of what is needed for theory development. Theoretical sampling necessitates that data is gathered as the analysis progresses, but not all studies that purport to use grounded theory analyse and collect data concurrently; moreover, studies are often not clear whether they have adhered to this part of grounded theory or not.

In practice sampling has practical constraints, e.g. it may be hard to find participants who can participate in the study, it may be hard to organise them in a particular order, there may be an opportunity to interview at short notice, and interviewees may cancel. Another consideration in the choice of sampling which affected this project was the developing skill of the analyst. As the analyst was training in the method and interview technique it was deemed sensible to carry out data collection on less experienced practitioners before moving on to more experienced practitioners who would be harder to recruit and have less time available. This choice was supported by theoretical reasoning as it would allow more experienced practitioners exposure to more developed ideas. This fits Chamberlain, Camic and Yardley's (2004, p. 74) description of sampling as moving from convenience to ‘filling the gaps’ as experts are less convenient to recruit and have a higher potential to fill gaps in the theory due to their experience.

We have spoken about sampling in relation to participants but it can also be conceived more widely as the sampling of questions. For example, if there was an area of theory that was in need of development then questions could be sampled for this purpose. Once again this varies the intake of data according to the theory that needs to be developed.

3.5.2 Interviews

For this project data for grounded theory was collected via interviews. These interviews were transcribed verbatim which provided the raw data for the grounded theory analysis.

Britten (1995) lists three different types of interviews:

- Structured: Normally performed with a structured questionnaire, whereby the interviewer will not stray from the set questions.
- Semi-structured: There is normally a set of questions or topics to guide the focus of the interview where open ended questions are asked and probed.
- Depth: Where only one or two topics are covered in great detail and the interviewer probes heavily in response to what the interviewee says.

Semi-structured interviews were used in this project. The interviews were conducted in a naturalistic conversation style rather than a question and answer session.

Wilkinson, Joffe and Yardley (2004, p. 40) state: "Talk can be viewed as a more or less accurate expression of inner thoughts and feelings of the individual, or as a social process of creating meanings and identities which serve social functions." But they also warn that people's answers may be affected by the desire to present a coherent and positive image of themselves. In this study interviews were conducted in a relaxed naturalistic manner. This style of interview would have greater potential to realistically engage with the interviewee who might otherwise be defensive or maintain a more official stance in a question and answer session. Soft strategies to engage and build rapport with the interviewee were also used, including humour and reflecting the style of the interviewee. The threat of interviewees wishing to present a positive self-image was also counteracted by the explicit understanding that the interviews would remain anonymous. In making the case for observational research Ballinger et al. (2004, p. 102) note that people may not be able to provide a detailed explanation of what they do because it may be part of a tacit understanding. This point is accepted. However, taking an interpretivist stance we should not expect to have access to full objective descriptions of the world but instead to people's limited interpretations and world views. This is a weakness but one that can be recognised and tolerated given the approach we are taking.

The grounded theory approach informed the interviews as data gathering and analysis were entwined. As the analysis progressed questions became more focused around the emerging theory and specific gaps or areas of interest could be filled and tested. Interestingly, in practice, conversations with one participant were carried over to the next. The analyst introduced topics and probed based on the summation of the preceding interviewees. On reflection, the first interviews were quite passive in the sense that the situation was unfamiliar; however, as theory, understanding and common ground developed the analyst felt more confident creating meaning with the interviewee to be tested and explored; informed by the emerging theory and grounded in the data. This form of development reflects Chamberlain et al.'s (2004, p. 74) description of theoretical sampling which moves from convenience sampling to directed 'filling the gaps' sampling, except here we are talking about questions rather than interviewees (sampling was expanded upon above in Section 3.5.1).

3.5.3 Transcribing

The interviews were recorded and transcribed verbatim. The transcriptions were done to sufficient detail to retain the meaning of what was said. This included symbolising some significant long pauses using '…' but was not at the level of detailing sighs, and length of pauses which would be necessary for a much finer grained analysis, e.g. discourse analysis where conversation turns and strategies are analysed. Insights from the data can come in the transcription process. Chamberlain et al. (2004, p. 73) recommend that the analyst does their own transcribing but they do not go as far as to suggest making additional notes whilst transcribing which has been a technique adopted here. The analyst cannot help but begin to understand the data during the interview, whilst transcribing and in the analysis. By keeping notes of insights and points of interest as they emerge the analyst keeps track of developing ideas. Serendipitous insights and trains of thought cannot always be repeated once forgotten. This use of notes relates more to the ongoing support of memos during the analysis, although we are unaware of advice to use them during transcription in the literature. Memos are discussed further below (Section 3.5.7).

3.5.4 Open coding

After transcribing the interviews the first stage of analysis in a grounded theory study is open coding. The reason for open coding to be called 'open' is that the data is open to understanding and needs to be 'broken open' for analysis (Chamberlain et al., 2004, p. 75).

In open coding, a code is created by identifying an excerpt from the text or 'quotation' and associating it with a label. This process is repeated throughout the text. Where quotations are similar they are coded under the same code; indeed the more quotations associated with a code the more grounded it is in the data and the more support it has for its existence. Codes can overlap, and lots of codes can be applied to the same quotation. At the end of this process the text will have been split into lots of codes, many of which will highlight important themes and characteristics of what has been said in the data. These codes are the building blocks for theory; they are the first step in shaping the raw data so it can be thought about and manipulated in a more abstract way. From the complexities of the largely unshaped raw data, coding produces lots of abstract building blocks that act as pieces in the jigsaw puzzle to create the larger picture of a theory.

To stay close to the data Chamberlain et al. (2004, p. 76) make two recommendations: that the labels for codes are, or at least closely reflect, the terms used by participants; and that the open coding analysis is done line-by-line so the detail of the data is sifted through so there is less room for 'seeing' what you want from the data. In practice there are different levels that one can code at, and a level that is too fine grained can often lead to unwieldy and confusing lists of codes that are too difficult to manage. This can be alleviated by coding at a level appropriate to the analysis and the data: i.e. there may be some parts which require a word by word analysis but often a higher level will do. In developing a coding style I found it useful to code at an intermediary level. When coding was first started I attended to each part of a sentence but this generated too many unrelated codes which were hard to manage. It was thought that coding paragraphs was too high and so a line-by-line style was adopted. Coding would also get more or less detailed depending on the quality and interest in that particular part of the data, i.e. interesting sections were coded at a finer grained level. Coding also did not stop the first time through. As the analyst, I went back and reread text, recoded and managed codes which included categorising codes under larger codes and splitting codes into finer detail – but here we are pre-empting the next section on axial coding which looks at the relationships between codes.

3.5.5 Axial coding

As codes are identified through open coding, they can be related to each other, which is termed axial coding. Depending on the data different types of relations can be made between codes: some might be hierarchical in that a number of codes might fit under a more general category, or a code may actually be a category of a number of smaller codes; there may be cause and effect relationships; the codes may be related in less specific ways like ‘occurs with,’ ‘is contrary too,’ or any other relation that helps the analyst make sense of the data.

We started axial coding once there were enough codes from open coding to start managing relations that became apparent between the codes. This aided the analyst in keeping a bigger picture (Strauss & Corbin, 1998, p. 141); i.e. when the coding process was first started at a very low level the assumption was that axial coding would be dealt with after the open coding was complete; however, axial coding was needed to help organise and handle the growing number of codes that quickly became unwieldy. Here, memos and diagramming proved invaluable. By relating the codes to one another the data is given shape. Some creativity was required in this process to perceive the intrinsic relations between the codes that ‘fit’ the data. Here we intensely engaged with the data to try to make sense of its parts: different relations were built, representations drawn and ideas played with, to develop an understanding of what the data was ‘saying’.

3.5.6 Selective coding

Selective coding happens towards the end of an analysis and involves selecting a core category which will be the focus of how the theory is told. The theory essentially rests on what emerges from the data and it is not until the parts of the jigsaw are put together that a story of what the data is ‘telling’ the researcher emerges. This narrative explains the theory: it explains what is important, how these important parts are organised and what this means for the issue in question. The core category provides the central overarching concept for the theory.

It may be that there are competing categories to be the core category, in this case the analyst will need to think carefully about the best way of dealing with the data, e.g. whether one category ‘works’ better than the others, whether a coherent story can be told with two core categories, or whether the reporting can be separated to different core categories and hence have different perspectives on the same data. In Chapter 4 we recognise four categories which were found to be important for usability practitioner in website design. These categories lacked a strong message, which motivated exploration of different data treatments in Chapter 6. This concluded by expanding the existing metaphor of ‘downstream utility’ of methods. This offers a coherent narrative and a stronger central message which is weaker when there are a list of categories whose relationships are largely unspecified.

3.5.7 Memos and diagramming

The grounded theory analyst cannot help but try to make sense of the data all of the time. Memos and diagramming are tools that support the analyst in this activity.

Memos are notes to oneself which the analyst is encouraged to make throughout the analysis. Strauss and Corbin (1998, p.217) mention coding notes which are notes attached to codes that give them more detail, and theoretical notes which might elaborate on the thoughts of the analyst as the research is progressing. To this we may add interview and transcription notes which are notes made during those processes. It is important to realise that there is little prescription to how notes should be used except that they should be used extensively and flexibly to support the analyst make sense of the data.

Similarly, mini-frameworks are diagrams that give graphical representations between codes and memos (Strauss & Corbin, 1998, p.141). Through these diagrams we get a picture of how the different concepts and ideas start to relate to one another. These notes and diagrams not only help the researcher get a more holistic picture of what is happening in the short term, but provide a ‘paper trail’ of the development of the analysis in the long term, which can be important for reflective purposes (one cannot assume that they are always aware of all the moves they are making in the analysis when they are immersed in the data).

3.5.8 Constant comparative method

The constant comparative method is one of the most important features of any grounded analysis and refers to the manner in which the analyst constantly compares meanings, segments, codes and relations in the data: in different parts of a transcript, between different transcripts, and in interviews. For example, when coding one would need to refer back to previous codes to check that assigning those codes to new data remains accurate; and that codes and insights from later analyses might provoke reanalysing and checking earlier transcripts.

Although we have presented open, axial and selective coding separately, they mix in practice as new codes are created from patterns, broad codes are further coded for more detail, and broader codes are created to categorise smaller codes. To illustrate, the following is an example of a broader code emerging from a wider perspective: a "researcher might label concepts of children playing as grabbing, hiding, avoiding, and discounting" and then "realise they are strategies to avoid toy sharing" (Strauss & Corbin, 1998, p. 115). Literature and past experiences also play an intrinsic part in the analysis, as they sensitise the researcher to what may be perceived in the data. The researcher constantly analyses, codes and recodes: exploring the data, developing insights and grounding them in data. It is the rigour of this analysis that maintains the standards of a grounded theory analysis – with the constant grounding of ideas in data.

3.5.9 Theoretical Saturation

Theoretical saturation is the stage where the theory has been developed and tested to satisfaction by the analyst. As the analysis develops, the theory will get more mature in conceptual depth and structure. Through the constant comparative method confidence in the theory will increase through comparing and testing the theory with new and old cases. When the stage is reached where further testing seems unfruitful, because the theory adequately describes the situation, then we have reached the point of theoretical saturation. This point is in part subjective as analysts will stop developing at different depths of analysis (from themes and hierarchies to rich explanatory accounts) and at different levels of focus (from looking at particular concepts to describing contexts).

3.5.10 Supporting software

Atlas.ti was used to support the grounded theory analysis. The power of the tool was realised in the management of data: coding quotations, retrieving quotations, linking codes, writing memos, diagramming with network diagrams, and keeping track of when memos were written. Atlas.ti helped the analyst in performing the grounded theory by making the administrative side of grounded theory easier.

3.6 Conclusion

This chapter sets the scene for the methodological approach of the thesis. We have seen that different styles of research question warrant different approaches and that this work takes a pragmatic view but errs on the side of interpretivism and constructivism as we are aiming to investigate practitioners' views of their worlds. This has direct implications on the methods used. Grounded theory was selected from the qualitative tradition, which builds theory through constant and close interaction with empirical data. The various elements of the grounded theory process were explained, and detail was given about how it was performed in this work.

Part II

Bottom-up: Listening to the data

This part accounts for the Grounded Theory (GT) analyses from the data from a bottom-up perspective. Here we apply GT to website and safety domains, and explore different treatments and representations for the data. We see that a system perspective of HF/usability practice is needed to explain the opportunities and barriers for method uptake in industry. The treatments of the qualitative analyses are developed, which culminates in rhetoric about understanding the downstream, upstream and the landscape of usability projects. These stand for the downstream influence of the method, how they are affected by things upstream in the project, and the contextual landscape through which the project flows. It is argued that method adoption and adaptation can be understood within this.

Chapter 4: Grounded theory of HCI practice in the website domain

This chapter is based on a paper I wrote under the guidance of my supervisors: (Furniss, Blandford, & Curzon, 2008).

4.1 Introduction

This chapter develops a descriptive theory of how usability practitioners work in professional web design. It does so through interviewing practitioners and using the grounded theory method described in Chapter 3. The description reported here refers to the wider influence of the commercial context on usability work. This brings to the fore such issues as: the client's influence on work, negotiation between clients and practitioners, the adaptation and use of methods, practitioner expertise and the consideration of 'people' in the usability process. We believe that this research focus, which moves towards wider issues in practice, is best conceptualised from a system level perspective where the goal is to coordinate resources to add value to the design process.

4.2 Method

A grounded theory approach was undertaken to explore the data, details of which can be found in Chapter 3. More specific information of what was involved in the study is summarised in the following three tables: Table 4.1 describes detail of the grounded analysis; Table 4.2 describes the semi-structured interview topics; and Table 4.3 outlines the interviewee profiles. Table 4.3 shows the three sorts of organisations that were sampled: full service agencies that are involved in the full design of websites for external clients, from analysis to implementation; usability consultancies that specialise in usability work and provide services to external clients; and in-house services that work internally within a wider organisation, e.g. a large department store.

Table 4.1: Details of the grounded analysis.

Section	Detail			
Number of:	Coders	Interviews	Codes	Quotations
	1	8*	77	1508
Literature involvement	Literature was reviewed to inform the analyst's understanding and help focus the interviews before they were performed. It was also used to inform and crystallise insights as the analysis developed (Strauss & Corbin, 1998, p. 96).			
Theoretical sampling	Interviewees were chosen for their industrial experience. As the analysis matured interviewees with more experience were involved. This was done for practical and theoretical reasons: people with less experience were easier to access, and senior practitioners were involved when the analysis and questions were more mature. Interviewee profiles can be found in Table 4.3.			
Interviewing procedure	The interviews were semi-structured and about an hour long each. Guiding topics can be found in Table 4.2. Topics were probed in an opportunistic fashion. Interviews were left days or weeks apart so analysis could be conducted between them; this informed the questions of the subsequent interviews.			
Coding procedure and style	Each interview was transcribed and coded. Analysis took place between each interview. After the fourth interview the transcriptions were re-coded to reduce the coding scheme, thereby making it more focused. The coding style of the analysis was loose in that codes sometimes overlapped during open coding. Selective and axial coding was developed through mini-frameworks and through memos, including coding notes and theoretical notes (Strauss & Corbin, 1998, p. 141 & 217).			
Tools	Atlas.ti was used to support the analysis.			
Reporting style	The reporting style adopted here aims to be story-like to convey the richness of the data. Also, since the interviews were opportunistic and the coding style loose, it makes less sense to report the individual codes and numbers of quotations of each participant. The aim is to convey the understanding that the analyst has developed.			
Validation	There are a number of possible levels of validation when doing a grounded analysis, e.g.: 1) Testing through data collection and analysis; 2) Verification by interviewees; 3) Verification by a wider population; and 4) Triangulation with other methods/studies. This study went to level one and two. In level two a report was sent to all the interviewees. 7 of the 8 interviewees verified that their quotations were accurately used; the other was not contactable.			

Table 4.2: Semi-structured interview topics.

Topic	Description
Background	Background of the person being interviewed. This aims to introduce the interviewee slowly and find out about their experience and perspective.
Work Organisation	This includes how work is organised, the structure of the organisation, whether there are teams, project lifecycle involvement, and what job challenges are faced.
Business: Client Relationships	This includes communicating with clients, both in attracting clients and handing work off to them. For example, how do practitioners communicate effectively and what challenges do they face?
Practitioner skills	What do practitioners do, why are some better than others and how do they get better in their role? This could give an indication about what is important in their work.
Tools and techniques	What methods are used, how are they used, when are they used, what is valued in a good technique?

* A ninth interviewee from this domain was interviewed opportunistically, but their data was too late to be included for the analysis in this chapter. Their data was supportive of the emergent themes reported in this chapter. This data is integrated from Chapter 7 onwards.

Table 4.3: Interviewees' profiles.

Participant code	Spread of Experience in years			Position at the time of study
	Full Service Agency	Usability Consultancy	In-house	
W1	1			In academia.
W2	2		1	In academia but freelances.
W3			1	In-house practitioner for ecommerce site.
W4	1	1		Information architect for full service agency.
W5	2+			Manager and practitioner at a full service agency.
W6	5+		1	In-house practitioner for ecommerce site.
W7	5+			Manager and practitioner at a full service agency.
W8		5+		Manager and practitioner at an independent usability consultancy.

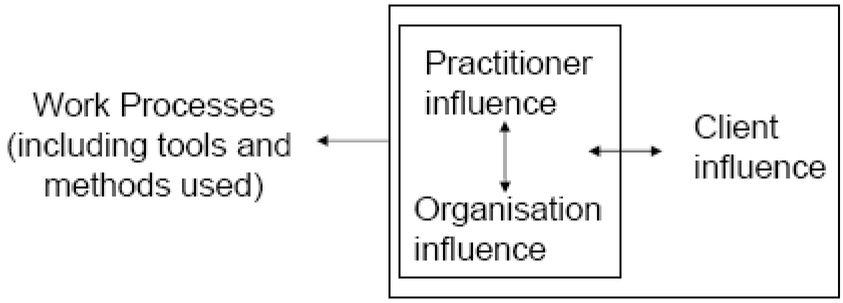
4.3 Introduction to Analysis

The analysis has been divided into two interdependent segments. Section 4.4 describes spheres of influence that affect usability work and processes. Here, we move closer to appreciating the influence of the client on work processes, tools and methods that are used in practice. Section 4.5 describes the complexity of design and business processes where we move closer to appreciating the role and integration of a 'usability component' within this context.

4.4 Spheres of influence: The Make-up of the Work Context

Usability research has focused on understanding and developing methods which form part of usability work. However, to understand this in practice we need a better measure of how the working context affects usability work. It was not surprising to find that the practitioners' decisions and behaviours are influenced by the organisation they work in; however, the data also showed a large influence of the clients' wishes. Figure 4.1 shows a representation of the influences on the resultant work processes in practice: the bi-directional arrow signifies the mutually dependent relationship of the practitioner and the organisation they work in; the larger box signifies the client's influence on the work they do. There is a bi-directional arrow between the client and the practitioner/organisation as it is the job of the usability practitioner to offer options of work and guide the client's decision.

Figure 4.1: Influences on work processes.



The client's influence is most powerfully shown when there is a tension between what the usability practitioner wishes, in terms of either the work undertaken or the recommendations for the design, and what the client wants to do. The quotation, below, between interviewer (I) and respondent (R), illustrates some frustration in that an ideal usability path has to be compromised by real business objectives:

The quotations reported here have the following notation: '…' signifies pauses in speech; and '[…]' signifies where text has been omitted or replaced for clarity, brevity and anonymity. The participant code is included at the end of the quotation. They are all 'W' codes as they are all from the website domain.

> "I: It must be interesting from the client side
>
> R: Yeah it's interesting, I work with [co-worker], who has done projects, who will come in with a view that I agree with, that it should be like this... and it's like we can't actually do that, unfortunately, I know that, you know that, but it's just not the way... you do have to have give and take in the experience
>
> I: Can it be frustrating?
>
> R: Yes, very much so... I mean it's a fine balance, it is a fine balance but it's definitely frustrating" W6

This situation brings negotiation skills with the client to the fore as both groups try to come to a common understanding about what balance is best for the business and for the user; and it is believed that this balance will increase the potential for market success:

> "one of the realities for commercial usability is that products that survive for a long time in a market place have to fulfil both the customers' needs and the business's needs, and somebody coming fresh to a usability project, especially if they haven't dealt with the realities of the market place very much, may make suggestions for ways to change an interface that would purely be in the users interest… from the user's point of view, but might undermine the business case for a product." W8

Even though there is interest in using more methods from a practitioner's perspective clients will not pay for something they do not understand to be either valuable or feasible under their constraints. It is part of the role of the client-facing usability practitioner to understand the client's needs and constraints, and work out a unit or units of work that will be most appealing and effective for the clients' particular situation.

> "Yeah the biggest thing really …was …the areas that we could sell in, and because it was more of an add on it was kind of difficult to do some ethnographic research or anything like that, which would be great, and we did try and push a couple of times, for that type of methodology but …it was just not feasible for our clients ... It meant that we were limited in the methodologies that we were going to use we just had to focus on two or three key points of the project that we could actually get involved in actually making a difference.
>
> I: So you're looking at where you could have the biggest effect?
>
> R: Exactly, so it's obviously getting involved as early as we possibly could, and try and making a difference before everything's got too far down the road otherwise you put recommendations in that are not achievable within their timescales" W6

This negotiation between the client and the practitioner can be conceived as designing a work project, which will depend on the details and constraints of the particular context in question.

> "There's not only ideal research conditions there's realities for times, budget …, and sometimes those things play off against themselves and when you design a research project you've got to think of the options, if we do this that lowers the cost, the effect might be a certain lack of robustness in this particular area …, or if you're having trouble getting users of this variety we could use this parallel group of users and change the methodology in such and such a way." W8

The spheres of influence illustrate that the work processes that are actually carried out in practice are not the choice of any one person, but are often a negotiation between different groups that have different values and perspectives. The skilled practitioner will be able to perceive how they can be of best use to a client in their terms, so the client can more easily see the potential gain in value and how usability can be easily integrated with their own processes.

The choices that are made at the project negotiation stage will impact on the type of work, the quality of work and the individuals tasked with carrying it out. Organisational culture can either attract or repel good usability practitioners:

> "…I love [company A]... they have a really good process in place, they don't undersell projects, what I mean by that is that they don't tell clients we can do this in 3 weeks when it's really gonna take 6. It's very very rare to do too much overtime, I mean you'll have an occasional evening where it's like damn I didn't get enough done today and stay a couple of hours late...
>
> I: And I s'pose it comes to down to [company A's] culture if you like their values and what they're going to do and what they're not
>
> R: Yeah absolutely... because at [company B] it was all about getting the most money for the shortest amount of time… It was really unfortunate it was one of the many reasons I chose to leave cos it was just a ridiculous culture, a ridiculous way of thinking." W2

This is an extreme instance of the effect of the organisation on the individual but there is a clear interdependence between the two where the individuals create the organisation and the organisation influences and impacts on the individuals. Different types of organisation will attract different sorts of people. The type of work will influence the frequency that individuals use different methods and encounter different situations. The different skills and experiences that will be employed on a daily basis will impact on how the individual develops:

> "one of the things that I would have liked to have done as well is to work for a pure usability consultancy, because obviously now I've done client side and I've done agency side in a large organization but I think the specialism for working in a pure usability consultancy would have been good as well, to see more different aspects" W6

Table 4.4 includes some trends that were observed in the data between different types of usability practice; it should be noted that these differences are in the degree to which these characteristics apply; i.e. all the characteristics apply to the different usability practice contexts to some degree.

Table 4.4: Differences in usability practice contexts.

Usability Practice Context	Description
Full Service Agency	More involved in the design side of usability, e.g. information architecture. Less onus on documenting evaluations, i.e. usability is more integral to planning designs than a stand alone evaluative piece of work.
Usability Consultancy	Deeper specialisation in evaluation, with the opportunity to encounter many different types of interface and a greater opportunity to apply methods. A great bank of usability knowledge and expertise.
In-house Usability Work	There is a greater degree of ownership of the interface and the risks associated with changing aspects of it. Deep understanding of the interface as well as business, political and technical issues associated with it.

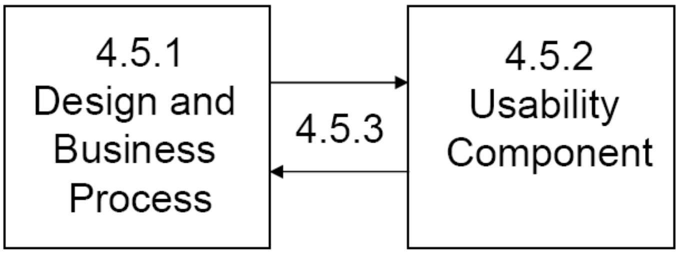
4.5 Design and the Business Process

Design and business processes often transcend the expertise and work of any one person and so we need to appreciate how these parts fit together as it will impact on the role and work of usability practitioners. Many people contribute to a design and business process and must be coordinated to work together effectively. There is a recognition that the people in these component parts will have a certain understanding and will want different things:

> "it's a very collaborative world, you end up being almost a negotiating power between different groups in a company, if you're doing consultancy then you may be the negotiating power between what you know can be done and the client, and the client's desires, or if you're working internally for a company then you end up negotiating between I guess the designers, the artists, the technology people, the business people who want the product to do a certain thing or look a certain way." W2

In appreciating that there are many component parts that make up the design and business process, the successful role and integration of a 'usability component' comes to the fore in usability work: what the usability component does and how it integrates with the rest of the process. The design and business process will vary from company to company but is likely to involve many different parts that link and integrate in different ways, including: graphic designers, interaction designers, developers, middle management, senior management, marketing, accounts, customer service, and project managers. This situation is made more complex when we think about the personalities and relationships at a more individual level as people come together for work. The usability component could fit in with a combination of these parts in practice. Figure 4.2 has bundled up this complexity to the relationship between usability work and the wider design and business processes. The three features of this diagram are discussed further below: in Section 4.5.1 we discuss the design and business process; in Section 4.5.2 we address the usability component; and in Section 4.5.3 we discuss the information flow processes that connect the two.

Figure 4.2: Usability interfacing with design and business process.



4.5.1 Design and Business Process (left-hand box in Fig. 4.2)

The influence of the client on establishing what usability work is carried out has been discussed as an important sphere of influence in Section 4.4; this section expands on how clients differ in ways which affect the work undertaken.

Clients are by no means a homogenous group. Participants reported that their clients differ in why they seek usability services. The majority recognized an underlying motive of revenue generation but upon questioning interviewees about why clients seek usability services other reasons were also noted:

- They may believe that usability input will directly increase revenue, e.g. e-commerce.
- They may believe usability input can save them money, e.g. reduced call centre work.

- They may want to improve communication with people, e.g. Government or advertising.
- They may want to make services more accessible, e.g. Government.
- They may want to comply with legislation, e.g. Disability Discrimination Act.
- They may be interested in the steady evolution of their product lines.
- They may just want to provide a better service.
- They may just have heard of usability and think it is a cool thing.

These reasons are not independent, so a client may have several of these goals. Clients may also not know what they want or what they might be able to achieve with the help of usability input. It is the job of the skilled practitioner to understand the clients' needs and translate them into a project that will suit:

> "…well the unspoken assumption behind that question is that all the clients know why they have come to us, and they don't. Sometimes the biggest portion of our job is to work with them to figure that out." W8

It would also be wrong to assume that clients in a particular context agree:

> "I only had contact with the middle management team for a while, and they loved the work, they absolutely loved the work, presented it back and they were ecstatic, then they arranged for me to meet the director who was going to make the final decision and he hated it, hated the whole lot, he just said it doesn't meet our business objectives at all and I think he might have had a point. Because the remit I was given was to come up with the best user experience proposition and nothing else, if I had been thinking about the business proposition in that project then I might have taken more his point of view." W5

This demonstrates that the negotiation stage of a project is vital for a project's success; truly understanding the client's real needs cannot be underestimated as a misunderstanding can lead to failure. Once again the need to balance between user experience and business interests are demonstrated. The task to understand a client is an important one at the start of any client-consultant relationship, and is easier if the consultant already knows the client:

> "... generally work with the same clients over and over... occasionally you get a new client, what you want to do as a new business is work with a client over and over because it's cheaper to do it, you've got a reliable relationship, you know their needs but also you build more links within an organisation rather than starting all over again." W5

Also clients are dynamic in that they evolve and educate themselves over time, so the beginning of a client relationship might start with a small piece of work that will lead to more work further on:

> "…a client might approach a company because they've got an issue, and because an expert evaluation is a lot cheaper than a redesign or a usability test, they'll often say well look at the site we'll pay for an expert evaluation, and that's a good way of not only meeting their initial requirements but also building the relationship and taking the next step on." W4

This not only impacts on the relationship between the company and client, and the personal working relationships between people, but the client will also start to educate themselves about the content and the value of usability, and how it can be used:

> "R: There's an education process definitely…, I remember 4 or 5 years ago at [company D] trying to explain just the very basics, why you should do usability testing at all during the process never mind the different techniques or anything…
>
> I: Do you think that's changed now?
>
> R: Yes, but... even quite recently I remember … clients getting confused,.... it's a lot better, it got to a point at [company D] where clients were actually coming in and saying we want testing at this point, this point, this point...." W6

This indicates that clients undergo a process of education whereby they may start off slowly introducing themselves to usability practice but then gain more control and confidence in how they can utilise usability research for their own endeavours. In the long term this gradual take-up and appreciation of usability services might not only be within certain consultancies and clients at a micro-level, but an industry movement on a macro-level. In trying to probe for how practitioners measured the quality of their work many were satisfied and confident with the fact that they were receiving recommendations and repeat business: the burden of proof for return of investment is not always at the crux of securing usability work and does not always lie with the practitioner. Observations suggest that this applies differently to successful usability companies that are regularly approached to do work, rather than being in the position of trying to convince a prospective client that the work is worthwhile – the relationship changes.

4.5.2 Usability Component (right-hand box in Fig. 4.2)

There are three recognisable elements of usability work: 1) attracting work; 2) doing work; and 3) communicating work. These three elements are interdependent and will be influenced by the skill and experience of the practitioner, their company, and the clients' circumstances. We have discussed the influence of the context of work above and now move on to the expertise, skills and methods of usability practitioners. Two important techniques emerged and will be focused on here: user testing and Heuristic Evaluation.

Practitioners reported using a variety of different methods but they differed in their use, their name and the contexts in which they were used. These techniques were adapted and combined to achieve the goals of their usability research in an efficient and effective manner. These characteristics contribute to an environment that is focused on cost effective results rather than method worship, an environment that focuses more on the skills of practitioners in coordinating resources to achieve results which leads us away from scientific validity and into what is termed below as commercial and design validity:

> "I don't have wide experience of academics teaching this stuff, but the ones that I have seen teach it don't have any experience of industry, don't have any experience of the turn around times that are required, don't have experience of what commercial organisations and government organisations really need when you're developing a website, they still tend to be quite statistically focused, they still tend to be, as you say, be quiet, don't speak to the person don't bias it, it's got to be scientific validity. We don't give a damn about scientific validity, we give a damn about commercial and design validity" W5

This difference in culture can almost be viewed as a conflict between the rigour and detail of academic work and the pragmatics of getting work done in a timely, cost effective manner in practice:

> "between all the really, really minute research that we do in academia, in fact most practitioners don't give a damn, they're not going to care if Malay don't like pink, if they're dealing with a Malay client then the Malay client will tell them that in 3 seconds, they don't need four months of research to tell them that. It is really interesting but I think having experienced both I think what we do here in academia does influence them to some extent as it does percolate up, it's not like they're in a vacuum they know who Nielsen and Norman are and they know other researchers out there" W2

Relationships between academia and practice are complex. The attitudes above reflect that there is a difference in the values and activities of academic research and practice. Further work needs to be done to establish what this relationship is, what the status of knowledge is in both camps and how one informs the other. One clear similarity between academic research and practice is that they are both seeking to find right answers through research; however, research methods, values, constraints, goals and interests can differ.

User testing is a common method used in academia and industry; a comparison between the uses of the method in these different contexts provides a way of probing the nature of its use by juxtaposition. One difference is the way that practitioners can be proactive in eliciting user views about particular aspects of the interface:

> "the other thing about the way that we do usability testing in academia is much different than in the corporate world, because you will point blank in the corporate world ask the user "what do you think will fit under this piece of navigation?" and then click on it "is this what you expected to see?" Whereas you probably wouldn't do that in academia because you're leading a user down a path which you probably would avoid in academia, but here you're purposely leading the user down a path… it's just a different... It's more about validating the way that you have organised something …, I'm specifically trying to find my mistakes, or specifically trying to get them to use something that I hope will be used. As opposed to academia where I would not want to influence the user at all and see what they would make out of the product." W2

Other samples of the data suggest that these strategies of sitting back or engaging with the participant in the user test depend on what the circumstances and objectives of the test are:

> "Sitting back and not saying something sometimes has its place, so if we're looking at a detailed purchase process and the person's got to go through certain steps and fill in certain forms and stuff like that sit back and say nothing; but if we're looking at a wider marketing proposition sitting back and saying nothing isn't going to get you what you need, you've got to engage with people." W5

Other differences in the administration of user tests include performing interviews and questionnaires before or after the test to elicit information that might be pertinent to the research goals of that project. Another commonly reported technique which differs in its administration is Heuristic Evaluation. However, the variety of ways in which this method is performed leads us to question what actually qualifies as method use. One example of heuristic use is in an ad hoc manner to add weight behind justifying recommendations:

> "Almost in a very ad hoc manner, you came up with your wire frame, people ask you why you did that, maybe you had reason, if you don't then look up the heuristics and try to justify it afterwards" W1

The ad hoc use of heuristics for justification purposes appears to add some structure and common ground for the client to relate the issues to, as well as a link with accessible theory:

> "going back to heuristics... it's more on the client education, so if you identified an issue we'd probably list a heuristic that it would apply to, so the client would go OK, and maybe it helps with some credibility as far as they are concerned cos they go like 'ah, that's one of the main issues and I can see how that applies'." W6

Other people reported using them implicitly as part of their expertise as they had assimilated them through education and practice:

> "especially when you do a competitor analysis because you have those heuristics in the back of your head because someone on some masters course pounded them into you, tested you, examined you on them, so yeah you do of course. So you're evaluating other websites which are book stores and in the back of your mind … those are hopefully playing." W2

It was also reported that heuristics were adapted to go beyond what were commonly referred to as 'Nielsen's ten heuristics' and were sometimes used in a more rigid manner to perform a competitor analysis to approach clients in the hope of generating work. The more rigid use of heuristics was criticised for being too negative and sometimes detached from the context of use which a cognitive walkthrough would not be. Where heuristics were used in a more implicit manner the method appeared to resemble more of an expert evaluation in its description, whereby the labels are even used interchangeably (terminology issues are expanded in 4.5.3):

> "Actually, I think that when I do a heuristic review I do it on much wider stuff, … I know about perception and mental representation and I've also looked at models of mental representation as applied to interface design… so actually when I'm doing an expert review I'm referring to all that kind of applied theoretical knowledge that I've developed over ten years, and I think a lot of that has become extremely implicit in the way that I apply that stuff nowadays as well, I don't actually know that I am applying it even though I am." W5

This implicit expertise is developed through years of practice:

> "Yeah, seven years of practice, it's like anything else it's not that a new doctor just having graduated from medical school has any necessarily less knowledge or the ability to have as much knowledge as someone who's been working in the field for ten years, and it's just that the doctor working in the field has seen the cold for ten years and can probably diagnose a cold within three seconds of seeing the patient.... it's just repetition, repetition, repetition and it just builds up." W2

Also:

> "Once you've been a consultant for two years you may have worked on three or four retail sites, three or four services sites, and if you keep on websites you will encounter the same problems, like what does the contact page look like, so you are repeating, applying the same knowledge to a version of the same sort of thing" W3

People's perceptions and thinking change through experience and so emphasis should be placed on this dynamic:

> "a lot of your thinking is pre-done, you've automated that thinking in some sense because you've seen these types of patterns before and you can just go yeah I can see that" W5

This idea that some thinking has been 'pre-done' because similar patterns have been encountered in the past appears to build up a knowledge bank of cases – where similar problems have been encountered and what interface widgets work well and where. In this particular case it appears that practitioners build up a library of interface widgets through which they can apply analogical reasoning so they can bring insights from one interface style across to another, e.g. from the Amazon site to a newspaper site:

> "I: Do you feel like there's particular widgets or features that you would expect on certain sites that you would get asked to design... so...
>
> R: yeah... send to a friend and that sort of thing... yeah there are definitely …features that people have picked up along the way that I would say would be an expectation on certain sites
>
> I: Such as..
>
> R: well things like send to a friend facility on certain pages you'd tend to have... that thing like… on Amazon where they say 'people who looked at this looked at that', so... I think there would be an expectation to applying that even to say a newspaper site, where you know people who thought that article was interesting, you might think this article was interesting... yeah... you're not looking for a list of what they are…

I: No... as I've been going through the study it's become more apparent to me that when you're a usability expert you're so familiar with what works and the best practice that's out on the web, then you build up a

R: A library of things... yeah definitely... and they're actually books on that they're not called library they're called patterns." W7

These implicit pools of knowledge are sometimes realised in tangible artefacts as companies develop and share resources with their staff either through their ongoing work or through specific efforts to establish a bank of expertise to use as a company resource:

"usability consultancies have a lot of experience at applying this knowledge and they actually have slides that are prepared about information scent and whatever … they spend …time gathering all this research that's been done by … researchers and say OK they work for three or four retail sites and they basically apply the same principles to each site" W3

The effective use of specialist information is a strong competitive advantage in carrying out projects as it provides a bank of knowledge as a starting position for a more concentrated effort on the next piece of work. This collective pooling of knowledge transcends individual practitioners in some sense and leads to the development of a company's expertise.

4.5.3 Information Flow Processes (the arrows in Fig. 4.2)

As has been discussed in Section 4.5.1 the design and business process resembles a complex system because many different component parts interact, which need to integrate with the usability component (Section 4.5.2). This integration depends a lot on the experience and expertise of the skilled practitioner seeing opportunities for input, and negotiating work and recommendations on, and in, the client's terms. This section expands on how the design and business process and usability component integrate, which includes themes that have been alluded to elsewhere.

The use of terminology in usability is not straightforward both in terms of job titles and roles, and in terms of the labels used for methods. Recognising people have their own definitions, some practitioners employ a pragmatic solution:

"personally I don't like definitions of usability at all, I think they're quite self-indulgent academic exercises and everyone that works in this field has their own opinion on what usability is, user experience is, information architecture is… talk to someone you can't nail them down, so actually as a very pragmatic user experience specialist or usability specialist you use the meaning that the person uses themselves, you know just be pragmatic about it." W5

This lays the basic foundation for negotiating with clients which appears to be one of the major enterprises of coming to agreement with people with different backgrounds and values:

> "I really believe that one of the most important skills in HCI is the sort of negotiating between other people and between what's there and what needs to be there and trying to build that pathway in a way that's, it doesn't have to be aggressive or mean to people you just have to explain like 'look I know that this kind a worked for you guys before but maybe we should try this out, let's put it in front of users, let's see if they like it.' I think that this helps clients a lot. Because they've actually hired you to try and help, but not tell them that they're all wrong all of the time." W2

The idea of stopping at the stage of identifying problems for clients seems poor practice, and many practitioners are conscious that how they communicate their findings and results will have an impact on whether the client receives them well in the short term, and whether the client seeks further usability input in the future, both of which have a significant effect on how usability is dealt with in industry:

> "we also include positive findings from our study, there are a couple of reasons for that, …we …treat our clients like human beings … people often work months or years on a product and I know how dispiriting it is to have someone to come along and evaluate it and only point out the parts that aren't working well… if they don't have a picture of what is working well the temptation would be to fix a small problem by breaking a large positive, so you can actually make a problem worse by trying to fix tiny little niggly bits at the edge when the core of the product is working extremely well. We always try and give an overall picture of how a product is" W8

This appreciation of clients and colleagues as people is a theme that pervades successful negotiation whether that is external or internal:

> "I: […] do you use personas at all?
>
> R: I have got some…, I don't stick them out in front of developers as that would be quite condescending I think, people have quite a good sense of the typical [company C] customer in their head around the office and I don't want to be condescending to them." W3

Getting people on the side of usability and listening to the issues and recommendations that it raises is undoubtedly important. Therefore the communication of usability work seems to be a critical step; however, this varies by client and circumstance. For example, some practitioners thought that large Word documents were too cumbersome but others saw instances where they would be useful:

> "R: Again it can vary from client to client, I've worked on one where it was a presentation, it was a round of usability testing… others where it is more of a forty page document that says this testing took place, this happened, this happened, this happened.... it depends on what the client's after. If they want to use it for politics within the company then obviously a report or something like that is much more tangible and is more useful than having a presentation or something like that, but if it's purely to communicate to senior people and what have you, where a report might not be necessary, a presentation or something like...

> I: And I s'pose you might mix them up and do both
>
> R: Yeah I mean... a report and then a presentation looking at the main points, because most senior people won't read a big fat report so it's a case of communicating to the people as quickly as possible, the higher people
>
> I: Do you have any thoughts about how effective these different things are?
>
> R: Personally I think a face to face is very important otherwise it can become a bit detached - and certainly things like usability testing, I think that it is always good when the client comes to see some of it…" W4

Variations of reporting include presentations, PowerPoint files, Word files, video clips, quotations from users, giving recommendations and positive feedback, and organising the issues in some way, e.g. by priority. Two of the most important concerns appear to be to convey the meaning of the issues to the client and getting them to appreciate the issues. The idea of 'detachment' referred to in the quotation above draws us to a dimension of 'closeness' in terms of communication. Practitioners understand the advantages of close, high-bandwidth, communication as seeing a usability test with your own eyes holds more significance than a document reporting its findings:

> "… when you go through a usability process and you suddenly see what it is actually like in the real world for your product to be used, it's such a compelling event that people learn from it." W8

The idea of learning is also an important one. If we think about usability work and reporting, not as a discrete interval in a design process, but as part of people's ongoing experience, we realise that it has important side effects: from doing the work practitioners learn about the usability of a product and the clients' reaction to the work; and clients learn more about what usability work is about and how the information provided by this type of research can help them achieve their goals. Both groups can reflect on their experience and adapt their behaviour accordingly. The idea of clients educating themselves was also discussed in Section 4.5.1. Informing others about usability issues and practices so they can understand and appreciate them themselves appears to pay dividends in people's normal routines. Participant W3 demonstrates this in talking about her colleagues below:

> "Yeah... they're actually quite user centred as a group… 90% of the time they come up with something which is good, which is nice. I'm kind of coming to the conclusion that if you give all your developers and graphic designers a certain education in usability they inherently include it in their work" W3

4.6 Discussion

This section discusses insights from the analysis under four subsections: Section 4.6.1 discusses methods and processes; Section 4.6.2 addresses relationships; Section 4.6.3

discusses communication and coordination; and Section 4.6.4 refers to psychology and expertise in practice.

4.6.1 Methods and Processes

The analysis has shown that usability work is heavily influenced by the clients' needs. This commercial focus puts emphasis on effective and pragmatic choices that will deliver results to agreed time and budget scales. This is reflected in Wixon and Wilson's (1997) move away from science to "the art of the possible under constrained resources" in usability practice; and Cockton's (2004) claim that HCI should be more about delivering value than finding the truth. This is perhaps what one participant meant when distinguishing scientific validity from commercial and design validity.
To achieve this value transfer we have seen that the 'usability component' must be flexible to fit in to projects where it can, to suit time-scales, budgets, and research needs. It is proposed here that an adaptable usability component can be considered a 'plug and play' technology. Here, the skilled practitioner plays a critical role in seeing how methods and processes can be adapted, designing projects that will meet the clients' needs, and fitting the organisational context. The fact that method and process choices will be influenced by organisational issues is discussed further by Grudin and Markus (1997).

Methods are combined and adapted to suit the research goals of the project. Wixon and Wilson (1997) observe that user tests can vary in their degree of formality, but elaborate less on informal solution-focused testing which forms part of what has been observed here. Nørgaard and Hornbæk (2006) elaborate further on the details of think-aloud testing in practice, including the influence of practical realities, and the use of different probing practices which goes beyond the more formal prescriptions in the literature. More work of this nature is encouraged in different design contexts and in observing different methods. For example, as observed here, Heuristic Evaluation appears to be used in a wide variety of ways, e.g. ad hoc justification of decisions, to aid communication with clients, implicitly in evaluation (like an expert review), and as a basis for competitor comparisons; so a more focused study on how this is perceived and used in practice would prove enlightening.

4.6.2 Relationships

Clients are not a homogenous group. They ought to be addressed according to their particular circumstances. Indeed, we begin to get a more realistic picture of usability in practice when we move away from considering method use by rote, and discrete input into specific design processes, and move more towards considering the people in the process: that develop expertise, that learn from their ongoing experiences, that have different backgrounds and understanding, that react emotionally to criticism and praise, and that make intelligent decisions to achieve the results they do in a commercial setting.

Dumas (Redish et al., 2002) believes the most important factor in responding to usability recommendations in the long term is the relationship between the usability specialist and developers. Our data has also emphasised the importance of relationships: in knowing the company, people, politics and practices that you are working with. Relationships can start with a small study before moving on to larger investment in usability services as the client becomes more familiar with usability services and more confident in their provider. Practitioners also make efforts to foster working relationships by including positive findings in reports, in not being condescending to colleagues, in having high-bandwidth communication with clients and encouraging them to watch user testing.

In academia we may debate the merits of a value-centred approach for HCI (Cockton, 2004), but in practice it appears a matter of economic survival, and one that is intimately related with the working relationships people and companies have with each other.

4.6.3 Communication and Coordination

It is paramount that the 'usability component' fits well with different design and business processes. It is the job of the skilled practitioner to provide a suitable interface with non-usability specialists and to design a work package that will suit that particular business need. Like other design processes, designing a suitable project for a client is dependent on their particular situation, which will influence what is done, when, and how the work is reported back. It may be the case that usability input is a more ongoing collaborative effort and so an official reporting back stage is not suitable. How usability results are delivered is an important area of practice which impacts on changes to the design in the short term and the perception of usability in the longer term.

Research on usability reporting includes: Molich (Redish et al., 2002) who comment on usability reporting problems from an empirical study (e.g. reports that are too long, have no summary, and no positive findings) and suggests an approach that encourages buy-in on the developers' side and the faster communication of results; and Dumas et al. (2004) report on a similar study that makes recommendations for usability reporting under four main themes: emphasise the positive, express your annoyance tactfully, avoid usability jargon and be as specific as you can. In this grounded analysis stopping at problem identification was recognised as bad practice, which is supported by the empirical work of Hornbæk and Frøkjær (2005) who suggest that reporting problems with redesign proposals can have a higher utility for developers. More novel in this chapter was the conveying of the 'bigger picture' that was mentioned in our analysis, so the team can make informed decisions and not make a bigger mistake by trying to fix a smaller problem. It appears that closer high-bandwidth communication between evaluators and designers has greater potential to avoid this problem. The issue of the 'bigger picture' relates well to Klein's (1998, p. 225) discussion on communicating intent so team members can make more informed decisions. Further research could look at this more closely; for example, developing a protocol based on Weick's (1983, cited in Klein, 1998, p. 228) streamlined version of a commander's intent:

- Here's what I think we face.
- Here's what I think we should do.
- Here's why.
- Here's what we should keep an eye on.
- Now, talk to me.

Entwined with communication is coordination, i.e. how information transfers between component parts. For example, group size has already been observed to play a role in communication (e.g. Rosson et al. 1988; and Grudin & Markus, 1997). Where usability practitioners are closer to the designers and developers they have richer high-bandwidth contact which can avoid problems that a detached usability report may run into. How the usability component is organised to integrate with the wider business and design processes will influence the work and reporting mechanisms that are used.

4.6.4 Psychology and Expertise

Where work appears to be varied and complex the skills of the individual practitioner come to the fore. They adapt methods to provide commercially viable solutions targeted toward the current design setting. The skilled practitioner can perceive, through their experience, what working arrangements might be best for the client and what recommendations are most likely to influence the design in a positive way. Here we move away from questions such as 'what is the best method?' to trying to understand how practitioners work, how they gain understanding and insight into the products and people they work with, and how they add value in the commercial context. Klein's (1998) work moves in a similar direction by valuing the expertise of the practitioner over structured methods which are seen to support novices more. He believes that the development of expertise leads to a change in the perceptual ability of the expert. Future research could look toward the psychology of the usability practitioner: particularly how they perceive design situations. The perception of design situations includes the higher level of how a usability project should be composed, and the lower granularity of what problems and potentials lie within particular interfaces or technologies. Considering practitioners in more detail might lead to supporting novices and experts differently.

Practitioners develop expertise as they experience more and more in practice. Like experts in other domains they appear to build up a bank of knowledge that is sometimes used implicitly and perceived as patterns: e.g. expert chess players chunk patterns of pieces (Chase & Simon, 1973). This can take the form of being familiar with common usability problems and solutions within a certain domain, and building up a catalogue of interface widgets that form the basis for analogical reasoning between cases (Klein (1998) talks about analogical reasoning at length). This analogical reasoning may influence design recommendations and evaluative judgements about the state of the art and best practice. If this form of reasoning is shown to play a significant role, as we suggest, informal methods for developing these internal patterns or schemas could be developed. Related work includes that of Hammond et al. (1983) who studied elements of decision making by designers (i.e. their perception of the design process, theories of users and view of human factors); and Piegorsch et al. (2006) who have developed a conceptual framework for ergonomic decision making. Work of this nature will have to be specific about the participants under study (e.g. novice/expert, job role, domain) as their experience will play a significant role in shaping their expertise.

Companies build up tangible expertise through research: developing their personnel and building up their portfolio of work. The organisation of this portfolio can provide a great competitive advantage as it helps constitute a company's domain expertise. Further research could be done to find out the significance of this expertise for novices and experts in a company, and tools could be proposed to manage what Perry, Fruchter and Rosenberg (1999) call organisational memory.

4.7 Conclusion

This exploratory study has sought insight into how usability practitioners work in professional web design. This has been done through a grounded analysis of eight interviews with practitioners. We have argued that there exists an outward movement of research for usability practice, where questions have developed from method development to organisational issues in practice. This research contributes to the higher levels of usability work in professional web design. These higher levels provide an opportunity to study factors that have a significant influence on usability, as practiced in industry, but are rarely addressed when research is focused at a lower level of abstraction. From this higher level of abstraction we believe that usability practice is best conceptualised from a system level perspective, where the goal is to coordinate resources to add value to the design process. We also believe that research at this level of abstraction will complement research at lower levels of abstraction by sensitising it to issues in practice, in this way the different levels of research work in a synergistic way.

To develop this analysis, in Chapter 6 we report a grounded theory analysis of human factors practitioners in the safety-critical development domain. The analysis in Chapter 7 investigates the similarities and differences in themes between the two domains. We also explore how the analysis can be developed to better understand, represent and communicate how methods are used in practice. Before the safety-critical development analysis we orientate the reader to this domain through a literature review in Chapter 5.

Chapter 5: Safety-critical system development literature Review

5.1 Introduction

This chapter provides a literature review of safety-critical system development from a human factors (HF) perspective. Its purpose is to give some foundation to the reader for understanding issues in HF in safe system design rather than usability in HCI, which was covered in previous chapters.

The chapter is divided into seven sections. The first section introduce safety-critical systems in relation to dependable and high-reliability systems. The second section highlights issues concerning the contribution of scientific advice and the increasing risks posed by modern systems. The third section outlines areas of focus which are useful for developing an understanding of the safety-critical domain from a human factors perspective. The fifth section discusses design approaches and procedures, and the sixth section methodologies. The final section summarises the main themes that this chapter has covered.

5.2 Dependable, high-reliability and safety-critical systems

As the name suggests ‘safety-critical systems’ are those systems that have the potential to be hazardous by causing injury or fatality. It can be assumed that this refers to human life, but it is easy to see how safety-critical systems might also be applied to other organisms and the wider environment, e.g. designing against oil tanker spillages, and mechanisms used to handle animals’ medication in zoos. In all cases the core concern is safety.

To situate our understanding of safety-critical systems it is useful to consider its relation to the broader category of dependable systems. The assumption behind dependable systems is that there should be a keen interest in the design, development and maintenance of systems to avoid the potentially heavy costs they may incur – to human life, non-human lives, and the environment; through fatality, injury, and other loss of value. Costs can be incurred in the design, build and use of systems, e.g. when expensive systems are built wrongly they may not be easy or cheap to change. It is easy to envisage that a stock market system which crashed frequently would incur high costs, and that once a naval vessel or control room had been built it could not be easily changed. It is interesting to note that dependable systems do not need to be safety-critical, and this is because they have a wider scope of 'heavy cost avoidance' rather than just 'safety'.

Good and Blandford (1999) recognise three different levels of integrity to which systems can be built: dependable, high-reliability, and safety-critical. Common sense would suggest that the higher the potential level of loss the higher the level of required integrity to protect against it. However, there may be a mismatch between the potential loss and the level of integrity in design due to negligence or oversight; e.g. it may not be enough to have a life support machine which is just highly reliable.

Cacciabue (2004, p.2) identifies the main areas of human factors application in the safety-critical system domain: design, safety assessment, training, and accident investigation. He also identifies the main fields for this type of work:

> "energy production (nuclear and conventional), transportation systems (aviation, railway, automotive, maritime), medicine, economic system, chemical and petrochemical environments, manufacturing, and economical systems." (Cacciabue, 2004, p.2)

Due to the focus of this project this chapter will focus primarily on the design aspects of this work, across the different fields, with only brief reference to the other applications where appropriate.

The terminology that we have used throughout this project has been safety-critical system development, but we are not precious about distinguishing this from high-reliability and dependable systems. The important point is that they are systems which need to be built with a high-level of integrity because of high risks associated with their use.

5.3 Scientific Advice and Risks of Modern Systems

This section provides comment on the place of scientific advice in safety decisions and the increasing risks posed by modern systems.

Leveson (1995) draws a distinction between science and trans-scientific issues. Trans-scientific issues relate to the values, politics and motivation in making trade-offs in cost and functionality to secure safer systems. Leveson (1995, p. 510) makes the role of technical advice clear:

> "…engineers have a duty to clarify the risks for decision makers and to make sure that complacency or other factors or pressures do not interfere with the engineering issues or risks being given due consideration in decision making." (Leveson, 1995, p. 510)

Science can develop methods, measures, and make claims about validity, and should not confuse itself by trying to answer trans-scientific questions scientifically, such as, what is a reasonable investment into safety given available budgets. The situation is analogous to government officials briefing politicians on the costs, pros and cons of a decision so they can make informed choices about what to do.

Costing human damages is a very controversial subject and one that illustrates the difficult decisions in the trans-scientific domain. Stakeholders and managers have to decide a level of investment in safety and an acceptable level of risk for their users, customers and employees. The crux of the problem is what value translates to human injury and fatality. Leveson (1995, p. 15) illustrates this difficulty by stating that a technique for quantifying compensation on injury and fatality involves multiplying 'the remaining length of life' by 'yearly earnings'. However, the acceptability of this technique could change depending on whether the subject was an employee on the payroll versus a relative of the decision maker.

Leveson (1995) makes a case for why safety-critical system design is more important in our modern time as the scale and pace of technological advancements has increased. In previous times tools and technology evolved at a slower pace and were often the product of the people that used them in the context they were used. In recent times, particularly with the advent of computer technology, systems have become more powerful and complex, and have been implemented faster. This speed and complexity leads to an increased potential for the design to mismatch the context, task or user and so cause problems for its intended purpose. This places a special onus on the expertise of designers to design systems that match the user, task and context. Cacciabue (2004, p. 9) suggests that the increased reliability of software and hardware has pushed further emphasis on the human element as many accidents are attributed to human error. It is the place of human factors to educate what 'human error' is and how it can be better controlled (discussed further in Section 5.4.2).

This section has highlighted scientific and trans-scientific issues and risk factors associated with modern systems. Designing safe systems is more challenging in our modern industrialised society as the scale, complexity and speed of technological implementation increases, providing more opportunity for mistakes and mismatches. We must also recognise that there is a strong trans-scientific element to safety decisions. Scientific research has the duty to inform the technical aspects of safe system evaluation and design, but should not try to engage with political and value centred issues scientifically.

5.4 Areas of focus

This section introduces four areas of focus which are useful for developing an understanding of the safety-critical domain from a human factors perspective: 5.4.1 how safety differs from reliability and usability; 5.4.2 human error; 5.4.3 human reliability; and 5.4.4 the system safety perspective.

5.4.1 Safety differs from reliability and usability

Safety is related to reliability and usability but it is important to note where they differ and this is best demonstrated in examples where they actually conflict.

Reliability is assumed to be synonymous with safety by reliability engineers but this assumption is only true in special cases (Leveson, 1995, p. 163). Generally reliability is about keeping every component part functioning in its intended manner without failure. Reliability may conflict with safety if by increasing the safety of a system you decrease its reliability. For example, an emergency stop function on machinery might be more reliable and less prone to damage if it slowed to a halt, but the safest stopping rate might be immediate and consequently damage the machinery (Leveson, 1995, p. 13). To further the distinction between safety and reliability it is interesting to note that many accidents happen where there is no component failure, and that there are situations where components fail which do not lead to an accident (Leveson, 1995, p. 164). In the system safety view we will see how safety is an emergent property of a system, whilst reliability is not (Section 5.4.4), i.e. emergent properties come about through the interaction between system components rather than in individual components

Usability is generally assumed to be the activity of making things easier to use but there are often wider goals in system design than just making things as easy to use as possible (Leveson, 1995, p.450). A common example used in the games domain is that if a game was designed to be as easy to use as possible then it would only have one button labelled “press here to win”. Obviously this should not be the designer’s intention. In safety terms it may actually make sense to make a system less usable to make it safer. For example, entering a password more than once, and confirming an action can be irritating and redundant but may also safeguard the user against unwanted hazards (Leveson, 1995, p. 450).

Safety, reliability and usability overlap. In practice the design of safe systems should take all three into account and consider them accordingly.

5.4.2 Human error

In human factors and safety-critical systems work it is now received wisdom that ‘human error’ is a grossly overused term to attribute accidents to (e.g. Leveson, 1995, p. 43; Cacciabue, 2006, 9). Instead, one should consider the multitude of factors that have indirectly and directly contributed to the accident; including: the designers that designed the tool, the managers, the policies, the culture, the technology, and the physical environment that the person had to work in. Indeed, what might be considered a simple operator error actually has a complex set of causes that is only drawn out through detailed accident investigation. Leveson (1995, p. 59) provides an example which highlights the complex, hidden causes of accidents:

> “In fact, a case can be made that the most important causal factors in terms of accident prevention (the root factors) are often the unmeasurable ones. As just one example, the Bhopal accident involved such unmeasurable factors as the refrigeration being disconnected, an operator ignoring or not believing a recording on a gauge, operators putting off investigating the smell of MIC until after a tea break, the vent scrubbers being turned off, the insufficient design and capacity of the scrubbers and the flare tower, and the failure to inform the community about what to do in case of emergency.” (Leveson, 1995, p. 59)

We speculate that the term ‘human error’ has emerged out of juxtaposition with ‘technical error,’ but whilst developers have greatly improved the reliability of hardware and software in high-dependence systems control of the human element has not risen to these standards (Cacciabue, 2005, p. 9). This is in part, because it is easy to stop at human error for blaming purposes but also because humans are not as predictable as machines.

It is unlikely that we will move on from using the over-generalised term ‘human error’ any time soon but Leveson’s (1995, p. 108) sentiments are shared when she says:

> “Perhaps the time has come when human error ought to go the way of phlogiston, the ether, and protoplasm. Perhaps we should let the term “human error” fade from our vocabularies, stop asking if it is the “cause” of an accident, and instead ask what action is required to prevent it happening again.” (Leveson, 1995, p. 108)

The main message here is to move from blaming the individual to engage with the complicated issues that cause error so we can understand them and help prevent them in the future. By not moving on we admit that human error is the summit of accident causation and that there is little we can do other than remove humans from the system (Leveson, 1995, p. 99).

This section has supported the claim that ‘human error’ is an over generalised term; and that the multitude of factors that contribute to errors should be considered instead. Behind this is the motivation to move beyond blaming individuals to understanding and rectifying potentially hazardous incidents. We have also seen that the multitude of factors that should be considered can be at a higher level to the operator error, e.g. the fault of the designers, managers, lack of training and company culture. It is the duty of human factors to understand and inform on the causes of failure so safer systems can prevail.

5.4.3 Human reliability

As discussed above reliability is not synonymous with safety although there is a strong overlap (Section 5.4.1). Also, software and hardware have improved their failure record by making progress in reliability which has focused attention on human reliability and error issues (Cacciabue, 1995, p. 9). Here, we reflect on reliability and human reliability issues further so we better understand how they can and cannot contribute to the design of safer systems.

Before moving on to consider human reliability we offer a definition of reliability and outline some ways in which engineers improve the reliability of systems. Leveson (1995, p.172) offers a definition:

> “Reliability is the probability that a piece of equipment or component will perform its intended function satisfactorily for a prescribed time and under stipulated environmental conditions.” (Leveson, 1995, p.172)

She also outlines some techniques which reliability engineers use to improve reliability, e.g.: parallel redundancy where components work in parallel; standby sparing where one component will take over if another fails; safety margins where components are several times stronger than is necessary, and time replacements where components are replaced before they wear out (Leveson, 1995, p. 163).

It might not seem too problematic to include the human element within these strategies for dealing with reliability, e.g. it is easy to envisage that parallel redundancy and standby sparing could involve two people working side by side rather than two electronic or mechanical components. However, the difficulty occurs in the fact that humans are harder to reliably predict than software and hardware components (Avison & Fitzgerald, 1995, p. 40). This is particularly problematic when the reliability field is used to the luxury of quantitative metrics; which may not suit complex human decision making and behaviour. Quantitative approaches to human reliability are discussed below (Section 5.5.3).

Reliability engineering has seen success in the development of software and hardware systems but a real challenge for Human-Machine System (HMS) design is incorporating the human element to the same degree.

5.4.4 The Systems Safety Perspective

The systems safety perspective can be juxtaposed with the limited human error view discussed above (Section 5.4.2). It is built on the premise that accidents are often caused by the interaction of factors at different levels in the system. It is a more holistic perspective of accidents, where the operator who made the critical error on the machine is only seen as part of the contributing factors. For example, other factors may include the designers, training, attitudes, policies, managers, culture, the interface, environment, and machinery. Safety is a systems problem and should be considered so, an approach that only looks at one aspect of this system will have limited effect (Leveson, 1995, p 99).

Expanding on the systems perspective Leveson (1995, p. 138) explains how safety is an emergent property of a system, meaning that it is meaningless to lower levels of the system. At the lower levels component parts can be shown to be reliable under the conditions and time period they were designed for but they cannot be shown to be safe. Safety only becomes meaningful when the entire system is considered together, with the component parts interacting together, in context. The example used to illustrate this is a valve in a plant. Determining the safety of the plant by inspecting the valve is impossible, but we could see whether the valve was reliable. To determine the safety of the plant we need to consider the valve and all the other components of the plant working together in context.

Aristotle's dictum that the whole is greater than the sum of its parts (Avison & Fitzgerald, 1995, p. 39) is foundational to systems theory. But for explanatory purposes it may best be considered that the whole is different from its parts. Here the whole can exhibit emergent properties which the parts do not. Safety is one of those properties. This systems perspective provides leverage for a different view of the world to that offered by reductionists that focus on reliability and 'human error'. It recognises a network of interacting components which can give a different and more complex view of causality compared to simple linear models. For example, Leveson (1995, p. 138) stresses that optimizing low level components does not always lead to improved system performance, and in some cases an overemphasis on components can even lead to a reduction in system performance overall.

With this wider perspective on safety we more easily see the important role of wider contributing factors to errors and accidents. Leveson (1995, p. 53) recognises three higher level factors or root causes that can contribute to accidents: (1) deficiencies in the safety culture of the industry or organisation, (2) flawed organisational structures, and (3) superficial or ineffective technical activities. Entwined in these three are management procedures and responsibility which Leveson (1995, p. 155) states may be the most important factors in preventing accidents.

In appreciating the far reaching effects that these high level causes could potentially have it is no wonder that sympathisers to the systems view see 'human error' as an over-simplification of the cause of accidents. It is interesting to note that the wider factors that emerged as having influence on method choice and use in Chapter 4 has resonance with a system view. In the same way 'human error' needs to be elaborated for accidents, perhaps 'method value' needs to be elaborated for HCI practice, to account for wider factors on system performance.

5.5 Approaches

There are many different approaches that are available for safety-critical system design. Here we present some high level approaches before moving on to outline some methodologies. This section introduces design procedures which highlight evaluation and design stages, formal descriptions which include mathematical expressions and proofs, quantitative approaches which focus mainly on risk and probabilities, and holistic approaches which look at safety in its wider context.

5.5.1 Design procedures

Design procedures include advice on how to structure and understand the design of safe systems. Here we refer to Leveson (1995) and Cacciabue (2004) as two examples.

Leveson (1995, p. 397) states:

> "There are two basic approaches to safe design: (1) applying standards and codes of practice that reflect lessons learned from previous accidents and (2) guiding design by hazard analysis. These approaches are complementary and both should be used."

This statement provides a good starting position for understanding safe design as it only incorporates two categories. The first is about incorporating past experience and the second is about looking forward at potential hazards. This provides two elements that should be included in a design process but not a stepwise procedure for carrying out that process.

Cacciabue (2004) introduces a stepwise procedure for carrying out a design process for a safety-critical system development context. In his book he introduces Human Error Risk Management for Engineering Systems (HERMES) which provides a holistic framework for applying human factors to design, training, safety assessment, and accident investigation. At a high level the methodology involves stages, which go through goal setting; the application of different models of cognition; developing measures for preventing, recovering and containing unwanted events; evaluation; design; monitoring and training.

Design procedures give advice and structure on how to go about design. Some may recommend methods but others may intentionally be vague on this point for the reasons Leveson (1995, p. 249 & 288) describes: the system safety design process has to be tailored for each project depending on such things as the potential hazards, culture, personnel, industry and application; and she notes that there is no perfect method but many that can and should be used.

5.5.2 Formal methods and Formal design

Avison and Fitzgerald (1995, p. 86) state:

> "A methodology which incorporates formal methods uses mathematical precision in specification and design… A formal design attempts to express these requirements (the what) concisely, unambiguously and completely and convert them into a design (the how) which reflect these requirements. The requirements statement drives the design."

This approach seems amenable to software engineering as the logical format suits the development process. Avison and Fitzgerald (1995, p. 86) question whether the design of the human-computer interface and behavioural components are suited to mathematical expression; however, others are making progress in this area (e.g. Rukšėnas, Back, Curzon, & Blandford, 2008). Formal models/methods/notations vary in how formal they are from mathematical expressions to diagramming techniques, and will vary in what they formalise and to what depth (Furniss, Dix, Ponsard, & Zhang, 2006). This will affect the choice and use of methods, which may suit some contexts more than others, e.g. where a certain degree of certainty has to be maintained in the design and development process for the sake of safety and security.

5.5.3 Quantitative approaches

Leveson (1995, p. 291) warns that quantitative methods should be used with care. One danger is quantifying only what can be quantified, which does not provide an accurate prediction of risk and can miss the most important unquantifiable factors. To support this Kletz (1985) states:

> "time is usually better spent looking for all the causes of hazard than in quantifying with ever greater precision those we have already found." (Leveson, 1995, p. 326).

Quantitative estimates of human reliability should be taken with a note of caution. Estimates are sometimes derived from similar environments or tasks that are not the same, are speculative, or have been derived from laboratory studies. Leveson (1995, p. 356-7) makes the case that quantitative measurements face an even more challenging task in human machine system design with the rate of technological implementation increasing and the role of humans becoming less repetitive and more supervisory in the human-computer partnership.

Despite these challenges methods have been developed to provide quantitative estimates for errors and human reliability, which are used in practice.

5.5.4 System Approaches

System approaches to safety take a more holistic view to design and evaluation. In contrast to more formal approaches they do not specify and reduce systems to individual components. They focus more on the emergent behaviour between parts of the system, which they would maintain cannot be sought from a reductionist view. An example of a system approach includes Leveson’s (1995) System Safety, which was discussed in Section 5.4.4. This approach emphasises integrating safety in the system rather than bolting it on to a system, it takes a larger view of unwanted events beyond actual failures, it emphasises qualitative rather than quantitative approaches, and the importance of tradeoffs and conflicts in system design (Leveson, 1995, p. 150-2).

5.5.5 Section Summary

This section has given a brief overview of four high level approaches to system development, which include procedures for design and evaluation, formal approaches, quantitative approaches and system approaches. These approaches differ in their perspectives (e.g. qualitative or quantitative); their formality (informal or formal notations); their focus (e.g. subsystems and complete systems), their leverage (e.g. quantitative probabilities versus breadth of insight); and their strengths and weaknesses (e.g. validity of data, specification, breadth and depth of analysis, and completeness of analysis). Although some approaches seem conflicting, they can be used conjointly, and so could complement each other.

5.6 Methodologies

There are a wide variety of methods that can be employed for system development. Avison and Fitzgerald (1995, p. 417) described the large number of system development methods as a ‘jungle’ in 1988 when it was predicted there were over 300 methods worldwide. Although sceptical about the figure they now quote research that estimates that this figure had cleared over 1,000 by 1994. They elaborate that some of these are differentiated only for marketing purposes and some are in-house, but neither of these alleviates the fact that there is a wide and confusing array of available methods which continues to grow.

It is not the purpose of this section to be comprehensive but instead give a flavour of the sorts of methods available without getting too immersed in the detail of any one. As has been referred to elsewhere in this chapter there is no one perfect method and the choice of the right method will depend on the circumstances of the case/project, which is why a cook book approach to safety design cannot be offered (Leveson, 1995, p. 249 & 288).

In this section we briefly outline the influence of models; hazard analysis; safety assessment; checklists and guidelines; ethnography; cognitive task analysis; human reliability assessment; and verification.

5.6.1 The influence of models

Leveson (1995, p. 186) identifies two uses for models in accident investigation that can be generalised to other areas: (1) models are used in a top-down fashion in analysis to provide a perspective on events, draw out features of events, make sure features are not missed and to organise data; and (2) models can be used for prediction by describing patterns of events and their subsequent consequences, i.e. how causes lead to consequences. So (1) looks at describing the system in its past and current states, and (2) looks at making inferences about what will happen to this system in the future. The type of model will give a perspective to (1) and (2) which will influence what is sought, found, analysis and insights.

To highlight the breadth of the model landscape without looking at the detail we refer to Leveson (1995, p. 185-224) who details over 20 models, and Cacciabue (2004, p. 67) who compares five other models not referenced by Leveson. This range of models includes single events, chains of events, emergent events, cognitive error and performance, social models, task models, environment models, and models based on the computer metaphor. These models will highlight some features and deemphasise others, which will have a large impact on the design and evaluation of safe systems.

5.6.2 Hazard analysis

Safety-critical systems, high-reliable systems and dependable systems all try to prevent and mitigate failure. As part of this they will recognise potential hazards which might lead to failure so they can be eliminated, monitored and controlled.

A hazard analysis is used to characterise the hazards and risks within a system. There are various ways of recognising such elements with the system. This recognition will be shaped by the assumptions of the model used and the approach taken to recognising them. For example, a system approach will adopt a system model and might do some qualitative analysis to find potential risks in the system; and a quantitative approach might adopt a deterministic chain of events model and use a fault tree analysis to work out the likelihood of certain events occurring.

A fault tree analysis (FTA) is a type of root cause analysis (RCA). RCA is a method of analysis that seeks to find the root cause of a potential failure. So, rather than looking at the immediate local factors which contributed to the unwanted event it will trace the causality back to the event that started the unwanted chain. There are different types of RCA of which FTA is one. FTA starts with an unwanted system state at the top node on a network. It will then look at the contributing factors that would have led to this event, then the factors which led to those factors and so on branching further and further down. Doing this creates a tree-like structure with all the branches eventually leading to the top node which is the unwanted event. Each branch on the tree recognises those contributing factors and so across the whole network those elements near the base of the tree can be recognised as the root cause. Probabilities can be attached to these events, thereby making estimations about a particular sequence of events.

Cacciabue (2004, p. 230) outlines different types of safety assessment, which are a form of hazard analysis. One of the most well known is the Quantitative Risk Assessment (QRA). As the name suggests QRA aims “at establishing the frequency of occurrence (and associated uncertainty distribution) of the consequences of certain events” (Cacciabue, 2004, p. 93). QRA are also known as Probabilistic Safety Assessment (PSA), or Probabilistic Risk Assessment (PRA). QRA methods have a special stature in some hazardous domains as they require a concerted effort to show that the potential likelihood of an accident and damage caused by an accident are kept to a minimum, often encouraged by safety regulations. For example, the chemical industry and nuclear industry both appear to have a duty to quantitatively assess the potential chance and consequences of hazardous events (Cacciabue, 2004, p. 93-4).

Many different types of hazard analysis exist. All have different strengths and weaknesses, different coverage and validity, and are suited to different projects and contexts (Leveson, 1995, p. 313). Given this a certain amount of knowledge is useful with regard to knowing what methods are available and knowing when and where they will be useful.

5.6.3 Checklists & Guidelines

Checklists and guidelines are recognised as a way of crystallising and summarising knowledge and lessons learnt from the past (Leveson, 1995, p. 314). They can reflect best practice and industry standards or can be more personal to individual organisations when updated and edited locally. Guidelines are different from checklists in that they are to be considered with application to a situation rather than worked through and ticked off. They are similar in the way that they pass on knowledge and suffer some of the same criticisms in that they can be large and difficult to use, lull the user into complacency by ignoring things not on the list, and inhibit careful thinking about the particular circumstance (Leveson, 1995, p. 315). The crux of whether thinking is inhibited or enhanced comes from the fact that these lists draw people’s attention to some aspects of the situation and withdraw their attention away from other aspects.

5.6.4 Ethnography

Ethnography is often used as an umbrella term for techniques that allow the study of the people, technology, practices and activities in their working context. Ethnographic work can have advantages as it engages with the real context of the situation. Careful observation can reveal important emergent and contextual occurrences that might be hard to recognise away from the context.

5.6.5 Cognitive Task Analysis (CTA)

Cognitive Task Analysis (CTA) is a method which seeks to elicit the nature of a cognitive task and then infer insights about performance. Cacciabue (2004, p. 71) defines CTA as “a method that attempts to specify the interaction of mental procedures, factual knowledge, and task objectives in the process of job performance.” Klein (1998, p. 169) promotes the use of cognitive task analysis in situations that involve expertise so we get to understand how people structure their thoughts and make decisions.

5.6.6 Human Reliability Methods (HRM)

As the name suggests Human Reliability Methods (HRM) seek to ascertain whether the human component in a system will be able to maintain performance. This will take contextual features into account which might affect the potential for failure, e.g. training, fatigue, the time of day, the heat, and the complexity of the task will all impact on human performance.

Cacciabue (2004, p. 93-4) distinguishes between first and second generation. First generation methods concentrated on overt behaviour and gathered quantitative reliability measures from accurate field studies. One example of a first generation method that Cacciabue (1995, p. 93) mentions is the Technique for Human Error Rate Prediction (THERP), but he also mentions that there are many others that have been compared and reviewed. Second generation HRM take into consideration the cognitive processes and decision making elements of people and so can be considered more fine grained and complex. An example of a second generation method which Cacciabue (1995, p. 94) cites is ATHEANA (A Technique for Human Event Analysis) which goes through a lengthy process that includes scoping the analysis and prioritising events; identifying human failure events and unsafe acts; identifying causes; quantifying these causes and doing a quantitative analysis.

HRM are closely related to QRA, and suffer from the same criticisms as other quantitative approaches (see Section 5.5.3).

5.6.7 Verification

At a general level verification means checking whether something does what it is meant to do, or checking that something does not do what it is not meant to do, or both. There are different types of verification. Leveson (1995, p. 496) gives an introduction to formal verification:

> "Formal verification essentially provides a proof of consistency between two formal (mathematically rigorous) specifications of a system. If one contains the safety-related properties of the system, then the other can be shown to be consistent with those safety properties. "Proof" here is used somewhat loosely – the goal is to apply careful, analytical thinking about the system description in order to convince ourselves (and others) that the system has the desired properties." (Leveson, 1995, p. 496)

Formal verification lends itself to formal methods and formal design. The general process is to formally specify what a system should do under assumed conditions, build the system, and then check whether the system satisfies its specification.

Whilst the application of formal methods and formal verification appears to have many advantages Leveson (1995, p. 496-7) warns against applying them to problems that can be solved by less costly techniques, and overemphasising those parts of a system that lend themselves to formal analysis. To illustrate this last point we may use Leveson's (1995, p. 497) analogy of searching for a needle across the street where the light is rather than where the needle was dropped. We need to employ the right methods for the right job, to maximise their use and the information that they can give us.

5.6.8 Section Summary

This section on methodologies for HF in safety design has given a brief tour of some of the different options open to designers and analysts. The number of different approaches available to designers and analysts makes it a challenge to grasp. The overview above has not included the many models, acronyms, methodologies and procedures that Leveson (1995) and Cacciabue (2004) outline. Expertise is not only needed in the application of individual techniques but also in choosing appropriate ones to apply: i.e. knowing what is available and when and where they will be effective.

5.7 Conclusion

The design and management of safety-critical systems is more important and challenging than ever in our modern industrialised society because of the increasing complexity and wider deployment of these systems. Safety-critical systems are related to high-reliability and dependable systems: all concern themselves with preventing and mitigating failure but to different levels of integrity. The chapter also distinguished scientific and trans-scientific issues, the former being factual and technical, and the latter being value laden and political.

The rest of the chapter has given an overview of approaches and methodologies to safe design. Through this overview we have seen that there are different approaches which employ different perspectives and assumptions, which relate to different methods, which will produce different results and insights. For example: some approaches are design and evaluation based, some are on parts of the system and some more holistic, some are quantifiable and some are qualitative. It is important to remember that each adds a specific focus, which has its own strengths and weaknesses for different contexts. Expertise is not only needed in the application of individual techniques but also in choosing appropriate ones to apply: i.e. knowing what is available and when and where they will be effective. In the next chapter we report a grounded theory study which engages with how human factors practitioners choose and use methods in their work.

Chapter 6: Grounded theory of safety-critical system development context

6.1. Introduction

Following the qualitative study of usability practitioners in website design, this chapter details a similar study carried out on human factors (HF) practitioners in safety-critical system development contexts. This second domain was chosen to broaden the sample base, and to provide an interesting contrast between the two domains. The comparison between the two domains is left for later discussion (Chapter 7), here we outline the qualitative study, its results and discussion.

Unlike the presentation of the previous grounded theory chapter of website design, this chapter explores three different data treatments to see how it affects its analysis and subsequent representation. In doing this work we have come to the view that the analysis, its representation and its subsequent communication are intimately related (supported by Miles & Huberman, 1994, p. 11), hence it is interesting to explore the potentials of different treatments. We first outline the general method undertaken which remains close to the previous chapter, then we move on to the three different data treatments, including: summaries of each interview, a view of the code network created through open and axial coding, and a selective coding perspective.

The comparative analysis of these data treatments satisfies more than an analysis of the three different ways to treat qualitative data. Perhaps most importantly, it allows the reader a closer engagement with the data and its treatment. This may not be available in a single abstract presentation of the analysis. By doing this the choices and consequences made in the analysis become more tractable and inspectable. This process also provides a more varied analytical engagement with the data than a single treatment, and some validity is gained in the sense that similar conclusions are derived from different treatments. We first outline the general method and then move on to the presentation and reflections on the different data treatments.

6.2. Method

A grounded theory approach was undertaken to explore the data, details of which can be found in Chapter 3. More specific information of what was involved in the study is summarised in the following three tables: Table 6.1 describes detail of the grounded analysis; Table 6.2 describes the semi-structured interview topics; and Table 6.3 outlines the interviewee experience and current status. The tabular form of presenting the method was developed so important aspects and nuances of each qualitative analysis could be more easily inspected and compared.

Table 6.1: Details of the grounded analysis.

Section	Detail			
Number of:	Coders	Interviews	Codes	Quotations
	1	13	128	1125
Literature involvement	Literature was reviewed to inform the analyst's understanding and help focus the interviews before they were performed. It was also used to inform and crystallise insights as the analysis developed (Strauss & Corbin, 1998, p. 96).			
Sampling	Interviewees were sampled opportunistically. Generally as the analysis matured interviewees who were less well known to the analyst and more experienced were involved. This was done for practical and theoretical reasons: people who were less approachable and more experienced were involved when the analysis and questions were more mature. Interviewee experience and current status can be found in Table 6.3. Table 6.3 shows that eight companies were involved, with 5 interviewees from one company.			
Interviewing procedure	The interviews were semi-structured and about an hour long each. Guiding topics can be found in Table 6.2. Topics were probed in an opportunistic fashion. Where possible interviews were left days, weeks or months apart so analysis could be conducted between them; this informed the questions of the subsequent interviews. Where interviews were close lessons from each were still tested and clarified in the subsequent interviews.			
Coding procedure and style	Informal analysis took place between each interview. Each interview was transcribed and coded. After the fourth interview the transcriptions were re-coded to reduce the coding scheme, thereby making it more focused. The coding style of the analysis was loose in that codes overlapped and were not mutually exclusive. Open coding and axial coding were done simultaneously. Mini-frameworks and memos, including coding notes and theoretical notes were used throughout the analysis (Strauss & Corbin, 1998, p.141 & 217). Selective coding was committed to at write up.			
Tools	Atlas.ti was used to support the analysis.			
Reporting style	The reporting style adopted here is in three separate sections. The first gives a summary of each of the interviews, this gives a broad picture and shows the diversity between the interviews. The second gives a view of the hermeneutic unit, so named in Atlas.ti, which gives details of the open and axial coding: i.e. the codes' links to each other in a web of interrelations. The third is the selective coding stage where main codes are described to emphasize a coherent story through part of the hermeneutic unit.			
Validation	There are a number of possible levels of validation when doing a grounded analysis, e.g.: 1) Testing through data collection and analysis; 2) Verification by interviewees; 3) Verification by a wider population; and 4) Triangulation with other methods/studies. This study went to level one and two. In level two 10 out of the 13 interviewees checked that their interview summaries were correct (Section 6.4), the rest were non-contactable.			

Table 6.2: Semi-structured interview topics.

Topic	Description
Background	Background of the person being interviewed. This aims to introduce the interviewee slowly and find out about their experience and perspective.
Work Organisation	This includes how work is organised, the structure of the organisation, whether there are teams, project lifecycle involvement, and what job challenges are faced.
Business: Client Relationships	This includes communicating with clients, both in attracting clients and handing work off to them. For example, how do practitioners communicate effectively and what challenges do they face?
Practitioner skills	What do practitioners do, why are some better than others and how do they get better in their role? This could give an indication about what is important in their work.
Tools and techniques	What methods are used, how are they used, when are they used, what is valued in a good technique?

Table 6.3: Interviewees' profiles.

Participant	Company	HF Experience in years	Currently
S1	A	30	In-house ergonomic design consulting.
S2	B	5	Works for independent research organization.
S3	C	10	Works for multi-sector HF consultancy.
S4	D	0	In-house management and system maintenance (he was an engineer with experience of a large project with HF influence).
S5	E	30	Affiliated to HF consultancy.
S6	F	> 3	Works for multi-sector HF consultancy.
S7	F	5	Works for multi-sector HF consultancy.
S8	F	> 6	Works for multi-sector HF consultancy.
S9	F	5	Works for multi-sector HF consultancy.
S10	F	5	Works for multi-sector HF consultancy.
S11	G	17	HF representative and adviser for a particular domain.
S12	H	> 5	HF consulting for large research and development organization.
S13	H	11	HF consulting for large research and development organization.

6.3 Introduction to Analysis

Generally, qualitative data analysis is a process of data reduction, i.e. the raw data is treated, transformed and summarised to give a more abstract reflection of the data (Miles & Huberman, 1994). This analysis has been divided into three sections, each of which treats the qualitative data differently. The first gives a summary of each interview, the second gives a perspective of the code network developed during the open and axial coding stages of the grounded theory; and the third represents the selective coding stage of the grounded theory. These separate results and representations are discussed in the discussion section.

6.4 Summaries of each interview

The first data treatment is a summary of each of the 13 interviews. For brevity, four of these summaries have been chosen for their contrasting content and are listed in Table 6.4, the rest are included in Appendix A1.1. Each summary provides the most important points that were covered in each of the interviews. It is perhaps telling of the representation that it is not in an easily digestible form but leaves the reader with a lot of work in terms of bringing the different summaries together to form a general picture or message. However, an advantage of this representation is that it provides insight into each individual interview and allows some engagement with the breadth and differences in the data rather than presenting a more aggregated view.

To aid engagement with this representation it is worth looking at the cultural differences between interview S1 and S2. The former is from a design context and the latter from an independent research agency which has interesting implications on their role in design and their communication practices. Also, by way of introduction we have highlighted some points of interest which can be traced to their source. The themes listed below, can be found next to corresponding interview summaries, these indicate where these points of interest are more apparent:

- **Distance**: Different practices can work closely with, or be more independent from, design.
- **Communication**: Communication can happen in different forms, e.g. wordy reports, pictures and meetings. Communication should be the right message, to the right person, in the right way.
- **Capability**: There seems to be a pattern of supply and demand. The former being HF capability, the latter being the client need. From the HF side capability management is very important.
- **Tools**: Tools can play a key role in inhibiting and enhancing capability.
- **Problem**: There are different types of HF problem, and the detail of each context is very important to consider.
- **People**: People, and the relationships in the practice matter, e.g. personal preference, style, understanding, personalities, reputation and rapport.
- **Audit**: More senior HF practitioners, and HF practitioners from other companies, will check the work of others to make sure it is of an acceptable standard.

- **Client power**: Clients hold the power. Meeting their needs is almost the *raison d'être*.
- **Environment**: Behaviour at a local level can be influenced and shaped by the environment, e.g. ideal solutions are often traded-off to make more streamlined and pragmatic solutions.
- **Methods**: Methods are not used for the sake of it, they are orientated to solve the client's need. Practitioners have a repertoire of methods, which can evolve over time. Proven and well practiced methods are easier to sell, easier to apply and more predictable for the client and practitioner.

Table 6.4: Summary of each interview.

Summary of interview	Bullet code
Respondent S1 Here design solutions were driven through iterations with input from people with knowledge of the products and working practices, rather than the specific identification of safety issues through evaluative methods. Much of the communication is captured in design drawings and so documentation is in pictures and notes rather than wordy reports. Even though they work in-house they still have to sell their ideas and services, and face the same issues of not being involved or being involved too late that out-house people face. The design-solution focus forces them to engage with the real trade-offs. They apply patterns through analogical reasoning to aid the design process, i.e. they are familiar with reoccurring issues which inform designs.	Distance Communication Environment
Respondent S2 This contrasted with solution focussed consultancies in that it was quite formal, independent and research driven. Rather than taking a design orientation the work appeared to be very evaluative, a lot of it taking the form of controlled experiments where safety could be independently evaluated. Reports were written in a similar way to research reports that you might find in academia. Written communication seemed to dominate client contact so an audit trail was maintained and misunderstandings reduced. The rigor of their research and independent status characterise the company's offering. Often they do not know what happens to their results and subsequent designs as they are detached from the process. Expert panels and discussion groups were recognised as useful methods for tapping into domain expertise.	Distance Communication Environment
Respondent S8 Quality control is important. Repeat business provides a large proportion of work so keeping clients happy is paramount. Big differences between academia and consultancy include speed, commercial pressures, and sociability – this softer side of consultancy is important. There is a clear career progression within the company, with senior members providing support and checking the quality of more junior members. In communicating work one should be aware that different people are interested in different things; for example engineers might be looking for the solution in the project output, whereas other HF practitioners might be checking methods and processes have been executed well. It is important to scope your work and claims, and have a common understanding of the deliverables between the client and service provider. Tools are useful, some are developed in-house. They will use multiple sources to test and validate claims when they can, e.g. use simulator after an expert review, and get client feedback. There are trust issues and the community acceptance of research work like in academia (with more senior members judging the quality of work); you need to have a good reputation as a company and practitioner, and be able to defend that you have robust results through good work and processes.	Communication Tools People Audit

Summary of interview	Bullet code
Respondent S12 Human Factors is multi-disciplinary and bridges different areas of expertise, e.g. psychology, physiology, and modelling. Capabilities need to be managed so the business can perform successfully. Recent budgetary pressures have led to a more consultancy based style of working where the delivery to the customer is the focus. This means that the company's offering has to be streamlined and competitive within the market place, which can lead to less freedom in experimenting with methods, practices and research. There is a sense that you should play to your strengths so the company does the sort of work that it knows it can do, and can do well, through experience. Methods are influenced by context-shaping factors like what is technically appropriate, what the practitioner is used to, the amount of time permitted, and access to users. Outcomes have caveats where an ideal research process has been balanced with the realities of the work. Depth exists in individual expertise in methods and domain knowledge, and there is also breadth so support can be given elsewhere. Organisational expertise exists in reports and team work. Staff develop through increasing levels of complexity in their work and increasing responsibility. Personality is important for client facing roles carried out at more senior levels, because it is people that give you work and repeat business. You have to negotiate specific objectives for projects, particularly where the client is unclear what they want; and then give the client guidance in how to exploit the outcomes of the work. The best way to communicate value is to do the work and do it well. Human Factors has challenges in being involved earlier in projects, and in communicating what it does. Perhaps more standardisation in methodologies could help.	Capability Problem People Client power Environment Methods

6.4.1 Conclusion

A strength of this form of data treatment is that it shows the breadth of issues that have occurred in the interviews. This diversity was enhanced by the semi-structured interview technique and the philosophy that the issues important to each interviewee should be explored within certain bounds. For example, some interviews may have more emphasis on tools (S7), on communication (S8), on the softer side of practice like reputation (S11), on working with different groups and people (S6) and on tackling problems (S5). Naturally occurring differences are also apparent, a good example of a contrast between interviews is between interview S1 and S2, where the former is much closer to design work and the latter is orientated around independent research.

Making generalizations from these interview summaries is a further process of data reduction. One form of analytical slicing highlights three factors under the general motivation of meeting the client need: capability, people and resources. This encapsulates the technical need of the client: i.e. they have a demand, which would normally be a HF problem, and HF has the capability to meet that demand. This encapsulates the important social elements on the softer side of practice, i.e. the way that people work together and integrate in business and design. Here personal preferences, personal style, understanding, personalities, reputation and rapport can have a big impact on how HF is performed and received. It also encapsulates how resources play a key role in shaping HF practice as projects will often need to be streamlined and pragmatic rather than ideal in research terms. It is important to realise that it is the client who allocates resources and they are in a position of power for negotiating project options. So, we have an interplay between technical needs and capabilities, the softer side of relationships and communication, and the allocation of resources and power; which integrate and shape projects and outcomes directed toward a client need. All three of these factors play a significant role in the organisation of practice, which affects the selection of methods and the transfer of value.

6.5 A view of the Code Network: Open and Axial Coding

The second treatment of the data shows a web of interrelated factors developed through grounded theory. The code network was developed in the open and axial coding stages of analysis. The former recognising the codes and the latter recognising the links between them, these stages are performed in parallel in practice.

Coding is the process of labelling ‘chunks’ of data; in this case words, sentences and phrases in the transcriptions. This can be done at different levels and the same piece of text can have several codes related to it. The analyst decides what codes are significant and what level of granularity to code at. Linking the codes in axial coding also has different mechanisms when one reflects on this process in a fine grained way. The most direct is where there is a clear link made in the actual transcript; for example this quotation by respondent S5 has the codes ‘method advice,’ ‘resource constraint,’ and ‘risk and predictability’ associated with it:

> “It’s got some good characteristics: it’s cheap, you know what it is, you know what it’s going to do, they’re the sort of characteristics that you want in a tool.” S5

In total 128 codes were derived from the qualitative analysis. In this section we focus on codes that were either highly grounded (i.e. they had lots of quotations in the data), codes which were dense (i.e. they had lots of links to other codes), and a subjective selection of codes to complement this view. Table 6.5 shows these codes; how grounded they are; how dense they are; the spread of respondents that mentioned this code; and the codes that they link to. Appendix A2 contains a more complete view of the code network. We first present a graphical view of the code network, and then describe the codes with their interrelations to each other. The concluding section reflects on the lessons learned from this treatment of the data.

Links between codes are included in the subsequent descriptions of these codes after Table 6.5 which has come from repeated engagement with the interviews, data and analysis. Here, the analyst has formed a picture in mind ('theory building' in Ryle's 1949 sense) and these links express that picture. The special cases that have zero values in Table 6.5 are: Code 12 (Comments on academia) and Code 40 (Method). 'Comments on academia' does not link to any other code because it was judged to be external to the system of how practice worked, i.e. a meta-commentary of the perceived differences between the contexts. 'Method' was a special case as it was created as an empty code at the end of the analysis to be a parent to all those specific methods that were grounded in the data; it links to every method code for house-keeping reasons but is not directly linked to the data itself.

A comment about the significance of numbers in Table 6.5: These numbers should be read much more loosely than those associated with an experiment. They give an impression of the data but the real work is in the semantics of the qualitative analysis. For example, the more grounded and dense a code is, the bigger a part it played in the transcriptions but this does not relate directly to its semantic importance. It makes little sense to rank order the importance of codes in this way. It is more meaningful to 'see' what is said and how concepts relate to build a picture of the area. Also, there is only so far that one is able to take the analytics of a qualitative analysis before it moves into semantics and meaning. Our view on grounded theory is that it is primarily a tool for the theory building of the analyst (other methods like content analysis are more analytical and number driven), therefore one should not be too precious about the figures: i.e. quantities do not map directly to the qualitative interpretation.

Table 6.5: Code number, name, groundedness (number of quotations), density (number of links to other codes), spread (number of interviewees that mention code) and code neighbours (their links to other codes).

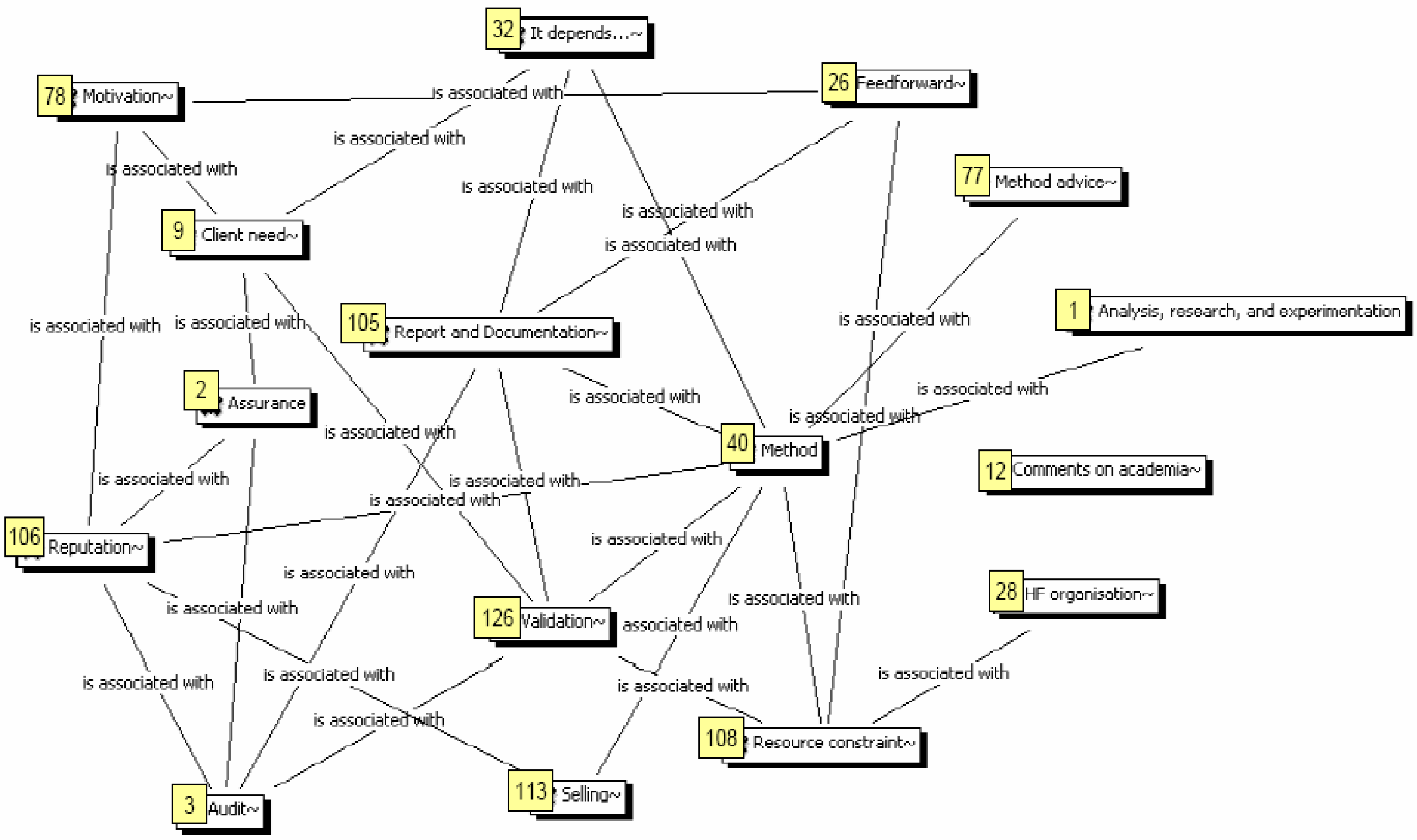
No.	Name	Grounded	Density	Spread	Code neighbours
1	Analysis, research, and experimentation	24	2	10	Systematic, method
2	Assurance	14	6	6	Audit, capability, client need, reputation, stringency, usability vs safety
3	Audit	11	7	6	Report and Documentation, Reputation, Assurance, Quality, Redundancy in people, Regulations and Regulator, Validation
9	Client need	54	10	12	Capability, Decision and negotiation, Perspective and perception, Problems: closed, open, simple, complex, Assurance, It depends... , Motivation, Relationship, Validation, Window of opportunity
12	Comments on academia	38	0	8	
26	Feedforward	58	11	12	Decision and negotiation, Scope claims, Communication, Motivation, Priority, Project output, Quality, Rapport, Recommendations, Report and Documentation, Resource constraint
28	HF organisation	43	9	12	Closeness, Company organisation, Communication, Process, Project design phase, Project length, Project roles, Resource constraint, Scope of development
32	It depends...	49	6	10	Client need, Method, Perspective and perception, Reflective practice, Report and Documentation, Variety
40	Method	0	64	0	Analysis, research, and experimentation, Closeness, Communication, Early, middle, late, all. , External knowledge, In the trenches, It depends..., Lab vs Real world, Literature review, Method advice, Practitioner experience, Practitioner skills, Pragmatics, Prejudices, Problems: closed, open, simple, complex, Process, Project design phase, Qualitative and quantitative, Recommendations, Report and Documentation, Reputation, Resource constraint, Risk and Predictability, Selling, Standards, Stringency, Tool, Validation [plus all specific method codes]
77	Method advice	18	2	9	Method, Tool
78	Motivation	35	8	11	Client need, Feedforward, Frustration, Prejudices, Regulations and Regulator, Reputation, Capability, Politics

No.	Name	Grounded	Density	Spread	Code neighbours
105	Report and Documentation	37	10	12	Communication, External knowledge, Feedforward, It depends... , Method, Regulations and Regulator, Audit, Audit trail, Project output, Validation
106	Reputation	13	9	7	Expertise and background, Method, Succession and Repeat business, Assurance, Audit, Motivation, Prejudices, Risk and Predictability, Selling
108	Resource constraint	64	11	13	Bidding, Decision and negotiation, Feedforward, HF organisation, Method, Power, Priority, Scope of development, Pragmatics, Risk and Predictability, Validation
113	Selling	16	10	9	Bidding, Method, Project design phase, Reputation, Succession and Repeat business, Window of opportunity, Capability, Communication, HF to admin, business, management, Rapport
126	Validation	16	14	7	Audit, Client need, Closeness, In the trenches, Lab vs Real world, Method, Quality, Redundancy in people, Report and Documentation, Resource constraint, Risk and Predictability, Scope claims, Prejudices, Recommendations

6.5.1 Network diagram

The network diagram in Figure 6.1 shows some of the main codes and their interrelations. From the codes that are focused on in this section we can see some have more links than others. Method has the most links; whilst validation, reputation and report and documentation come second. These links are elaborated on in the next section which describes their meaning. From the graphical view it is apparent that there are different dependencies between the codes.

Figure 6.1: Network diagram to show some of the main codes and their interrelations (The numbers relate to the superscript numbers in the description.)



6.5.2 Code descriptions

This section contains a description of the codes represented in Table 6.5. The superscript numbers refer to the number of the codes when placed in alphabetical order, e.g. 'method' is 40th in the list. This numbering is to aid referencing between different code descriptions, as the codes are explained in the web of codes around them.

1. Analysis, research, and experimentation

This code was borne out of the fact that some human factors (HF) projects do not involve specific HF methods[40] but can be more generally conceived as analysis, research and experimentation. For example, a client's need[9] might require a practitioner to come in and view operations on a ship as they may have problems with a new piece of kit, or it might require a practitioner to sort through accident reports to find patterns, or it might entail setting up an experiment to identifying the most suitable product for a task from a selection.

Each method[40] has advantages and disadvantages, and it is up to the practitioner to know which should be chosen and why. The aim should be to get the right information in the right way.

Depending[32] on the sort of research project that is being carried out it may be more or less systematic[119], the less systematic might entail an exploratory study, adapting to what is found, taking photos, measurements, interviews in a workplace, and creating designs to get feedback from; the more systematic might entail setting an agreed criteria for making a decision and having a formal process to go through to make that decision.

Methods[40] are an important part of analysis but there is a lot of analysis that goes on outside of methods. For example, negotiating what the project should be with the client[10] will entail trying to understand what issue they are dealing with and how to best go about helping them[91]; and a practitioner may think things through and doodle on a pad to help themselves try to understand a situation.

2. Assurance

Clients will want[9] assurance that the work has been done competently and that the recommendations and claims can be trusted. This might include auditing[3] the company to check their processes are adequate, and having an audit trail[4] in terms of the methods that were used and how the recommendations were derived.

HF practice should have the capability[6] in terms of expertise and experience[24] to deal with the issues they aim to address. Some assurance will be given by the reputation[106] of the HF practice and practitioners, but work will have to be stringent[116] and of good quality[97] for this reputation to be maintained and improved. This will impact repeat business[117].

Clients may need more assurance in some cases than in others. For example a high safety risk[109] may need more than a low usability issue[125]. Practitioners are wary about properly scoping their claims[111] so a system may only be deemed acceptable as far as the tests have shown, e.g. testing the workload of a train driver does not make driving the train safe. Safety claims should be made with caution.

3. Audit

Auditing refers to the checking of the quality[97] of a process[90], performance or work. It is to provide assurance[2] that standards have been met. Auditing the quality[97] of work has potential to impact on a practitioner's or a company's reputation[106].

Internally, staff performance may be monitored which may affect career development[7], etc. Externally, client satisfaction may be monitored; some practices do this explicitly through surveys[68] others are satisfied with implicit monitoring of how projects have gone and whether there is repeat business[117].

In safety cases there will be a redundancy in HF knowledgeable practitioners[101] to check on each others' work: that the right things have been done, that they have been done well, and the right recommendations made. They can check how the project was carried out as they share this specialist knowledge.

Work can also be audited during the project, for example, in methods like HAZOP[54] domain experts[21] will review a task or process and they will raise concerns if they are not satisfied that it is safe. Different domain experts[21] are involved in HAZOPs to check the system from different perspectives[81].

There is a relation to closeness[11] in auditing. If a person lacks a particular knowledge base they will not understand what is going on and cannot judge the quality[97] of it. HF practitioners want the client to understand what they are doing at least to some degree. Even when a client is not interested in HF details, and they just want the problem to be solved, there may be third parties that have an interest in auditing the details of the work, e.g. company directors might be told by regulators[103] that they have a HF problem[9], they then utilize HF services to solve the problem but do not care about the details[78], but the regulators[103] may then check the work of the HF practice to make sure the problem has been properly addressed.

Documenting[105] work is important to leave an auditable trail[4]. Sometimes reports serve different purposes for different audiences; taking the example above a client might be motivated[78] by the solution, whereas regulators may be more motivated[78] by the process and methods that derived the solution. Similar to academic work[114] people will judge the validity[126] of the results on the process, methods and arguments that have led to them.

Goal Structuring Notation (GSN)[50] was described as a method that breaks down the argument that HF has adequately covered the different parts of a system and then links up what has actually been done on a project to cover those parts. This makes the argument and evidence more structured, and aids auditing. Not all projects will need this level of detail. Environments and projects which are more designy[20] may be less inclined to keep an audit trail[4] of why design decisions were made.

HF practitioners may develop tools[121], checklists[42] and guidelines[52] so non-HF qualified people can carry out audits of their own in working contexts.

9. Client need

A client need is often the driver and initiator for the project. Clients will be coming from their own perspective[81] and may be motivated[78] by non-HF issues, e.g. to satisfy regulators[103], to increase revenue, to get safety assurance[2], and to reduce manning levels. The HF practitioner will need to engage with the client's issue and negotiate[17] a programme of work aimed at addressing it[91]. Sometimes the client might not understand what their HF need is. One practitioner believed that it can be complicated in that you may think you are employed to solve a technical problem, but the actual problem may be something else, like organizational change. Like in academic research[114] the real nature of the issue might only reveal itself after the work has begun. What programme of work is decided upon will depend[32] on the type of problem[89], the resources invested in it[108], the risk[109] involved if the problem is not addressed properly, the level of validity required in the solution, and the capabilities[6] of the HF practitioners and practice.

Client needs bear a lot of influence on the methods[40] that are used. One practitioner stated that they would turn to methods they had not tried if a client requested it. Practitioners' work needs to be paid for and so they are largely restricted to what the client will pay for[108]. The client may be willing to invest more resource into projects where there has been a window of opportunity[128] for HF, e.g. when they have a big problem with new navigation systems on ships, or highly publicized train crash; or where they have a good relationship[104] with the HF organization.

The integration of HF differs in different industries[22], some where it is mandatory, like nuclear power; some where it is strongly encouraged, like transport industries; and some where it seems less well established, like hospital design and renewable energies.

12. Comments on academia

This includes practitioners' comments on academia. These point to understanding the practitioner context better and providing research outputs which are more suited to this context:

- there could be more work in developing commercially viable tools, validating tools and methods, and generally bridging the gap between what academia produces and what practice can use. Practitioners can adapt methods so they are more suitable to practice, but perhaps academics should take into account the practitioner context more. Many incremental developments are not significant enough to change practice, e.g. a slightly updated attention model will probably not make much difference to practical workload studies and recommendations.

- some academics could do more to market their ideas by producing more studies and more papers.
- academics can focus on ideal method use rather than taking into account the pragmatics of the situation, e.g. practitioners focus on value and the solution, rather than the method per se. Recommendations have to be grounded by talking to clients and operators. Claims should be appropriately scoped by the systems and evidence engaged with.
- doing HF work in practice, under commercial constraints, and where recommendations could mean loss of life is very different to academic claims presented in journals and conferences. When your decision could mean loss of life the sort of judgment you make changes.
- there should be a better appreciation of practitioner work including the organizational swirl, attitudes and politics involved; you need to be battered by organisations to appreciate these complexities.

26. Feedforward

This is the transfer between components in a system, which essentially focuses on the interaction between parts of the system. This provides the glue that holds the system together, without which we would have an impoverished view of the components of the system and not how they interact or work together.

Feedforward is quite structured in that it assumes that there are different parties and processes doing different things[94], that these different parties and processes are coordinated, and there is feedforward between them. This could be the transfer of some value, information, opportunity and technology from one part of the system to another. In terms of usability practice's integration with design good feedforward would impact on the actual design, poor feedforward what not lead to design impact even if the actual work was good.

Projects are engineered to meet a client's need[9]. The feedforward of this information should be of enough value to the client that they will invest resources[108] to fund the project. There may be some negotiation[10, 17] in what work is carried out and what the HF service will provide. The transfer of value is not only important to design, but for business as well. Good HF work[97] and early HF work[23] may feedforward to lead to further projects and more contracts[117].

Feedforward should not just stop at the project output[93] but should consider how well the transfer of recommendations[100] takes place. So this goes beyond what is transferred, for example scoping claims[111] properly, and making sure recommendations are properly couched in the details of the context[30]; to how transfer happens which emphasizes the communication[13] of recommendations[100], which can be prioritized[88], design solutions, in words, pictures, reports[105], meetings[39], etc. Softer factors can also facilitate the transfer of recommendations like the rapport[99] and relationship[104] between the client and practitioner. Feeding forward also has to be timely, for example, in 'designy' contexts[20] over emphasis on recording details, decisions, etc. can hinder the speed of design input; and practices that work at different speeds have to find some suitable way of working effectively.

It is important to consider what information you feedforward, to whom, and how. For example, chief executives might not be interested in the detail and might not have time to read a big report; developers may need detailed information for implementation but not be interested in the HF sides; regulators might be interested to see that appropriate HF methods have been performed; and accountants might be interested in costs and savings. Here, reports[105] may serve multiple functions as different people are motivated[78] by different things.

It may not be in the interests of HF practice to try and feed all recommendations forward. It is wise to manage this process and choose which battles to fight as good rapport needs to be maintained. Also the client may be working under constrained resources[108], might be contractually restricted on what they can do[112], and might not be able to do everything. This negotiation[17] can involve political[82] elements.

Feedforward is also affected by process[90]. Different information will be gathered, processed and fed forward in different stages of the design process, e.g. there may be a literature review[38] of previous work and standards[115] at the very start and there may be tests[71] once a prototype[60] is available. If HF is involved too late in a design cycle[23] then there may be little potential to influence the design. HF might also be organized[28] to prevent feedforward from one department to another, so evaluative departments are not involved in the development, and so they can independently evaluate the design.

The feedforward of knowledge[37] might also be more implicit and diffuse, for example, in educating clients about methods[40] they can offer, and in mentoring[118] more junior members of staff. Indeed, non-HF people may become aware of its philosophy by coming into contact with the work. Away from traditional design cycles one practitioner recognized the importance of the process of doing HF work; where talking to people, having meetings and working through options actually achieves the desired outcome for the client rather than delivering a report with recommendations, which he related to organizational change. Here it appears that you become part of the process of introducing new technology.

There is also the sense of feeding forward from academic research to industry practice[12]. If methods[40] are not sufficiently different and add value to current practice; if they are too costly in terms of time and budget; if they are complicated; and if the topic or approach cannot be sold to clients then the likelihood of transfer will be severely reduced.

A client might be using HF for political[82] means so they can feedforward results in their own organization, e.g. their opinion might not be listened to on its own but an independent research report might. A report[105] captures conclusions and is a stable artefact that can be passed to others; correctly produced it has a certain presence and authority that might be missing from verbal communication.

28. HF organization

This code refers to the organization of human factors within a company, between companies, in projects and processes[90]. There are different dependencies[32] that will affect the organization of HF. Methods[40] are only part of a wider HF offering that should fit with the project and the client.

There can be different HF practices involved in large projects[92] at different stages. These can be organized to do checks on each other's work[101]. Even within a company HF practices might be kept separate[11] so they are in a position to perform an independent evaluation on the company's own work. HF practices might have to adapt their communications and procedures depending on how the client is organized[14], e.g. clients might have specific preferences and report structures.

Clients may want close contact[11] and regular informal feedback, projects may involve integration in to a wider design team, or work may be quite detached, structured and independent. What is considered early project[23] involvement will also vary between projects as some may have a vague idea of a design, whereas others may have moved to a specification and prototype[60]. Once a HF practice has started on a project they have an internalized understanding of the design, issues and client practices which may make them more efficient to continue working on the project rather than someone starting from fresh.

HF can be brought in at different stages of a design process[23], or even as problems arise outside of design processes. HF want to be brought in early so they have more opportunity to influence the project but this is not always the case. HF involvement is dependent on the available budget[108] and the client's own perspective on HF[78], e.g. pro-HF clients might be more willing for extended involvement of HF services. HF is normally organized around satisfying a client need[9] and specific methods[40] and actions will be agreed at the project design phase[91]. It is here that the HF practitioner will have to negotiate[10] and sell their offering to the client[113], perhaps in competition with other HF offerings.

There are different project roles[94] in projects. It was recognized as good practice to speak to different people to engage with the details and issues of the stakeholders and users[30]. It was also recognized that different industries[22] have different organization, languages and practices which need to be accounted for to work with them effectively. It was recognized as important to deliver the right recommendations in the right way to the right people to improve the feedforward[26] of recommendations. Rapport[99] also needs to be maintained so recommendations are listened to and HF is seen as approachable and useful.

HF practitioners might do other things than technical HF[29]. For example, they may take part in selling HF services, project management, mentoring staff, training, and accounting. In terms of career development practitioners may be involved in more complex, responsible and management roles as they mature. The capabilities[6] of different members of a HF team will have be managed for short term project completion and staff development in the longer term.

HF organization between companies will also be affected by contracts. Contracts will limit the scope of investigation from the HF perspective. Contracts will also affect the feedforward[26] of recommendations that are made outside the scope of development[112], e.g. a software company may be contracted to update a software interface in a train cab and they might have employed HF services to help them, recommendations about the hardware in the train cab discovered in tests will be outside the scope of development of the software company.

32. It depends...

It depends... relates to the variability in different contexts, and the fact that practitioners and working practices will adapt to suit those contexts. Dependencies will affect the type of work, how it is done, how the results are communicated, and whether they are taken on board. These will include preferences, capabilities, personalities, skills, experiences, time, budget, strategies, project roles, type of problem, the stage of design, relationships and people. There are a lot of project options and a lot of variability[127]. This is negotiated[10] and decided in the project design phase[91] where stability is added into the system, so the client and the practitioner can agree a contract. Below are examples of variances and dependencies in the system of usability practice.

Some projects are open to competition, some are not; some projects are big and some are small; some are additions to ongoing projects and some are repeat business[117]; some may be new clients and others may have familiar working practices with the company. If there is a bidding process[5] the client will have options to choose from. Some clients might want[9] to go cheap, some might want to be thorough, some may feel more of a fit with a company or a practitioner. Some clients might be HF savvy, some naïve; and some HF friendly, some not.

The methods[40] proposed will be dependent on external factors like the client need[9], the sort of problem faced[89], the resources available[108] for the project like time and money; and internal factors like capabilities[6], skills[85], and experiences[24] of the HF practice.

They will depend on the required level of validity[126]: i.e. it might be paramount that everything is absolutely right first time, which will generally be governed by the risk[109] involved in the system. For example, a user test[71] might be short, with a few substitute users on a mock up of the system towards the end of the cycle; compared to repeated user tests, with real users on fully operational simulations of a system in many different scenarios[64]. The stringency of the audit trail[4] will also be influenced by the environment, for example, more designy[20] contexts might not need the detail that safety checks in nuclear power plant input will need.

Project options will be heavily dependent on the sort of issue it is[89], e.g. it might be an attention issue, a workload issue, a physical issue, or a context issue. Even within these the context of the situation has to be taken into account[30]. Unlike engineering issues that have large reliable generalities, like the behaviour of copper and iron; issues in social science will be heavily influenced by the context, e.g. the sort of people, training, expertise, the local environment, task design, interface design, displays, audio, protective clothing and interactions between technologies. Here the devil is in the detail[30].

Project options will depend on the stage in the design lifecycle[23], and HF services may be sought outside of design lifecycles for input into particular problems that arise. The project length[92] may also vary from a couple of days to years of work which will affect project involvement. Project roles[94] may vary as HF practitioners may have to act as a design friend or as an auditor in different projects. Sometimes the client is seen regularly, sometimes not; sometimes the practitioner is working in a team, sometimes they work more independently.

Preferences and established practices also play a role in project options. Practitioners will develop templates[120] of projects and have ideas about what things work well, e.g. some might prefer workshops for giving feedback, some might particularly like task analysis, some might like running experiments, some might like tables and others graphs. Some practitioners might be more open to new methods, look at new research developments and look to adapt their practices[102]. Some practitioners like to work analytically, some like to work in a more exploratory manner.

The way recommendations[100] are communicated[13] also has dependencies. Some clients may want a large report, some may want something more concise. A report[105] can also serve multiple functions and have different parts that are relevant to different people, e.g. the chief executive, regulators and developers will look for different things. The project roles[94] and relationship[104] may influence whether recommendations[100] are dictated or worked through with the client.

People make decisions[17] about projects that have different perspectives[81], political motives[82], prejudices[87] and understandings, so these will play a role in determining project choices as well. In sum there are many different dependencies which will affect the design and the outcome of a project. HF practitioners engineer project options for clients. Sense and stability is added in the apparent fluidity of project options by practitioner expertise, preferences, project templates and methods.

40. Method

This code encompasses all the methods mentioned by practitioners. Methods are central to HF practitioners work. They structure the work, provide capabilities[6] that can be sold to clients[113], and they provide convenient packets of work which facilitate communication[13]. Here methods represent externalized HF knowledge[25] and processes. Many methods can be adopted and adapted for projects, and how this happens has many dependencies[32].

Methods are selected to address a client need[9] which will normally be a certain sort of problem[89], e.g. it may be a workload issue, it may be to evaluate an interface, it may be to plan a control room, or it may be to change a task in response to some new technology. However, there may not be a specific HF method label to put on the work, instead the work may be more inline with general analysis, research and experimentation activity[1]. Depending on the project requirements it is generally recognized as good practice to really engage with the details of the users, tasks, and context of the system under study[30] rather than just apply a method.

Other factors also constrain and influence method selection; not least of all the resources the client is willing to invest[108], which if tight will lead to a compromise and a pragmatic solution[86]. Also, the stage in the design may limit feedback[23], e.g. very early on there might not be a design and so something like a literature review[38] might be appropriate; too late in a design will leave little opportunity to influence the design. Feedback to the client will also be influenced by how close[11] the methods are being carried out, e.g. a workshop[76] will involve clients in working through an issue, clients could observe a user test[71] in person or through video, or a more formal independent review may be quite distant with little communication. The process[90] of the method should fit these wider project factors.

Methods can be qualitative or quantitative[96]. They can be performed in the laboratory or in context[35]. All methods have pros and cons and these should be factored into the design of the project[91] and the scope of the claims[111]. The level of validity[126] needed by the client[9] will also influence what methods are used and how they are integrated. The stringency[116] of the work will in part depend on the level of risk[109] that the client's system is exposed to.

Risk[109] does not just lie in the system being investigated by the HF practitioner. The client is also taking on risk when entering into a contract with a practitioner. Generally it will be less risky to enter a contract with a practitioner that has the adequate skills[85], experience[84], support[118], and tools[121] to apply a particular method successfully. Experience will generally lead practitioners to apply a method faster, more effectively and to a higher standard[115]. Here the practitioner's reputation[106] in applying a particular method and their work in general can help them sell their services[113]. Practitioners and clients will also have preferences and prejudices[87] in methods and ways to approach problems. Practitioners adapt methods to suit the project, the need and the client in reflective practice[102].

Different methods will facilitate different forms of communication[13], e.g. a workshop, observations or meeting[39]; but generally all will lead to a report[105] with conclusions and recommendations[100]. Practitioners advice on what should be sought for in a method used in practice[77] can be found under code 77, method advice.

77. Method Advice

Practitioners requirements for methods included that they add value; are useful; valid; pertinent to the client's need; easy, cheap and fast to use; easy to understand and understandable to the client to some degree; reliable and predictable; and easy to interpret. In practice trade-offs between these requirements will need to be made, and different trade-offs may be appropriate for different contexts, e.g. a well funded project that is safety-critical may have cheapness low in its list of priorities, whereas a small internal project comparing website usability for business opportunities may weight speed and cheapness very highly.

78. Motivation

There are many different motivators or drivers involved HF practice which stem for different people and different contexts.

Clients will have different motivations for seeking HF work. Some may be very pro-HF[87] and look to have a large involvement of HF to improve the quality of their project; some may just want a small contribution; and others may be forced to seek HF advice by regulators[103]. These factors affect HF organization[28]. Clients may be attracted to projects that are cheap[108], that are stringent[116], or that are managed by practitioners with a good reputation[106]. The client will have a need[9] and this might not be a HF need directly, e.g. they may want to raise revenue, adhere to regulations, improve weapons capability, reduce manpower, or gather evidence to support internal political[82] arguments within a company. When communicating[13] recommendations[100] it is important to give the right message to the right person in the right way to facilitate feedforward[26] from HF work. Recognizing there are different audiences for HF work allows for a report[105] to serve multiple purposes, e.g. the chief exec might just want to know the problem has been solved, regulators may want to know about the process and methods followed in the work, and the developers may need to know the technical detail of the implementation.

Practitioners will have different preferences[87] and be motivated by different types of work. Some may be frustrated[27] by working through detailed guidelines, standards and checklist, some may be very analytical and like running experiments, others may be more motivated by interface work rather than physical ergonomics. These motivations might play an influence on the sorts of projects they do, the methods they use and hence the development of expertise[24] in that area. From a wider perspective these developments will affect the capability[6] of the HF organization.

It is wise to realize that people will be coming from different perspectives[81] with different political motivations; and that non-HF people will generally have concerns that HF can help with, but they will not be too interested in HF detail. This knowledge can facilitate communication[13] and feedforward[26].

105. Reports and Documentation

This code has much to do with communication[13].

Documentation can capture knowledge externally[25] which can then be distributed. Reports and documentation can hold advice, procedures, regulations[103]; they can request services and initiate action; they might be the basis for agreement and negotiation; and they may provide a record for decisions and actions for auditing.

Design processes before a prototype is created generally involves the development of some external documentation, from design idea, to design specification, and all manner of communication in between including user specifications, design requirements, etc. Information gets gathered and distilled at different stages of the design process. So documents can act as vehicles to feedforward[26] information to the next stages of design and decisions, and they also leave an audit trail[4] so the process can be reviewed.

Documentations may be wordy, they may be concise, they may contain pictures, and video[72]. They may be written with different audiences and purposes in mind. There are many dependencies[32] which will influence how a document is composed and how effective it is to facilitate communication[13].

Different methods[40] may facilitate different forms of communication, e.g. a task analysis can be displayed diagrammatically, statistics can be displayed in a graph, and users tests can be observed. Documentation from methods will not just contain the project output[93], but will form an argument for why those conclusions are valid and should describe the scope of the claims, so they can be audited[3] and provide assurance[2].

106. Reputation

There can be the reputation of HF in general, the HF organization, the HF practitioner, methods[40] and ideas; and this can be influential in organizational decision making.

Reputation has to be worked for and quality[97] maintained. The reputation of a practitioner will facilitate selling[113] their services as it will provide the client with some reassurance[2] that the work will be completed to a good standard[115] and their recommendations[100] will be sound. The expertise of the practitioner[24] will be linked to their reputation, and greater experience will reduce the risk[109] of a project failing. New practitioners, new methods and new practices that have a weak track record will make a project less predictable. There will be a motivation[78] and prejudice[87] to select practitioners and methods that they have confidence in.

Practitioners and organisations can be audited[3], by clients and regulators, to check their quality which will influence their reputation. Good work will more likely lead to repeat business[117] and attract more work.

108. Resource constraint

This code refers to the management of resources, for example time and money. People can also be considered resources that have different qualities, such as knowledge, skills, contacts and experience. Indeed, knowledge and skills in a particular domain would qualify that person as a domain expert[21]. In design it is important to get the right project roles[94] working together, as people will have different perspectives[81] and expertise[24] to contribute. Here, resource and capability[6] management overlap; whereby the individual or organisational capability[6] can be considered an asset or resource.

Projects hinge on the client's need[9] and it is their decision how to best use their funds, they hold the power[83] in terms of investment. It is important to realise that projects are not all about money. For example, the availability of funds might be a low consideration in making a nuclear power plant control panel safe to use, or to enhance the weapon system controls of the latest military aircraft. Managing resource is to do with the transfer of some sort of value for the client[26]. Where funds are tight recommendations and services should be prioritised[88]; for example, safety concerns will outweigh usability concerns[125]. Recommendations from projects may lie outside the scope of development[112], e.g. the development contract may be funded to develop new software and so recommendations to improve the physical controls involved in interacting with the software might be outside the scope of development.

A balance between resources and options may lead to pragmatic[86] rather than ideal solutions. For example, there may be different risks[109] involved in projects and there may be different levels of validity[126] about claims; the higher the potential losses the more the client might invest to be sure about the claims.

Resources can be loose (allowing redundancy and flexibility) or they can be tight (putting pressure on the system to be streamlined and efficient). Decisions made about resource allocation will impact on system behaviour, for example the length of the project[92], the methods[40] chosen, which could impact on the stringency[116] of the recommendations[100].

Generally resources will be negotiated[17] and allocated at the project design phase[91], based on the client's need[9]. More flexibility in resources for projects may be allowed where there is a good relationship[104] between the client and service provider; and where there is a window of opportunity[128], e.g. they wish to do a gold standard project for marketing purposes, or a recent rail crash might have heightened concerns for safety.

Resource management is important for a successful business. In human factors this will mean streamlining services. For example this will encourage working for the same clients and doing projects in ways which are predictable[109] and are known to be successful; rather than spending time on developing new methods and purchasing new tools that may prove unsuccessful. The business has to concentrate on what the client will pay for, and will generally have to assure[2] them they have the competence to deliver before the client commits to the contract. Human factors practices operate in a competitive market and so their bids[5] for contracts and projects need to be competitive. They will often engineer a project to satisfy a client's need[9] by employing suitable methods[40] and organising the human factors[28] to 'fit' the client's structure.

113. Selling

In practice it is common for practitioners to play a role in formulating projects[91] and trying to sell work to clients, which is beyond the application of HF methods[29]. The projects will be designed with the client's need[9] in mind, it will include options for methods[40] and capabilities[6], and have associated resource costs[108].

There may be some competition in trying to win projects[5], which will not necessarily favour the cheapest offer. There are issues of stringency[116], validity[126] and quality[97] to consider. Certain practitioners may have a good reputation[106] in a certain domain[22] or method[40]. Practitioners may have a good rapport[99] with the client, or may be building on previous work[117].

Selling is tied into communication[13], in convincing clients that certain methods[40] and work-packages are worthwhile; and in selling recommendations[100].

There may be a window of opportunity[128] that facilitates selling, e.g. a client PR motivated project may allow for inflated resources that might otherwise not be available, or a highly publicized accident may allow for extended HF work.

126. Validation

This code refers to the validity of the conclusions, recommendations and results.

The project is based on the client need[9] and this may have certain validity requirements, e.g. a huge risk[109] in safety or large financial loss may mean that the design has to be right first time. This will have to be balanced with the resources[108] that the client is willing to invest in the project. The HF practitioner will try to design a project to meet the client's needs. They might employ different methods[40], and combine methods to improve the validity of their results. Each method has pros and cons, e.g. controlled studies can be performed in a lab[35], but this might miss important contextual variances in the real world. It was recognized as important to get into the trenches[30] and engage with these contextual details for the recommendations to be valid for that context.

HF can be organized in different ways[28]. The closer[11] that HF is to the design phase the less it is thought to be able to cast an independent critical eye over the design which may be important for a valid evaluation. For example, one practitioner said they had a favorite design[87] in a user test and was disappointed when it was not the users' favourite. However, closeness is a double edged sword in terms of validity as it may be important to get close to the design, the stakeholders, and users to make suitable contextualized recommendations[30]. Here we can see that there are different processes in projects, and they should be managed effectively to maximize the quality[97] of the project output[93] under constrained resources[108].

The project output[93] will normally be some form of recommendation[100] and this should have adequate supporting documentation[105] for auditing its validity. The case for auditing[3] may be more important in some contexts than in others. Auditing can take different forms, to audit technical HF practices requires auditors with HF knowledge[101]. In any case, the HF claims and recommendations need to be adequately scoped[111] as the client will rarely invest enough resources for all the HF checks to declare that the system is safe.

6.5.3 Conclusion

This form of data treatment is an explicit part of grounded theory, which is a preliminary stage to selective coding which is represented in the next section. An advantage of presenting the data in a coding network view is that the reader has closer access to the process of data reduction in this qualitative analysis, and they get a picture of the different codes and the web of interrelations that has been built up through analysis. A disadvantage is the complexity of the web does not allow for an easy reduction of sound bites and conclusions. Instead the contribution is more diffuse, with some areas of the web being more pertinent for different messages than others.

6.5.4 Further data reduction in this section

To help provide some concluding message for the content of Section 6.5, which does not come easily from an interrelated web of concepts, we make further data reduction moves on this view of the data. We propose an interplay between five major themes shown in Table 6.6. Although we must remember that it is a limited view of the entire code network. Here, the five themes revolve around the design, implementation and conclusions of HF project work. Different drivers will have an influence in shaping this work, which will include how to allocate resources and the required quality of the work. The adaptable solution whilst being affected by this will also have to fit into the current project stage and structure. Once the work is negotiated and agreed then methods will be employed to gather data, process it and filter it – achieving the main technical information processing work of the project. Meanwhile the quality of work will have to be maintained in light of the resources the client was willing to invest and the limitations they were willing to tolerate. If things have gone according to plan then the HF project should have delivered what it promised and the practitioner's reputation enhanced, which might then feed back into quality, selling and repeat business.

Table 6.6: Five overarching themes and relation to main codes

Themes	Main codes	Description
Information processing	Feedforward[26] Report and documentation[105] Method[40] Analysis, research and experimentation[1]	Information processing refers to the analysis of the HF problem and the communication of the results.
Quality	Assurance[2] Audit[3] Reputation[106] Validation[126]	Quality refers to the standard of work, the practitioner, the recommendations and the process of assessing this.
Resource and structure	Resource constraint[108] HF organization[28]	Resource and structure refers to how projects are organised in terms of budget, time, teams, and reporting channels.
Driving forces	Client need[9] Motivation[78]	Driving forces refers to the motivators for the project, particularly the client's technical HF need but also softer considerations like interests and preferences.
Adaptable solutions	It depends…[32] Selling[113]	Adaptable solutions refers to the way in which projects are designed and solved to fit with the context, client needs, preferences, required quality, etc.

This further data reduction has been developed from the focused view of the code network presented in this chapter. The subsequent section performs selective coding on the entire data sample which can be found in Appendix A2.

6.6 Selective Coding

Selective coding is the final stage of the grounded theory process and involves selecting a code and telling a story from that perspective. Open and axial coding provides a web of interrelated codes but, as demonstrated in Section 6.5, there does not seem to be an easy route through the web. Selective coding aims to provide that route and add a conceptual structure.

The presentation in this section is abstract but still must be grounded in the data. It entails creativity but not in the sense of being fictional, rather in the sense of creating an intelligent solution to solve a problem. The problem here is trying to communicate a stronger and more coherent central story about what is important in the data.

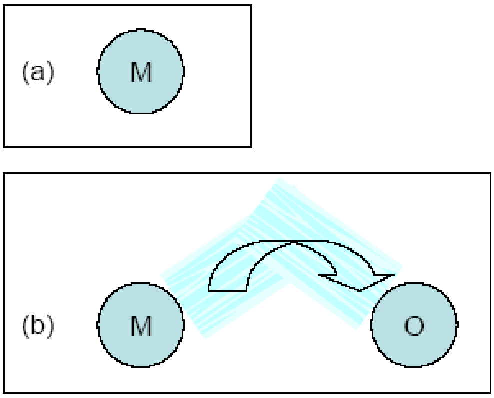
6.6.1 Engineering Client Solutions: Designing the stream with its landscape in mind

This perspective of the data aims to highlight how methods are adopted and adapted in practice, but this is in a wider system of ‘engineering client solutions’. Here we account for the contextual factors that influence HF projects by introducing a model we will call the Planning-Method-Output (PMO) model of HF work: project planning (P), method implementation (M) and project output (O). This perspective brings the code ‘It depends…’ to the fore, as various dependencies shape project planning, method use, and project output.

6.6.2 Expanding the metaphor of ‘downstream utility’ in HF project work

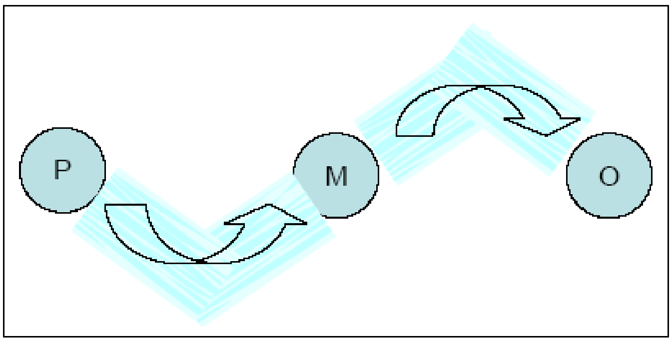
We start by expanding the metaphor of a stream of influence that has been adopted to talk about information and value transfer in usability practice research. Researchers were once focused on the implementation of the method, but research is now moving into looking at how information from these methods can have better transfer or ‘downstream utility’ (e.g. a recent workshop has been held on the subject: “Downstream Utility: The Good, the Bad, and the Utterly Useless Usability Evaluation Feedback, 6 November 2007, Toulouse, France”). Figure 6.2(a) shows the focus on method implementation where ‘M’ represents a method’s implementation; and Figure 6.2(b) shows the focus on a method’s implementation and its subsequent effects on design, where ‘O’ represents the project output. One does not want to just implement a method well, one should want to positively affect the design of the system which happens further downstream from the method’s application – different methods, practitioners, reporting practices will impact the project in different ways.

Figure 6.2: Illustration of (a) the research focus on method implementation 'M', and (b) the focus on method implementation on design 'O' which is further downstream.



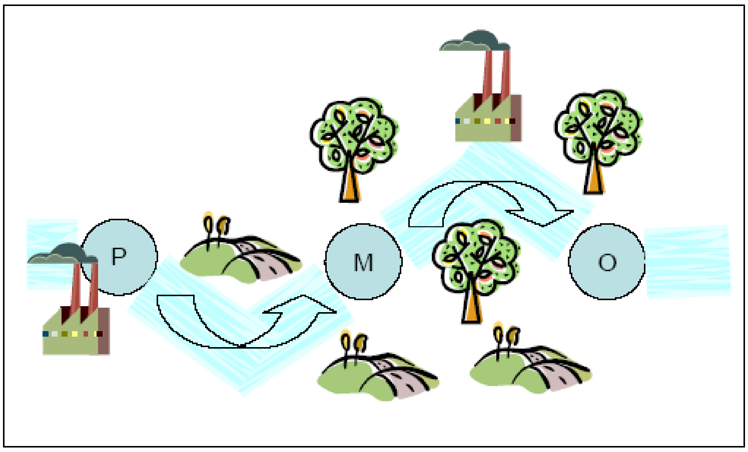
The issue of adopting and adapting methods in practice started with asking about method implementation, but this also moved to issues of downstream utility, e.g. communicating work to clients, and upstream utility, e.g. designing a suitable project for the client. Keeping with the metaphor we take a broader view of the stream. Figure 6.3 shows the project planning stage 'P', how this impacts on the applied method 'M', and how this impacts on the project output 'O', all of these stages have some carry over affect downstream.

Figure 6.3: Illustration of the project planning stage 'P', how this impacts on the applied method 'M,' and how this impacts on the project output 'O' which affects design; all which have some carry over affect downstream.



Projects are not designed in a vacuum; they are designed around the technical, social, structural, communicative, and resource constraints and potentials that already exist. Our current perspective looks at these contextual shaping factors (i.e. the landscape in which the stream flows). This landscape forms part of where the stream flows, what shape it is, and where it has problems in flowing. Figure 6.4 shows the project planning 'P', method application 'M', and project output 'O' linked together in a stream that is shaped by a landscape of context shaping factors that, in part, already exist.

Figure 6.4: Illustration of the project planning 'P', method application 'M', and project output 'O' are linked together in a stream that is shaped by a landscape of context shaping factors that, in part, already exist. The hills, trees and factories represent the landscape where some parts are man-made, and some are naturally occurring.



HF practitioners will need to survey the landscape before they can engineer a suitable route/solution for the client. Some aspects of this route will be negotiable, e.g. the money and time required for the project; some aspects will be non-negotiable, e.g. the client may just want a user test on the final product; some shaping factors will be internal to HF, e.g. the capability of the practitioner and the organisation; and some will be external to HF, e.g. clients want weekly update meetings on progress.

6.6.3 Elaborating the stages of the PMO Model

We now elaborate on the different stages of the PMO Model in turn. We describe the three stages of the stream before the five themes that account for the context-shaping factors:

P: Project planning phase

HF practitioners are first and foremost presented with a client demand, which is either in the form of a potential HF problem or needs to be translated into one. The HF practitioner will then have to design a project that will meet the client's need. For their project, no matter how big, small, expensive, cheap, or trivial they will plan a stream: they engineer a project plan to meet the client's technical needs which might be traded-off with the cost of the project, limited by the stage of design the product is at, shaped by the preferences of the client and practitioner, and communication nuances of that context. The process of engineering a project plan is done within a context that is already there. The HF practitioner needs to devise a stream with this landscape in mind that will satisfy the client and make good business sense.

M: Method adoption and adaptation

There is a wealth of methods that practitioners can choose from. Which ones they use and how they use them will be, in part, determined by the context. Methods provide convenient packets of externalised processes and knowledge that represent some capability which can be sold to a client. Methods will be influenced by the technical problem under consideration, e.g. the client has a workload issue; social issues, e.g. the practitioner likes doing task analyses; structural issues, e.g. the project is at a very early stage and does not even have a prototype; communicative issues, e.g. the chief executive has not got the time or interest to listen to HF detail; and resource potentials, e.g. the client has three months, a large budget, and the consultancy has a variety of workload study capabilities including two different methods and access to a simulator.

O: Output of the project

The output of the project, which is effectively the amalgamation of the route of the project, also has dependencies that should be accounted for. In terms of an endpoint, some clients may want large reports, some may want concise reports, some may want a meeting, and others may prefer a workshop. The output can be explicit and quite detached, like emailing a report; or it could be quite integrative and have a more diffuse effect on attitudes like observing a user test. The output should recognise that there are different audiences and that these different people will have different interests and needs. One should aim to deliver the right message, to the right person, in the right way. One also has to politically manage the relationship with the client, like building rapport, to facilitate the feedforward from the analysis phase.

All three stages of the PMO model are affected by the context. The project planning phase probably has most influence in surveying the landscape and planning a route through it, but this overall plan or structure will be reflected upon as the project develops and as the practitioner learns more about the context.

6.6.4 The Landscape: Five themes that account for the context-shaping factors

As elaborated above the landscape plays a critical role in constraining and structuring the PMO model. Table 6.7 elaborates five themes that account for the context-shaping factors.

6.6.5 From codes to conceptual structure

Table 6.8 relates conceptual themes of the PMO and landscape model to the codes in the grounded theory. This should make the move from codes to this conceptual framework more tractable. However, there is a sense that the analyst has built a theory in mind through prolonged and constant analysis of the data that cannot be completely captured in text, or in logical conceptual moves. These conceptual moves are not completely logical, neat and tidy, but conceptually fit the semantics of the data.

Table 6.7: Five themes that account for the context-shaping factors

Themes	Internal to HF	External to HF
Technical – the problems and issues	Methods and processes are primarily selected on their technical engagement with the issues at hand, e.g. workload methods for workload problems.	Clients will have a need which may be in HF form or may need translating into HF form.
Social – personal and group factors	HF practitioners and organisations have different styles, preferences, and practices. HF holds power through expertise. Reputation, rapport and relationships are important to facilitate work and communication.	Clients hold power through needing to be convinced that investment into services is worth their while. They might have their own motivations and strategies which influence the shape of the HF project.
Structural – coordination, roles, and processes	HF can be organised in different ways to suit a project and budget; e.g. they may have a few people on a project error checking, and they may be a design friend or an independent evaluator.	HF generally fits into wider projects. So wider projects will be at a particular stage, need some particular input, and have specified project roles and relationships.
Communication – information flow	People in HF organisations can support each other through explicit mentoring or just by having people in the same office to ask. HF communicates with stakeholders and users and filters their needs and requirements through to clients and the design process.	Depending on who the audience is should affect what is communicated, and how. Reports can serve multiple functions, e.g. summaries for management, details for developers, and methods for regulators where appropriate.
Resources – capabilities, resource constraints and potentials	HF offers different skills, expertise, methods and tools all of which can be considered capability to be marketed to clients. Redundancy in HF people can perform useful error checking functions, particular useful on safety projects.	Clients will have resources to invest to satisfy their need. The need comes from not having the internal capability to solve an issue, and so they have to seek HF help and negotiate some form of contract to secure the right help to solve their issue.

Table 6.8: Conceptual themes of the model and their link to the grounded theory codes

Themes	Grounded Theory Codes
P – Project Planning Phase	Bidding, HF organisation, Method, Client negotiation, Client need, Selling
M – Method implementation	Analysis, research, and experimentation, Closeness, Communication, Early, middle, late, all. , External knowledge, In the trenches, It depends..., Lab vs Real world, Literature review, Method advice, Practitioner experience, Practitioner skills, Pragmatics, Prejudices, Problems: closed, open, simple, complex, Process, Project design phase, Qualitative and quantitative, Recommendations, Report and Documentation, Reputation, Resource constraint, Risk and Predictability, Selling, Standards, Stringency, Tool, Validation
O – Output of the project	Feedforward, Meeting, presentation, discussion, Recommendations, Report and Documentation, Early, middle, late, all. , Priority, Problems: closed, open, simple, complex
Technical – problems and issues	Analysis, research, and experimentation; In the trenches , Method Problems: closed, open, simple, complex, Scope claims,
Social – personal and group factors	Client contacts, Prejudices, Rapport, Motivation, Other groups, Perspective and perception, Politics, Relationship, Reputation
Structural – coordination, and processes	HF organisation; Early, middle, late, all; Design evolution; Process, Project roles
Communication – information flow	Client contacts; Communication; Feedforward, Language, , Recommendations, Selling, Report and Documentation, Meeting, presentation, discussion, Project output
Resources – capabilities, resource constraints and potentials	Bidding; Capability, Selling, Pragmatics, Practitioner skills, Practitioner experience, Templates, Tool

6.6.6 Conclusion

This section has made conceptual moves to provide a structure and story to fit the grounded theory data. Here we have extended the stream metaphor for design by introducing the PMO model which captures three of the main processes in HF practice, and set this in a landscape of five context-shaping factors that influence how projects are planned, implemented and delivered. The jump from the code network view of the last section and the conceptual framework established in this section is somewhat bridged by making links back to the codes in the grounded theory (Section 6.6.5).

6.7 Conclusion

This section is focused on two aspects of this chapter. The first regards the merits of the different data treatments that have been performed. The second regards the outputs of these data treatments, and tries to resolve what we gain from them in a collective manner.

6.7.1 Reflecting on the three forms of data treatments

Three forms of data treatment have been performed in this chapter. The first was a summary of each interview, which showed the breadth of issues with commonalities and differences between each. The second was a view of the code network developed during the open and axial coding stages of grounded theory, which showed a detailed web of interrelations. The third made more abstract and conceptual moves from the second in selective coding, which developed a conceptual framework and metaphor in the form of a PMO Model and five themes that represented the contextual-shaping landscape.

Taken together these data treatments show that there are different forms of analyses that can be performed on the same qualitative data which can lead to different representations and results. The first has merit in showing breadth, the second has merit in showing an aggregated picture of detailed interrelations between codes, and the third has merit in describing a conceptual framework that tells a more incisive story about the data. Presenting different treatments of the same data demonstrates the potential for different analytical moves, but also brings the reader closer to the actual data and the moves that have been taken in the analysis.

From the point of view of creating insight from the data and communicating this insight in an effective manner selective coding appears most successful in our analyses. In this data treatment we have developed a metaphor and conceptual framework which gives a picture of the data which is more abstract, insightful and simpler to communicate. The interview summaries and the view of the code network do not provide the right level of access or conceptual power for readers.

6.7.2 Reflecting on the outputs of the three data treatments

The three different data treatments have led to focusing on different aspects of the data. At each stage we have identified conceptual themes. However in the summaries of interviews and the view of the code network this thematic step is an extra step. Table 6.9 shows the rough links between the thematic output of the three different types of data treatment. This comparison shows that the themes are roughly commensurate. Working down the rows there appears to be a technical theme of problem solving, information processing and meeting the clients need; there appears to be a softer social and people theme which provides politics, preferences and motivations; and there appears to be a resource theme to do with the allocation of resources, the transfer of value and the structure of work.

Table 6.9: The rough links between the thematic output of the three different types of data treatment in this chapter

Data treatment	1. Summaries of interviews	2. View of code network	3. Selective coding
Themes	Client need	Information processing, Adaptable solutions	Technical
			Communication
			Output of the project
			Method implementation
			Project design phase
	People	Driving forces	Social
	Resources, Capability	Quality, Resource and structure	Structural, Resources

From a comparison of the data treatments we have seen that we have three overarching themes that appear to encapsulate the data: technical information processing and needs; softer social factors, and resource management. These are likely to be under a bigger umbrella of quality management and the dependencies of the project in hand. These thematic moves seem fine in one sense, but we must remember that this is a further process of data reduction and our aim should be to deliver an insightful coherent story to explain the data, not just an accurate one. It is because of this that as a conclusion to this section we refrain from such an extra data reductive step and retain the story told in the selective coding treatment: *Engineering client solutions: Designing the stream with its landscape in mind* (Section 6.6). Here we are reminded that the objective of qualitative analysis is not to provide the simplest, most general set of themes to fit the data; but instead a story that fits the data, is intellectually interesting, coherent, and rhetorically powerful (Halverson, 2002) in delivery. These qualities are important as they contribute to the conceptual message and argument of the research. Here we go beyond an assessment of qualitative analysis that is 'valid' in the sense that it fits the data, and move to an assessment of how much it contributes to the sense-making of the context in question. The extended metaphor and conceptual framework contribute a greater story for sense-making than the other data treatments in this chapter.

In the next chapter we focus on the diversity in interviews, between interviews, and between the two domains we have studied. This focus aims to encourage specific analysis of tensions which may have been overlooked or downplayed thus far.

Chapter 7: Diversity in interviews, between interviewees, and between domains

7.1 Introduction

This chapter reflects on the practitioner interviews performed in the website development domain (Chapter 4) and the safety-critical system domain (Chapter 6). The purpose of this chapter is to focus on distinctions and tensions in interviews, between interviewees and between domains.

7.2 Methodology

The transcripts that were developed in Chapters 4 and 6 were re-analysed with a focus of recognising diversity within interviews, between interviewees and between domains. As the analyst was familiar with the interviewee data, his internalised understanding of what was said by each interviewee and between domains could be coordinated with a rereading of each transcript. Potential conflicts were highlighted and then explored. Quotations demonstrating diversity were gathered and these were grouped in the themes reported in the analysis. The previous grounded theories conclude at theoretical saturation. This means that the perspective of the data that has been developing reaches a level of maturity whereby further analysis and data gathering seems not to develop that perspective further. In practice, it is emphasised that these perspectives are subjectively determined by the analyst's developing view of the data. This chapter, particularly Section 7.5, looks to revive and consolidate parts of the data that show diversity which were not developed in the previous views.

In some sense every interviewee and project is different. We do not argue for a strict definition of what qualifies as a difference, instead we merely note those tensions in and between interviews that stood out as noteworthy. Five of the nine interviewees in the website domain, and eight of the thirteen in the safety domain, checked that their quotations were used accurately within this chapter.

Importantly, this chapter is not a repeat of the analyses in Chapters 4 and 6, although similar issues come through, e.g. communication and cooperation. Whereas in Chapters 4 and 6 the analysis accounted for these tensions in developing a more general account, this section takes them as its focus. Therefore it complements previous analyses.

7.3 Analysis

This analysis is divided into nine themes demonstrating diversity amongst the interviews, and four recognised loose ends that have not played a major role in the analysis of Chapters 4 and 6, but have been reflected and developed here. However, before describing these we reflect on the conflicts within interviews, between interviews and between domains at a more abstract level.

The analysis did not find much evidence for tensions within interviews which could not be easily reconciled within the context of what people were explaining. Interestingly the largest differences appear to be between interviews rather than between domains per se. This leads us to believe that the stereotype of each domain is not always applicable. Like many stereotypes there are trends that seem to persist but they do not always hold. For example, there are design cultures in the safety domain, there are perceptions of high risk in the website domain, there are long and short term projects in both domains, and the need for auditing and keeping a paper trail is not a priority in all instances of the safety domain work.

Also worth reflection is the fact that five interviewees in the safety domain were from the same HF company. This was a multi-sector company working in different industries, and the interviewees from the company had different backgrounds, skills, seniority and industry experience. They all reflected being part of a successful, busy HF consultancy. However, there were differences in views and approaches, e.g. whereas one practitioner was involved in and preferred more design-type projects another was keen on statistical analysis. Practitioners from the company said they were generalists and got involved in all sorts of projects, but there also seemed to be some that gravitated toward specific methods or industries. It seems this is more a difference in the projects than the people, but people and their preferences seem to gravitate towards projects that suit them. These practitioners were from a stereotypical HF consultancy. They provided a range of views within this context between projects, approaches, attitudes, tools and roles.

Throughout the analysis interviewees are referred to by code. Codes 'W' and 'S' represent the interviewees from the website and safety domain respectively. They are numbered in the order they were interviewed within these domains.

7.4 Nine themes

The following nine themes categorise a variety of differences between the interviews:

- 7.4.1 Diversity in the HF/usability market – finding a niche
- 7.4.2 The drivers for HF/usability project work
- 7.4.3 Cooperation
- 7.4.4 Communication
- 7.4.5 Differences in cultures in HF/usability practice
- 7.4.6 Practice – the way things are done
- 7.4.7 Documenting work
- 7.4.8 Risk, usability and safety
- 7.4.9 Different methods used, and perceptions of methods

The variety of differences reflects the pervasive response from practitioners: 'It depends…' because attitudes and practices change with personal views, roles, experiences, projects, and the organisation's place in the market, the client, the domain and so forth.

W8 highlighted the importance of considering the changing circumstances of the environment when reflecting on the developing theme of 'It depends…':

> "…back to our old theme of it depends. […] It's the great pleasure…, I think it's the great art of life. If we only had automatic responses to each new stimulus that comes it can get quite boring. Perhaps it's more interesting to sit down and assess the situation and figure out what it actually needs to succeed." W8

This eloquently highlights that we should be wary of de-contextualised responses and that we should attend to the idiosyncrasies of a particular situation to work out what it needs to succeed. Here diversity and context are not hindrances to scientific investigations that aim to control variables, but they are an inevitable source of interest that need to be considered for successful decisions in a changing environment.

7.4.1 Diversity in the HF/usability market – finding a niche

Towards the start of this project it was decided that two domains would be studied to provide a wider sample base, and provide the potential for creative tensions between the two. These were usability in the website design and safety-critical system development domains.

During the course of the study we encountered a range of perspectives within and between domains. These amounted to discrepancies between categories and what labels to give those categories. For example, my initial proposal was to study ‘usability’ within the website and safety domains. However, on the website side some people were more closely associated with ‘user experience’ than ‘usability’: where the distinction is drawn, user experience is normally a wider umbrella of which usability is a part. Other terms people used included ‘information architect’ and ‘experience architect’ which are more involved in the design side of the work than evaluation. On the safety side, ‘usability’ was not a popular word as those practitioners used the term ‘Human Factors’ because usability was understood to be more about websites, mobile phones and digital kiosks. After some rejected invitations to participate in the study, because people did not do ‘usability’, I adopted the term ‘Human Factors’ (HF) with greater success. Even after this, one potential participant whose professional work seemed to fall well within my remit of who I wanted to talk to rejected my invitation to participate because he perceived himself as a ‘safety’ person and said he did not really get on with the HF people. It was acknowledged by a lot of practitioners that the terminology within the area is a mess, and most are not precious about labels and try to engage with the vocabulary that their clients are using. So the study has proceeded with usability in the website domain and human factors in the safety-critical development domain, with HF/usability as the label to bridge across this divide.

Within the domains there is also discrepancy as the website people I interviewed attended to other interfaces like kiosks and mobile phones. Also, some of the practitioners on the safety side did performance testing, design work and consultancy rather than safety *per se*, even though their work contributed to high-reliability and safety-critical systems. There was a variety of HF/usability roles in the market place, within and between domains, which these quotations suggest:

- W2 reported that they rarely do just evaluations of products; they normal contribute to the design.
- W8 stated that they do not do design and focus on independent evaluation.
- S2 remarked that their organisation markets itself as independent, scientific and rigorous.

- W6 remarked on the more trendy culture of digital media agencies that design sites and the more academic culture of pure usability firms.
- W5 said they do user experience which includes the wider business proposition of the site as well as the nut and bolts of usability.
- S5 considered that he had actually been in the role of organisational change rather than just the technicalities of the project.
- W3 said they had ownership of their product which is different to consultancies.

These quotations show differences between independent evaluation and design; practitioners involved in rigorous methodologies; practitioners involved in organisational change; practitioners that have ownership of the site, whilst others are in advisory and consultancy roles; perceived differences between trendy and academic cultures, and different sorts of focus on: business, usability, performance, and safety. What holds this work together is the higher level goal of providing HF/usability support in design and business decisions.

7.4.2 The drivers for HF/usability project work

Different practitioners reported different ways that they would get work. For example some did mini-evaluations to show companies that there could be improvements for a particular product or service or that it lagged behind their competition in some way, and many relied on repeat work from clients. Two extremes include W1 who did a lot of pitching and found work hard to win, and the many other established consultancies that received recommendations and offers by word of mouth. In some cases this meant that they did not have to actively seek new work. This difference might have been influenced by W1's lack of experience versus the experience of well practiced practitioners; or the state of the market in which W1 was working as it was near the dot-com bubble bursting (around the year 2000) versus the relatively more established and buoyant modern usability market; when this research was conducted (2005-8).

W1 also found it hard to cost-justify usability which he attributed to his lack of experience and expertise in the area; whereas, for example, W8 and W9 did not find cost-justification an issue. W9 referred to a wealth of case studies that they would use to show previous successful work. W8 went on to comment on the insecurity that the usability field seems to have with this issue:

> "I don't know any other field that works so hard to prove its worth and it strikes me as a sort of insecurity about itself, […] An area that uses techniques that are parallel but not

> the same as usability is marketing, and if you.... nobody, no major corporation would ever doubt that understanding how their product is perceived in the market place will [help] their business, and similarly we find that any organisation that understands that formulation understands how important it is to have a good picture of how the product works once it's in people's hands. So I personally see that as a non-issue." W8

Practitioners referred to a range of reasons for why clients sought usability services. Most identified this with some underlying motivation toward revenue generation. However, some specified examples that were not about money, e.g. to comply with legislation, to conform to their own internal procedures, to fulfil contractual obligations, as part of a media showcase, to improve safety and performance, to do the same as competitors, because it is fashionable to do so, and for political reasons like gathering independent evidence to support an argument.

Practitioners also gave a range of ways that they were involved in projects with most saying that they give input as and when it is needed, or just when they can. W2 reported that the usability person was always the first person appointed on to a project team in their company which designed websites, whereas many others perceived that clients saw them as a bolt-on in the project life-cycle. S5 pointed out that it is not always useful to consider HF/usability input as input into a design lifecycle as some systems might just have HF/usability issues where practitioners can help. Two examples of this include S12 who talks about providing a client with performance information to inform their purchasing decisions, and S9 who was involved in a project investigating the causes of industrial accidents at Government level. In both these cases the idea of contributing to the traditional conception of a design lifecycle does not fit, as nothing is being designed. Instead, these practitioners are put in situations where they are able to help the client understand a situation better and make an informed decision.

7.4.3 Cooperation

There were different varieties of cooperation referred to by practitioners. W1, who was in a company experiencing difficulties, found cooperation in working relationships poor as programmers and graphic designers changed his designs without consultation. This contrasts with W2 who worked in a place with set procedures where people respected each others' roles and expertise. Respecting different people's roles and expertise is important for cooperation and increases the potential for the attitude to be reciprocated. Acknowledging this S6 spoke of a previous job where she tried to hold back some of her HF/usability colleagues from designing logos with their redesign proposals because she was clear it was a graphic designer's job and not their's.

Practitioners had different roles in design and evaluation, and different perceptions about how the two combine. At the extremes there were design agencies that design whole websites, and then there were consultancies that prided themselves on the fact they do independent evaluation and no design. There were also organisations in between that would do both; by either taking on different roles for different projects, or having safeguards in place so the design team kept their distance and independence from the evaluation team. Considering the relationship between design and evaluation W7 mentions her desire for establishing company procedures to ensure the person testing a design is not the person that designed it, because of the potential for implicit or explicit bias to influence results.

7.4.4 Communication

Communication is closely related to cooperation. Related to their cooperative states W1 and W2 demonstrate the difference in frequency and styles of their communication. These quotations show disconnect in W1's design environment with reference to 'shipping it out' and W2's close working relationship with her clients:

> "you design it, you ship it out to another team, either they're happy or they're not, if they're not happy then you argue with them - sometimes they take your ideas onboard and sometimes they don't" W1

and

> "…it's developed with them. You meet with them at least once a week, whether it's by phone or email, I mean we email back and forth all the time. […]" W2

S11 also talked about having frequent communication with her client when on placement for the project. Most practitioners would say the frequency of communication is dependent on the project, which seems to span across both the website and safety domains. Integrative design projects have more frequent communication whereas detached evaluation projects can be performed with limited communication with the client.

The frequent communication in design resonates well with Simon's (1969, p. 200) 'Parable of the Watchmaker'. Simon uses the parable of the watchmaker to argue that problems will be solved faster if a number of small, stable, intermediary steps are taken towards a solution rather than risking one big jump. In the parable he compares two watchmakers with different styles of working. One tries to build the watch in one big turn, the other divides the task into smaller tasks which can be completed. When building their watches both of them keep getting disturbed, which causes the first watchmaker to start over and the second watchmaker to pick up where he left off. So, when there is frequent communication in design the client can give input earlier, before the project has gone too wrong for too long.

7.4.5 Differences in cultures in HF/usability practice

Work practices are also affected by culture and there were different cultures experienced in the interviews. For example, practitioners were wary about admitting knowledge gaps, whereas others felt confident in saying when they were not sure. One practitioner recalled a pitch where they said they did not know the answer to the client's question and would need to think about it. This honesty seemed to be something the client was attracted to in a working relationship and they won the contract.

The treatment of staff seemed to vary from W2 talking about a previous job where the company undersold projects and overworked staff, to her now being in a more comfortable environment where projects were managed fairly.

Also, some practitioners were clear that their companies only sought to hire experienced personnel. Other companies were more willing to nurture HF/usability practitioners earlier on in their career. For example, W8 and S8 seemed to appreciate the role of a mentor in assessing the capabilities of an individual and what support they needed to develop further. It was clear that less experienced staff valued this guidance and opportunities to work with more experienced staff. This would allow development so they could tackle a wider variety of practice more confidently.

7.4.6 Practice – the way things are done

There were many differences reported between projects. In terms of length, some pieces of work might involve giving informal input into a design over a couple of hours to a control room upgrade lasting six years. This difference was not domain dependent.

Practitioners and domains differed in the methods they used. It was clear that there needed to be a market and demand for a method to be viable for a business solution. Both S2 and S3 said that they had not done modelling but their company would turn their hand to it if financed by a client. There were differences between the methods that both domains used as W8 reported usability testing to be one of the most popular methods whilst S3 said that they do not do much of it. However, the perceived demand for methods can also change within domains as S10 did not see a practical role for research on situation awareness whereas S13 reported it as a buzz word within their niche, which provided a 'foot in the door' for other work. In summary, it is for the practitioner and HF/usability organisation to equip themselves with methods, tools and practices to make themselves a viable enterprise in their market niche.

There was a range of opinion on the use of quantitative techniques for human reliability in the safety domain. Some practitioners thought you had to be very careful when handling and manipulating numbers from dated and limited human reliability databases, whereas others were happy using them but would qualify their claims. These sorts of human reliability quantitative techniques were not mentioned in the website domain and the majority of the safety domain participants did not have expertise in these techniques.

Statistics were used in both domains although their prevalence and role varied in both. Two extreme views are highlighted between W5 who said that he had never quoted a single statistic whilst being at the company and that his work was about demonstrating business and design improvements from sharp insight; and S2 whose work mainly consists of running statistical experiments. Figures did seem more prevalent in the website domain in terms of web metrics. The use of experimental approaches and statistics seemed more prevalent in the safety domain.

The reporting style for project work varied from practitioner to practitioner, and between different projects: W5 reported giving the client full colour bound copies and a CD with video outtakes so the client has something that looks 'pretty' which they can walk away with; S2 reported having a very academic style report with method, results and a discussion section; S7 proposed design solutions in picture form as this communicated the issues easily and concisely; S12 emphasised making how to exploit their research results explicit to the client; and W4 admired the use of quotations in a usability report he had read.

7.4.7 Documenting work

Different contexts put different emphasis on the need for documenting processes, decisions and communication. The trend suggests that this is more important in safety industries but this does not always hold. For example, S1 reported that much of their communication is done in screen shots, and that an overly formal record of detailed decisions would hinder the ‘ebb and flow’ of design. In contrast S2 emphasised the need for an audit trail, S3 took it for granted that everything is documented and S8 said that it is often a requirement to have auditable records for big clients who are very assurance driven. Rather than a distinction between website and safety domains *per se* the need for documentation appears to be more to do with formal evaluation and high risk systems on the one hand, and design and lower perceived accountability or risk on the other.

7.4.8 Risk, usability and safety

There is a trend toward associating the safety domain with higher risks than the website domain, but this is not always the case. For example, website clients may have multimillion pound systems which have a high perceived risk:

> “I mean I wouldn't be the one talking to our director if suddenly we weren't selling […] it's just too big a risk, I mean, we're talking thousands and thousands of pounds.” W6

Also, HF in safety may be performing a contributory role to a project where they are not directly accountable for the safety of the system. This lowers the perceived risk in their work even though they work with potentially dangerous systems:

> “We don’t, if I’m really honest with you, we don’t get involved in the safety side of things, the reason being is that we’ve got other groups within our business group to deal with that, so our ergonomics group tends to do all the safety things” S13

S3 recognises this tension between the different perceptions of risk in both domains:

> “it depends how important it is that you do get absolutely everything on the first time. So to me it seems awful, but if we get the design of the interface wrong there could be a massive accident, but if it just means that somebody is slightly annoyed because they don't like a bit of functionality on a mobile phone or something then actually... well I guess the client, for a big client that is trying to make money it still is important, because they want their product to be good.” S3

Here we see that the perceived risk depends on the role and accountability of the HF/usability practitioner, and the sort of system they are working with.

In summary, Section 7.4 has highlighted that there is a rich variety between interviewees and between contexts. This further illustrates the variances of practice when practitioners respond; “It depends…”.

7.4.9 Different methods used, and perceptions of methods

Different methods were mentioned between interviews and between domains. We present these methods below by domain and comment on them briefly. They are not described in detail but are included to give an idea of the methods that were mentioned.

This is not a comprehensive set because the interviews were not aimed at eliciting every method that practitioners used. However, the interviews were about methods, so it seems reasonable to assume that prevalent methods would be mentioned by interviewees.

In the website domain, user testing, Heuristic Evaluation and expert reviews were the most prevalent methods discussed by the interviewees. Through further probing it was found that interviews and questionnaires were sometimes combined with user testing. The analyst believed that this was initially overlooked as the main usability method was 'user testing' and these other methods were subsumed under it. Card sorting was mentioned by a couple of interviewees but only one had experience of doing it. The use of personas was mentioned by only a few interviewees but one of these said that they developed them informally, kept them at the back of their mind, and did not share them with other members of the team; and the other said they were just used for pitches. The latter use of personas is detached from the design and the former use of personas almost seems too informal to warrant the use of the term. Similarly, on the few occasions Cognitive Walkthrough was mentioned it appeared these were only at the level of walking through tasks rather than applying the specific questions that the method prescribes. AB testing was mentioned by two interviewees but only one of these did it. Three interviewees mentioned doing focus groups, and field studies were also performed. Wire frames were related more to people involved in design and information architecture roles. Eye tracking was also mentioned but the interviewee who discussed this did not do it and was just voicing concern over the true utility of this approach. In summary, the main methods used by interviewees include user testing, Heuristic Evaluation and expert reviews with questionnaires and interviews mixed in.

In the safety-critical system domain a wide variety of methods were mentioned. The most common underlying method involved some form of task analysis technique, on which other methods were built upon. Analytic methods for assessing risk and safety included risk assessments, root cause analysis, fault tree analysis, hazard analysis, HAZOP, HEART and TRACER. More empirical methods included experiments, user tests, simulator trials, and field studies. Data was also gathered and analysed via surveys, interviews, focus groups, expert panels and work shops. Data from accident reports were also analysed. Design type methods included prototyping, 3D modelling, mock-ups, static story boarding and wireframes. Link analysis was a specific task analysis method mentioned. GOMS was mentioned, but only as a method in the realms of academia. Goal Structuring Notation was mentioned as a newly adopted method to help argue the case that a piece of HF work had been competently administered. Social Network Analysis was mentioned as a method being explored for future business potential. Workplace assessments were common in HF work, and workload studies were also performed where appropriate. Situation awareness metrics were developed, and standards and checklists were also developed and used. Safety culture assessments were also performed. Only two of the HF practitioners mentioned performing quantifiable human reliability assessments, whilst other practitioners only discussed these methods in terms of their inherent limitations. This wide variety of methods was not consistent between interviewees but depended on the work the practitioner did.

The perception of the concept ‘method’ also seemed to vary between practitioners, which served a number of functions. Method labels seemed to provide a recognisable term for a process of working or set of activities. Methods need to be adapted to some degree to fit the context. However, they provide enough abstraction to generalise to different instantiations of that method’s use. The boundaries for what can be considered a legitimate application of particular method labels is unclear, e.g. Heuristic Evaluation and expert reviews seemed to blur. Method labels mask the complexity of method details and adaptations for novices. These ‘methods’ can be more easily communicated to others and sold to clients. There was some recognition that a method label added legitimacy to activities, e.g. one practitioner did not recognise ‘doodling on his pad’ as a method to support his sense-making of situations but we discussed the possibility of giving it an appropriate label and hence more legitimacy.

7.5 Interesting loose ends

The following interesting loose ends summarise insights that emerged at different stages during the interviews. They stand out as classes of insights that warrant special attention that could be expanded in later research.

7.5.1 Different classes of problems

This insight was developed after talking to W5 who paid special attention to the business proposition of a website. If this was wrong then the website would most likely fail even if the interface was good:

> “I: The other thing that I'm getting across from our conversation is how you view a website as, perhaps a traditional sense is a website of how you put the menus and the buttons in the right places, whereas your conception of it seems like more something that is used to communicate a brand a message.
>
> R: Yeah, absolutely... that's exactly what a website is. You've got to get all those interface elements right, but if you're working with good designers and you do proper usability tests and do expert reviews and you work with good information architects then you will get those things right, but if you get your initial communication proposition wrong then your website is buggered. I mean think of Friends Reunited or an online dating site or something like that, they are powerful marketing concepts that need to be communicated to people and the way that that service works, that's part of the user experience as well. If we're starting to do a new service for a bank online, I mean banks are now moving all their services to online, how do we communicate that, why should I do it online, why don’t I do it over the phone and get someone to do all the work for me, how do I put that across to someone, and if we don't put that across people will carry on going to the phone centres that will cost the bank millions. It's the wider experience but going down to the nitty gritty of where that button on a given page.” W5

W5 appears to hold special regard for the higher abstract business goals, which are different to the ‘nuts and bolts’ of the interface. This is different from Nørgaard and Hornbæk’s (2006) observation of usability tests where analysts appeared to prioritise usability problems over problems regarding utility for the user. In both observations we have a distinction between the nuts and bolts of usability, and then the utility to the user and the higher business goals. These different classes of problem and consulting issues will need to be managed with the client. Research in this area includes that of Uldall-Espersen (2007) who identifies five perspectives of usability which identify different types of problem; including low level interaction issues, task issues, product issues, context issues, and business issues. Uldall-Espersen (2007) suggests that these different perspectives can agree or conflict, have different relevance to different stakeholders, and have different prominence at different stages of the design process.

7.5.2 Tacit contributions, transitional systems and change agents

Following on from the observation above, that there are different classes of problems, S5 supports this by stating that there are a very limited number of problems which you could apply methods to in a simplistic way:

> “Now there may be some very limited questions, for example; lets say you’ve got people carrying water bottles in an office, they are carrying too many, so you can say, ok, we weigh the water bottles, we see how much needs to be carried on a trolley, we provide the trolley at the right strength, problem solved.”S5

This leads into his reflection on more complex problems whereby the contribution is as much about the process of doing the project work as the final output, and maybe even more so in some instances. S5 introduces a story which he associates with Lisl Klein’s research, which illustrates that project work is not just about the rote deployment of methods but has real substance in the process of talking to people, data gathering, suggesting alternatives, discussing issues, etc. in the client's workplace:

> "Now I think back to this navigation thing, and I can remember starting on this project and doing all the classics, ergonomics type things, because we thought the problem revolved around the display of information, and I worked on this for the best part of twelve years. Thinking about it subsequently, it was very little to do with the display of information, very little to do with it at all, but what it was to do with was a combination of two things: one was training, and the other was organisational change, and we were actually acting as change agents. Now it wasn't until many years later, that I realised that and there was a whole process, there was a lady called Lisl Klein who's got a good example about this: if you want to meet someone, you don't just whip round the telephone directory saying 'hello, can we meet?', what you do is you take your dog for a walk in the park, and when the dog jumps in the young lady's lap, you say 'ah, excuse me can I have a treat for my dog?' at which point you then proceed. I think that was her example, and I think it's the same in ergonomics, if you go in there and think, ah, let's get the telephone directory and do this, I think you might have missed the point, so you carry out some sort of strange gavotte and then at some point: "ah, we're happy now," and you say, "you're happy now?" "Yes, we are happy now," and when you first encounter this it can be quite odd, because you think: I'm not happy, why are you happy?" S5

This perspective seems very interesting in that the contribution of HF/usability project work, in some instances at least, is not confined to the output or the report at the end of the project. This relates, somewhat, to the observation by W4, W7 and W8 that clients greatly benefit from watching user testing as seeing their product perform with users is an enlightening experience which would be hard to replicate through a project report. The difference in this case is that these practitioners recognise the indirect contribution of the client observing user testing: it provides facilitation for change in terms of attitudes and ideas. Somehow the quotation by S5 above seems to go further, because he had not recognised the contribution he was making and presumably his employers were none the wiser about this tacit role either.

To elaborate on this seemingly tacit role we refer to Lisl Klein's reference in the quotation. Klein (2006, p.1165) attributes the story about the dog to Harold Bridger. The point of the story is that the dog represents a 'transitional system', i.e. it indirectly provides the opportunity for exploring the potentials for change. In this way S5's perspective of project work is that of a transitional system. The HF/usability practitioners work indirectly leads to acceptance of new possibilities and new systems through talking about people's issues, listening to their concerns, thinking through possibilities with them, etc. This appears to be the reason why the client is happy that they have accepted the changes taking place even when the practitioner has not completed a final analysis or report. Here the ebb and flow of social discourse and exploring project issues with people in context provides more of a contribution than the output of the project.

The contribution of the project work might be quite indirect from the one it has set out to achieve, and indirect from the final analysis and report, but nevertheless significant:

> "I: But the, so it's like a by-product, so you've solved the problem and you've been working with people to change the circumstances?
>
> P: Just think of the dog thing, you know, what you do isn't always the direct way of doing it, that is sort of the point. Just because you think you are doing that, doesn't mean that other people care that you are doing that, what they want is something else, you actually, things sort of swirl around a bit, if they are happy, well …
>
> I: Yeah, this is a very different concept of the academic standpoint of selecting a method, knowing that the method has been proved to be valid, because it is in some journal paper that it is valid, so you can apply it and get valid results from it and then you leave and that's kind of, that's the phone book isn't it?
>
> P: Well, yeah, this is where I part company with them as I say, because they seem to have very narrow view of how the world, how an organisation within that world actually operates." S5

Taking this perspective it appears that the traditional academic conception of defining the problem, selecting an appropriate method, performing the method validly, analysing the results and delivering recommendations is a closed loop which does not take account of the indirect consequences of project work, which facilitate change.

7.5.3 Emotional HF/usability practice

Norman (2004) argues that affect in designs can play important functional roles. For example, people who like a particular product will overlook its faults and spend more time learning its functions. This could be caused by it looking attractive or being fashionably desirable. Such 'soft factors' can also be recognised in the interviewee data. For example, W5 refers to the importance of having reports that look 'pretty', presumably because it might be more attractive and engaging to the client, and alludes to the importance of having something tangible that the clients can 'walk away with'. Interestingly, this marked handover point contrasts with the more subtle contribution discussed in Section 7.5.2.

W8 also makes comments on the theme of emotionally related phenomena in usability practice work. He refers to the emotional journeys that staff can go on when entering the usability field for the first time – so they can be supported and mentored appropriately; he refers to the consideration given to the designer's emotions in evaluating products – as a purely negative report would be dispiriting; and he refers to the connection between the practitioner facilitating a user test and the participant – so the participant relaxes and ‘opens up’ to give good quality feedback:

> “I don't have anything against the academic approach it's certainly important for certain kinds of research projects, for Nielsen style small scale discount usability projects what seems to overwhelm consistency is opening up users quickly and relaxing them and the truth of the matter is you'd probably be a brilliant facilitator for a particular user that I would completely fail at opening up, and vice versa, and in that sense diversity seems to work pretty well.” W8

The issue of engaging with participants so they open up and give good quality results also resonates with S5 who stressed the stage in a project where you would ‘make some tea’. This would be a time to sit down with the different people that worked with, and were affected by, a particular system or issue and truly engage with what they have to say:

> “I think lately, I think then you’ve got to start making the tea, […] you’ve got to work out the details, you got to sit with the leading people and the cabin boy, everyone else and say, tell me about what you do! And if you aren’t prepared to sit there, I’m very happy talking to [company], and I think they know, I was on [vehicle] last year and was sitting with the captain and laughing, and then you go down and talk to everyone else, and they all know I want to be there, and you’ve got to have that, and you are interested, if you don’t care about that detail, you shouldn’t be there. So there’s a twin thing, you’ve got to have that academic ability, but if you haven’t got the sympathy of the poor soul of the person with the problem, then you shouldn’t be there.” S5

Here we have three instances where the affect in HF/usability practice has a functional role to play in terms of getting results and giving results to clients. The functional role of affect in usability practice is seldom a topic for research, if at all, but it appears to have a functional role to play for the emotional journeys of practitioners, clients and users involved in research.

7.5.4 Community Acceptance in HF/usability practice and Academia

Being immersed in an academic context and investigating how HF/usability practice operates it seems reasonable that the analyst would reflect on the similarities between the two. We reflect on three themes that have resonance between academia and HF/usability work:

1) Standards and methods

Academia and HF/usability practice both perform research activities. Both contexts have their own accepted methods and standards that shape their research. Both have ideal research objectives and pragmatic considerations, but there are often different goals and pressures on their work.

2) Report structure and documentation

Academia and HF/usability practice research will commonly involve engaging with a problem, using some method, doing analysis, coming to some conclusions, and writing a report arguing why those conclusions are valid. In some HF/usability practices the reports are based on the academic model of introduction, method, results and conclusions.

3) Peer review and community acceptance

More prevalent in, although not restricted to, the safety domain was for subject matter experts to review the method and recommendations of HF/usability work. This relates to the peer review and community acceptance of work within academia. For example, when a journal paper is submitted it will be reviewed by subject matter experts to make sure that the literature has been well represented, a problem has been appropriately identified, methods have been used well, conclusions have been arrived at validly and the argument is sound. These senior subject matter experts are in a good position to critique because their knowledge of the area should be sufficiently mature for them to evaluate the claims and approach. Similarly HF/usability work is sometimes organised and checked by other HF/usability experts. Here they will check the standard of the work, which people naïve to the area could not do. Some companies, like the Rail Safety and Standards Board, will employ knowledgeable people to contract work out to so they can monitor it appropriately.

Community acceptance can also come from domain experts that know the operational detail of the product or service, as they might be able to foresee problems which non-experts cannot. For example:

> "my view has always been the best human factors team is actually two people, one is the operational person who has the detail and the other is the HF person, but the operational person will always have to be in the driving seat because they know the detail, they know how people could get killed or whatever, […] the thing that kills people is the detail." S5

This checking with subject matter experts adds to the validity of claims that might be made in both academic and HF/usability practice domains.

Similarities between academia and HF/usability practice do not always hold, but the idea of community acceptance and peer reviewing seems important for quality control. This seems particularly important in areas with complex problems and high uncertainty.

In both of the domains, I have moved from a more naïve position that people apply methods rigorously to find 'the right answer', toward a view that 'the right answer' is relative and that the standards that govern this are rooted in community acceptance rather than objective measures. For example, in assessing a research project we might note the problem, the suitability of the approach, whether there are weaknesses in the methodology and whether these have been acknowledged and accounted for, whether the approach has scoped appropriately, the quality of the data gathered and the analysis, and whether the conclusions are tractable from the data, seem sensible and are convincing given the context. More work could be done to investigate the community acceptance of HF/usability work.

7.6 Conclusion

This chapter has focused on comparing views within interviews, between interviewees, and between domains. These comparisons are part of the grounded theory analysis; however, their detail may not be included in the final output as discrepancies are resolved and lesser supported details are not developed into themes. By focusing on conflicts we get a better idea of the variety in the data. As previously noted, the classic grounded theory description developed in earlier chapters subsumes the variability rather than describes it (Table 3.2, Chapter 3 shows contrast between subsuming and describing variability). Describing variability has been a focus of this chapter.

Nine themes were recognised and described to demonstrate variety in the interviews. The variety reflects the common practitioner response: 'It depends…'. We first looked at the variety in the market place which ranges from evaluation to design, from focuses on scientific rigour to business insight, and from usability to safety. We also saw that clients employ HF/usability services for political, performance, procedural and safety as well as financial reasons; none of which are completely independent. HF/usability was sometimes a bolt-on and other times the managing component. Communication and cooperation were often organised differently between design projects and projects involving independent evaluation. There were also different cultures in HF/usability organisations, e.g. some practices nurtured practitioners toward the beginning of their careers whilst others would not. The differences between documenting practices was discussed, as were the links between perceived risk, safety and usability.

The four interesting loose ends stick out as moments of insight that warranted special attention. They were not developed in the grounded theory because they did not form part of the march toward the integrated and general account that was developed. Interestingly, giving a proper account of these loose ends reinforces their significance, which did not previously exist. This qualitative analysis gives a certain perspective of the data which is explored, developed and consolidated. What matters is whether these loose ends provide a critical challenge to the developed perspective. The four loose ends that have been highlighted in this chapter are not challenging in this way. As a reminder they include the observation that there are qualitatively different types of problems in HF/usability work; that HF/usability project work might have important indirect contributions in practice; that emotion is likely to play an important functional role in HF/usability practice; and that community acceptance appears to be an important phenomenon for ensuring that standards are upheld in practice.

The next phase of the thesis looks toward established theoretical frameworks as leverage for exploring the data in a top-down manner.

Part III

Top-Down: Application of theoretical frameworks as leverage

This part accounts for the top-down application of established theoretical frameworks to further explore systemic descriptions of the context. Two frameworks are applied in turn: the first is Distributed Cognition (DC), and the second is Resilience Engineering (RE). The DC leverage gives us a complex computational view of the system, and the RE leverage gives us a functional view of the system. Both views show that methods affect and are affected by wider factors in the HF/usability system. In the DC analysis we develop an explanation of the computational effect of the social factors, information flows, artefacts and tools, the physical space in design and the evolution of practices. In the RE analysis we develop an explanation of how functional parts of the system affect each other in non-linear ways. Here the practitioner must make choices which ‘positively resonate’ with the internal and external demands of the system so performance can be maximised under constrained resources. A functional network of HF/usability practice is then developed in the form of a FRAM analysis (Hollnagel, 2004).

Chapter 8: Distributed cognition literature review

This chapter introduces the Distributed Cognition (DC) theoretical framework. Chapter 9 uses this as leverage to explore the combined data and analyses from the website domain (Chapter 4) and the safety-critical development domain (Chapter 6). After an introduction (Section 8.1), we outline 4 core tenets of DC (Section 8.2), and then show how different representations, analyses, and themes manifest themselves in different DC studies (Section 8.3).

8.1 Introduction

This chapter moves from the data-driven grounded theory analyses of Chapters 4 and 6, and uses the Distributed Cognition (DC) theoretical framework as a theory-driven leverage for understanding the data. In this regard this analysis is more top-down than bottom-up, although in practice insights come from somewhere in between. In Miles and Huberman's (1994) terminology this analysis is much tighter than those more inductive and loose analyses that have come before. Here we are using a pre-existing conceptual framework to help provide assistance with what we can 'see' in the data, hence the theory is used for inspirational purposes. The fact that patterns that occur in our data are recognised in more general theory provides some vertical validation because similar phenomena have been observed elsewhere. For example, communication bandwidth might have functional implications on the bridge of a ship such as building trust through co-present communication (Hutchins, 1995a, p. 232), in a similar way communication bandwidth would have trust implications in usability practice.

We explain DC's selection as a theoretical level from two different levels of reflection. From the first more superficial level of reflection, DC was selected as a theoretical leverage because connections to the theory were evident during the grounded analyses (in Chapters 4 and 6). For example:

- **Communication** was important in relaying usability work to non-usability experts;
- **Coordination** was important in terms of organising usability projects so practitioners did the right thing and delivered on time;

- **Project roles** were important as different people with different skills and experiences work together in the design process;
- **Data transformation** was important as clients' problems changed to plans, to methods, to data, to recommendations; and
- **Representations** were important as practitioners made comment about using big reports, short reports, presentations, video and observation to communicate to clients.

These have proven to be significant in the data and strongly relate to DC theory. Indeed, the proposal to consider usability practice as a plug and play component in a wider system of design and business processes fits very well with DC theory (Chapter 4). This more superficial account of data linkage is true, but it does not engage with the subtleties of how the analyst recognised DC as a potentially appropriate theory to relate to the data. It also gives the impression that theory inclusion was a more discrete and deliberative process than it actually was.

Reflecting more deeply on the status of the theory's link to the researcher and the analysis we believe that researchers will inevitably come to a situation with some established ideas (Miles & Huberman, 1994, p. 17). We take the view that the lenses that colour our perception cannot be simply put on or taken off at will, instead they are more or less prevalent. As qualitative researchers we need to be aware of the lenses that we wear and how the lenses shape the way we see the world.

Being self-reflexive and transparent is especially important in qualitative research because the analyst is in some sense part of the interpretive processes. In the present case, the analyst is interested in, and has done extensive work on DC. This involved analysing the London Ambulance Service control room in terms of DC (Furniss & Blandford, 2006) and developing a method for applying DC in the same project (Blandford & Furniss, 2005). This method was subsequently applied to an agile software systems context toward the beginning of this research project (Sharp, Robinson, Segal, & Furniss, 2006). So, DC theory was familiar and readily available during much of the analysis reported in this thesis. In the sense of the theory as a tool, it was 'ready to hand.' The theoretical links between the data and DC theory has been consciously inhibited, so as to keep a separate opportunity for bottom-up analysis, and then a more explicit stage for a top-down analysis. However, the influence of DC forms part of the analyst's interpretive framework and so its effect could not be eliminated.

Indeed, at times, DC theory and concepts have appeared very applicable and so it is a welcome opportunity to be able to turn our attention to this perspective. It should be noted that this is just one theoretical framework that could be used on the data, we do not claim that it is '*the* right one' or the only one. However, we do hope to show that it is '*a* right one,' and a useful one for explaining the data.

The aim of the data treatment in this chapter is to further refine the analysis of the data in DC terms. When we refer to data here, we refer to the data and the analyses across both the website domain and safety-critical system development domains (how we move from different data and analyses is covered in the Method section). It is believed that through successive data treatments we can develop a better understanding of the data from different perspectives. When using a theoretical framework to help 'see' the data in a new light it should emphasise some features and de-emphasise others, whilst providing a vocabulary to construct and describe the picture.

8.2 Core tenets of DC

This section covers 4 core tenets of the DC framework.

8.2.1 The 'complex cognitive system' as the unit of analysis

DC is a theoretical perspective which views its unit of analysis as a 'complex cognitive system' (Flor & Hutchins, 1991). This encompasses the propagation of information between subsystems of agents and artefacts. It essentially takes the information processing metaphor for the mind, commonly used in cognitive science, and expands what is deemed cognitive. It is complex because it includes all those things that functionally affect the information flow in the system, e.g. social structure, artefacts, and the physical layout of the room; it is cognitive because it expands the information processing metaphor of the mind; and it is systemic as it views its unit of analysis as a system and not only what is inside the head. For example, it could be a writing system including a person, lined paper, and a pen; it could be an office desk system with an in-tray, out-tray, telephone, monitor, keyboard, mouse and person; or it could be an aircraft carrier system with all the people, machinery and communication channels that compose it.

Hollan, Hutchins and Kirsh (2000) state that DC can be distinguished by the way it expands: 1) the boundaries of the unit of analysis for cognition (e.g. from the skin and skull to the bridge of a ship (Hutchins, 1995a)): this is the ‘cognitive’ element; and 2) the mechanisms that are presumed to participate in cognitive processes (e.g. from internal thought processes to the external representation of speed in a cockpit (Hutchins, 1995b)): this is the ‘complex’ element. The fact that this perspective focuses on a ‘system’ view gives it a different level of analysis that notices things that are distinct from the level of the individual, e.g. recognizing the reuse of system knowledge (Flor & Hutchins, 1991). In the same way this chapter of my thesis recognizes systemic properties of usability practice that are distinct from analyses that focus on individual practitioners, methods or processes. Here we are interested in the computational elements of the wider system, e.g. people, sound, artefacts, communication channels, social hierarchies and organisational memory.

8.2.2 Marr’s three levels of cognitive description

The seminal work in DC is Edwin Hutchins’ (1995a), *Cognition in the Wild*. He focuses on the navigation system of a ship and describes it in DC terms. He describes the purpose of the book as being about softening the boundaries of cognitive activity that have been made explicit by other approaches, where cognition is socially distributed and where the cognitive properties of a group are not predictable from the cognitive properties of individuals (p. xiii). One of the most important elements of the book for understanding the nature of DC analyses is its use and relation to Marr’s (1982, cited in Hutchins, 1995a, p. 50) three levels of cognitive description.

- The first level is the computational level which asks what the system does and why it does it, e.g. amongst other things navigation systems answer the question: ‘where am I?’ This computational level provides a mapping from one kind of information to another, e.g. from various forms of location information to a point position.
- The second level is the representational level which makes further commitments to how this function is computed in the system in an abstract sense, e.g. in a navigation system this would be the inputs such as reference points, lines, and distances; processing and transformations such as algorithms, and working out curved and straight lines of position; and outputs such as points of position, areas of position and curved and straight lines of position.
- The third level is the implementational level which makes further commitments of how these representations are actually realized in practice, e.g. in navigation this may be a lighthouse, coordinates of longitude and latitude, lines on a map,

geographic representation on a map, the stars, a magnetic compass, the shore line, a GPS display and radar display.

Throughout the three levels we are concerned with the computation of the system, and as we go from the first to the third level we specify more detail. This increasing detail goes from the overall aim of the system, to the computational elements of the system, to how these computational elements are actually realized in practice. It is important to note that the implementational level has important computational implications, e.g. communicating coordinates from person to person via phone, email, paper, or shouting in a crowded room will impact on the speed of the communication and the propagation and detection of errors. In a similar way in usability practice the communication to the client will have different properties depending on whether it is a meeting, a report, a workshop or them observing user tests.

8.2.3 Problem solving as coordinating representations and re-representations

Hutchins (1995a, p. 117) believes that Simon's (1981, p. 153) characterisation of problem solving is useful for conceptualising the mapping discussed in the computational level, whereby information is represented and re-represented until the solution becomes transparent. Simon (1981, p. 153) says: "solving a problem simply means representing it so as to make the solution transparent." In navigation various representational states are propagated around the system and brought into coordination to perform the computational task of working out where one is. Hutchins (1995a, p. 131) assumes that "a principal role of the individuals in this setting is providing the internal structures that are required to get the external structures into coordination with one another." In a similar way usability practitioners may play a key role in coordinating the external structures for the computational system, e.g. bringing users, the system, some tasks, analysis, feedback, report, and the client together in a coherent way to impact on design.

8.2.4 Socio-cultural evolution of the environment: shaping thought and behaviour

Hutchins (1995a, p. 114-5) also demonstrates the complex evolutionary history of techniques and tools that permeate our culture. These ways of doing and thinking seem natural or inevitable to us, but we take for granted all the difficulties that were overcome in producing them and the power that they give us compared to their predecessors.

Hutchins (1995a, p. 115) believes that these assumptions only reveal themselves when we look at the history of the development of modern practice. It is also argued that our cultural heritage makes us what we are by supporting our cognition from all the many partial solutions that have gone before. Hutchins (1995a, p. 168-9) extends Simon's (1981) parable of the ant to show how our environment supports our cognition and how inheriting an evolving environment leads to cultural and historical advancements for our group, society and race.

The basic idea is that ants leave a chemical trail on the beach, and by following the trails laid by previous ants they can find food sources more readily. Over successive generations it appears that the ants become more intelligent, but it is actually the developing environment that supports their advanced performance because they are the same dumb ants. This is analogous to the cultural heritage of humans, who inherit knowledge, practices and technologies from previous generations. Here, the environment is inextricably linked to shaping human thought and behaviour; and this environment has evolved through socio-cultural heritage.

The affordances and potentials in the environment constrain and enable the computations in the system. So the developing landscape of tools and methods available to usability practitioners should lead to greater potentials in the computations they can complete in practice. Also, as advancements are made new challenges are encountered, e.g. Grudin (1990) makes the observation that there has been an "outward movement of the computer's interface to its external environment, from hardware to software to increasingly high-level cognitive capabilities and finally to social processes." So, we are only able to engage with the problems we do, in the way we do, because of the work of our predecessors. Chapter 1 and 4 make a similar case for the outward movement of problems and research for usability practice. Without the technical development of methods, we would not try to transfer methods, or look at what practitioners actually do, to what practitioners do with methods and their wider related factors in practice. The levels build on work that has gone before. In a truly Simonian sense we create artificial artefacts which create the constraints and potentials for human thought and behaviour.

8.2.5 Conclusion

DC is interested in functional systems. A DC analyst might look at a single artefact, operator, desk or an entire control room and then ask what the functional purpose of that system is; they would then map the inputs, outputs and transformations in the system; and then make observations about how these processes are actualized in reality which will impact on the computation of the system.

8.3 DC studies: Representations, analyses and themes

This section looks at several DC studies in more detail to highlight how these analyses are performed, what representations they use, and what themes they identify as points of focus, to inform our own analysis. This chapter moves through studies on individual interactions, system collaborations and then more structured analyses, all with the underlying focus on a Distributed Cognition perspective.

Kirsh and Maglio (1992) and Maglio and Kirsh (1996) looked at the fine grained interaction of a single user playing a computer game, Tetris. They provide experimental evidence for 'epistemic actions' which are performed to change the nature of the task or the problem in the environment. These are distinguished from pragmatic actions that explicitly advance towards the goal state. Epistemic actions use the environment to reduce the complexity of the task, help support solutions over time, and help mitigate against the unreliability of mental computation. For example, if we were playing Scrabble and had these seven letters, 'IGSATNE,' we might find it hard to come up with a word. However, by rearranging them to this sequence, 'SETINGA,' it is easier to see that SEATING can be made. The arrangement of the tiles affects the nature of the cognitive task. So an epistemic action would be physically rearranging your tiles to support the cognitive task. In investigating performance in a game of Tetris Kirsh and Maglio found that expert players perform more epistemic moves than novices, suggesting that experts have learnt to better use and manipulate the environment to support their actions. They state: "The point of a particular action may seem to be that of bringing an agent physically closer to its goals, yet upon more careful analysis the real point of that action may be to increase the reliability of a judgement, or to reduce the space-time resources needed to compute it" (Kirsh & Maglio, 1992). So, actions should be considered in a wider sense: to reshape the problem space to support the cognitive task to make judgements that are more reliable and use resources in an intelligent manner. In the analysis that follows we explore what evidence there is for epistemic actions in HF/usability practice.

Moving to multi-user collaborations Flor and Hutchins (1991) looked at a simulated collaborative software development task. They make the case for DC taking the complex cognitive system as its unit of analysis, as different people and artefacts coordinate to perform a task. They argue that this level of analysis recognises phenomena which are not apparent when looking at the individual components in a system. They recognise seven themes in this collaborative interaction, we highlight four themes here:

1. The reuse of system knowledge
   Programmers reused external portions of code to solve coding problems. This was the coordination of external structures to the programmers but it was the internal coordination of representations in terms of the system.
2. The sharing of goals and plans
   Goals specify what needs to be done and plans specify how the goals are going to be achieved. In terms of negotiating and sharing plans at a group level this leads to a wider search for alternatives and a shared memory for 'old' alternative plans than might be expected from an individual.
3. Joint productions of ambiguous plan segments
   People work together whilst under-specifying what they plan to do and how they plan to do it, relying on common ground. Flor and Hutchins (1991, p. 55) recognize a trade-off in that lots of common ground will lead to efficient communication but little exploration in alternatives, and conversely not enough common ground will lead to lots of time and effort negotiating.
4. Divisions of labour and collaborative interaction systems
   When people work together they negotiate functional roles and ways of interacting in the system to jointly work on the task. In their programming context Flor and Hutchinson (1991) observe that the programmer that implements the code is using the keyboard and mouse; this allows the shadowing programmer to engage with the task at a more abstract level, using the implementing programmer as a smart interface to affect the code. Here there are cognitive implications on the tasks of the programmers and the system they compose.

These themes highlight some system level features of socio-technical systems that would be less prevalent or missing from an analysis of individual components. The themes highlight how information is shared, propagated and transformed in a complex cognitive system. Whether in a highly collaborative setting, or an individual playing a game like Tetris, DC captures the functional system between a person, other people and artefacts they use.

Expanding on DC themes, at the system level, Ackerman and Halverson (2000) re-examine organisational memory, which is the information processed in organisations. In doing so they make the case for it to be considered as an object and process; as a phenomenon that can have many representational states such as an individual's notes or a standard group procedure for handling calls; that these phenomena are complexly distributed, interwoven and overlaid; and that as memory crosses between groups and across times it gets de-contextualised and re-contextualised. They use the concept of a boundary object introduced by Star (1989) to describe those objects which are shared by different communities. Across different communities boundary objects are robust enough to share common interpretation but at the same time these vary due to the different communities' perspectives. Organisational memory, as a boundary object, aims to serve the needs of the creator and reader but lacks the full context of either (Ackerman & Halverson, 2000, p. 64). So, the creator should project how the object might be reinterpreted, and by whom, so they can mitigate against it being interpreted in a fashion they would not wish. Evidence for these themes is discussed in our analysis.

Like Wright, Fields and Harrison (2000), Halverson (2002) makes the point that the criticism of DC treating artefacts in the same way as people, which denies their humanity, is wrong. Instead DC uses the same theoretical language for both, but people have an agency and a role in coordinating internal and external structures that artefacts could not. Halverson (2002) also draws attention to the potential for systems to dynamically reconfigure to bring subsystems into coordination should the demands on the system require it, e.g. the waiter at a small café may stop serving and help prepare food in the kitchen if the chef needed help in a demanding period. Halverson (2002) presents three different representations of the same task to show that they each emphasise different details; the specifics of which make them better for some tasks than others. For example, one representation shows detailed coordination between the hand, mouse, and computer in selecting an option; another representation shows a higher level view that loses detail but gives a better sense of the task's flow; and then the final representation uses diagrammatic symbols to capture agents, memories and transformations. It seems representations should be structured to support the message being communicated, and there is not a 'one size fits all' solution. For our purposes there is not a right way of representing a DC analysis, and that representations should be structured to enhance the reader's comprehension of the desired message.

In an attempt to add further structure to DC analyses Wright et al. (2000) present the *Resource Model* to support analysis of how individuals coordinate resources to support the performance of tasks, suited to single-user-single-system interactions. These resources are abstract information structures that aid action and cognition. They recognise six resources in their model:

- Plans: a sequence of actions that could be carried out.
- Goals: a state of the world to be achieved.
- Affordance: this is how apparent the possible actions from the current state are.
- History: a history of actions and states taken to reach the current state.
- Action-effect: this is whether the effect of the action is apparent.
- Current state: this is the current state of the system in terms of the position and values of the different information resources in the system.

A good example of how these resources might be coordinated is in a shopping list which can be interpreted as a list of goals in an abstract sense. If the products in the list are in the order they will be picked, the list can be considered a plan; and if the items on the list are crossed off then the list will show the current state. As items are crossed off the list to show the current state of the shopping activity, the list will afford actions to take: i.e. what items to get next. Without this external coordination of resources the individual will have to internally coordinate the activity, which will become more demanding with the increasing complexity of the activity. In the example described the shopper will have an internal history of the actions and states taken to complete the task. The action-effect resource in the shopping example can loosely be illustrated by selecting some fruit to be weighed and priced at the checkout, i.e. the effect on the bill is not immediately apparent on selection.

These resources can be actively configured in different ways to perform tasks. These different configurations are called 'interaction strategies'. Wright et al. (2000) describe four interaction strategies that are relevant to HCI:

- Plan following: this involves the coordination of a pre-computed plan, and a history of what has been done so the next step in the plan can be worked out. The goals will be steps in the plan and the current state may be needed if there are conditions in the plan.

- Plan construction: the output of this interaction strategy is a plan; and it entails coordinating goals, current states, action affordances and action-effects. First a goal or number of goals will be generated by comparing the current state with some future desirable state. Steps in the plan then need to be coordinated by recognising potential actions that can be taken at different stages in action affordances; and also what effects these actions will have.
- Goal matching: this is different from plan following in that users will make decisions on what to do next without a higher level picture of the order of their actions or how these actions fit together. They recognise and complete goals at a more local level. They will need to know what they can do in the situation (the action affordance) and they will need to know what their actions will do (the action-effect) to decide on appropriate actions.
- History-based selection and elimination: Whilst in the midst of interaction, history can play an important role. For example, to inform their choice users may use a history of past events: a previous choice which led to a good outcome would encourage users to make the same choice, and an unwanted outcome should prompt a different choice. An illustration of this might be going to your favourite restaurant where you know you'll get good food and good service.

These interaction strategies show some of the ways that people coordinate internal and external resources to perform tasks. Wright et al. (2000) warn that designing to support these strategies is not just a question of externalising resources. Interaction episodes have to be supported intelligently with the context, users and tasks in mind. The Resource Model provides a structure to start reasoning about the configuration of resources for action.

Also motivated to add more organization to DC analyses Furniss and Blandford (2006) report a DC analysis of the London Ambulance Service control room. This analysis was structured to make similar future analyses more guided, and the consequent prototype methodology was dubbed DiCoT: Distributed Cognition for Teamwork (Blandford & Furniss, 2005). This was motivated by observations that DC did not have an 'off-the-shelf' methodology (Rogers, 1997), which was thought to contribute to the lack of visibility and use of DC in the HCI domain (Wright et al., 2000). DiCoT has since been applied to an agile software systems environment (Sharp et al., 2006). The DiCoT approach was informed by creating overlapping models of the system as proposed in Contextual Design (Beyer & Holtzblatt, 1998). Five models are proposed in DiCoT.

Each has a set of DC principles that relate to it to help guide analysis (DC principles associated with each of these models are included in Appendix B). These five models are described below and are used to structure the analysis in Chapter 9:

(1) Information Flow Model

This model strongly relates to Marr's (1982, cited in Hutchins, 1995a, p. 50) upper levels of cognitive description in that it describes the abstract information flows without committing to how these are realised in practice, i.e. at the implementation level. First of all the overall function of the system should be described, then this can be expanded to describe how the information transformations and propagations happen. In the DiCoT analysis this goes as far as recognising what agents in the team are performing what tasks and what information they communicate to each other without commitment to artefacts and tools at the implementational level.

(2) Physical Model

The physical model describes those factors that influence the performance of the system, and of components of the system, at a physical level. This description is important from a Distributed Cognition perspective as those things that can be physically heard, seen and accessed by individuals have a direct impact on their cognitive space and hence will shape, empower and limit the calculations that individuals perform.

(3) Artefact Model

The influence of artefacts on the performance of system components, and hence the system as a whole, is very important for an analysis using Distributed Cognition. From a DC perspective the environment that we inhabit plays a central role in cognition, bringing artefacts, representations, and environmental affordances into coordination.

(4) Evolutionary Model

The evolutionary model considers how cognitive systems have evolved over time. This could be the reorganization of subsystems, the introduction of new technologies and tools, or the coordinating abilities of the individuals involved. The time frames over which these changes can be mapped can vary, e.g. a new member of staff learning to perform their job, or the developments in commercial aviation over a 100 year period. Hutchins (1995a) makes the case well that the current cognitive systems which we take for granted rest on the shoulders of their predecessors, e.g. typing this thesis has history in language, writing, typing, hardware, software, many published research papers and ideas, and my own ongoing development and understanding.

(5) Social Model

Hutchins (1995a) is specific that where different people are doing different tasks in a cognitive system doing without a social organization of the distributed system is not an option. This model considers the social organizational aspects of distributed cognitive systems. These may be the social structure, the power relationships between people, political agendas, and rapport between individuals.

The original DiCoT study was done on control room observations where there are physical and observable phenomenon, so it needs to be adapted for the current analysis. Also, the last two models, evolutionary and social, have not been well developed and so their application to our context needs to be evaluated. In terms of the current work DiCoT provides a further example of how DC representation, analysis, and themes differ, which gives inspiration and potentials for our own analysis.

8.4 Conclusion

This background section has introduced DC theory to the reader by first covering its core tenets (Section 8.2) and then showing how different representations, analysis, and themes manifest themselves in different DC studies (Section 8.3). This provides an appropriate theoretical grounding to move on to the analysis, where the interview data, insights from the data, and theory merge.

Chapter 9: Distributed cognition analysis

9.1 Method

The coverage of different DC studies in Section 8.3 illustrates that there are several ways to do a DC analysis. However, we now have a foundation of approaches, representations and themes to build on for our own study, the goal of which is to provide an explanation of our data in terms of the DC theoretical framework.

Halverson (2002) agrees that the value of theory should not be judged on whether it provides an objective representation of reality but how well it shapes and describes that reality for insight. Halverson (2002) also recognises four attributes for what theory should provide for CSCW (Computer Supported Collaborative Work), which relates to characteristics of explanatory theory more generally, and what we want for a description of usability practice:

- Descriptive power: the theory should help us make sense of and describe the world.
- Rhetorical power: the theory should provide a conceptual structure so that we can see how it maps to the real world, and allows us to communicate this perspective to others.
- Inferential power: the theory should allow us to make inferences, to see how things work and affect each other within its conceptual description.
- Application: the theory should be able to be applied at the right level, so the world can be understood and interventions can be made to impact on the situation in accordance with the theory's description.

When developing our explanation of usability practice from a DC perspective we should have these attributes in mind.

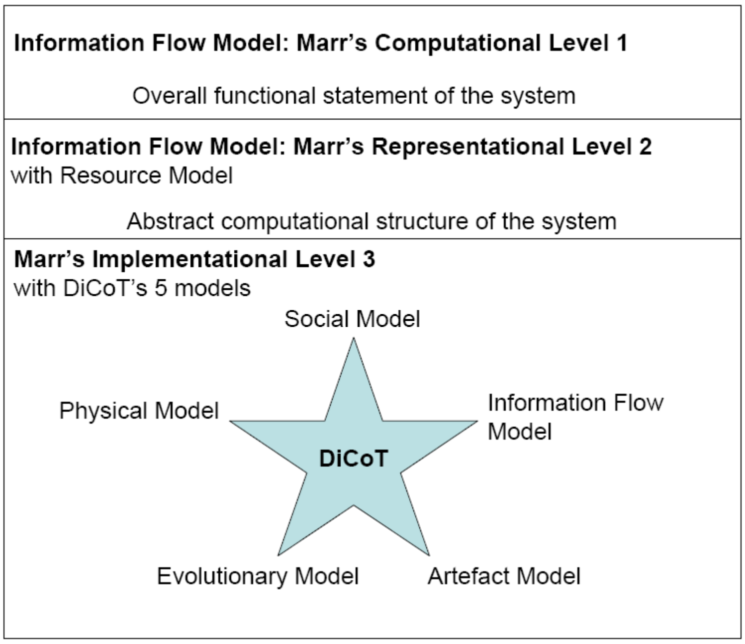
Hutchins and Klausen (1996) describe the application of DC theory to observations of one simulated airline flight as a problematic cognitive activity where data and theoretical concepts need to be mapped. In our case, different types of propagations and transformations have affected the analysis. For example, a research issue has led to the reading and exploration of certain papers. This has led to methodological decisions, sampling decisions in terms of the interviewees and the questions asked. The interviews have been an expression of the interviewees' views and experiences, which have been transcribed verbatim, then coded, and qualitatively analysed. Finally now DC has been selected to apply to the data. In terms of a coordinated activity this is a complex process involving different levels of representations, propagations and transformations. In their observational work Hutchins and Klausen (1996) state that they will "weave together the data, action, the interpretations, and the ethnographic grounding as they are needed in a narrative that seeks to present a theoretical account of the observed events." Similarly, we will weave together the data, quotations, codes, insights from the qualitative analysis and the DC theoretical framework to create an explanation from this perspective.

DC themes emerged from the data in a bottom-up fashion. The DC literature was then used in a top-down manner to exploit how this theory could further enhance and consolidate patterns in the data. This analysis takes advantage of the theory that has been built in the analyst's head. One can therefore draw on insights between data and theory as they present themselves to the analyst since there is not a simple, fruitful, systematic way of combining the two. For the sake of validity a template of 'theory, support, and discussion' will be adopted to bridge the gap between the theory and the data where appropriate. This theoretical step builds on the qualitative analyses performed in the website domain (Chapter 4) and the safety-critical system development domain (Chapter 6).

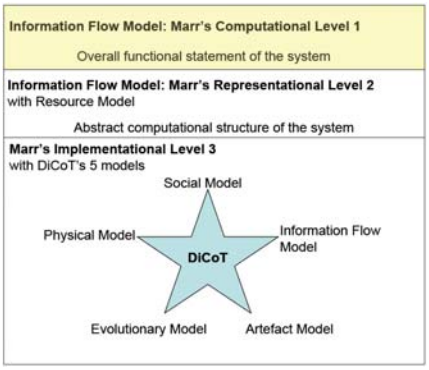
Determining how best to represent this DC analysis was non-trivial. It should involve insights and representations from the literature, and have a structure amenable to the insights from the analysis, the union of which is not immediately obvious. The structure of the analysis follows Figure 9.1. It has been developed through iterative engagement with the literature and how best to represent the emerging analysis. There was not a prior structure for the analysis. Marr's three levels of cognitive description provide the backbone to the structure. The first two levels overlap heavily with the information flow model presented in DiCoT. Through iterative development the Resource Model appeared most applicable at the representational level, level 2, where computational structures are coordinated but the actualisation of the implementational level is not made. The implementational level of the analysis, level 3, uses the five DiCoT models to structure the analysis with DC themes woven throughout.

Figure 9.1 will be used as a map to support the reader's awareness of where they are at the beginning of each section of the analysis.

Figure 9.1. Structure of the analysis.



9.2 Information Flow Model: Marr's Computational Level (Level 1)



9.2.1 Theory

Something that Marr's three levels of cognitive description gives DC is the ability to describe the functional properties of a system at different levels (1982, cited in Hutchins, 1995a, p. 50). The highest level is the computational level which captures the overriding computational purpose of the system. In HF/usability practice the overriding computational purpose of the system is:

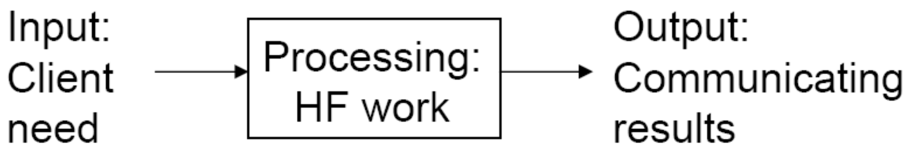
To provide Human Factors/usability input, feedback and advice to satisfy or exceed a client's need under constraints and finite resources.

9.2.2 Support

This computational purpose of the system is evident throughout the interviews in both domains. The work is driven by some sort of need, something is done to meet that need, then the result of what was done is communicated to the client to hopefully fulfil the need. This is the service that usability and HF professionals are paid to provide.

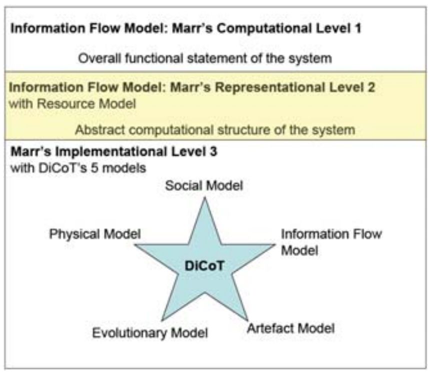
As discussed above, this computational level provides the main mapping that needs to be performed by the system. In this case, the mapping is between the client need and the capabilities of HF practice. This defines HF practice as the unit of analysis, recognised previously as the usability component, with the client need as the input, the processing as the HF work, and the output as the communication of results (this is represented in Figure 9.2).

Figure 9.2. HF practice at the computational level.



9.2.3 Discussion

This representation seems trivial but it provides focus on the computational functioning of the system. In terms of a more detailed analysis all three parts are expanded upon and realised in different ways at the representational and implementational levels. As an analytic tool for this research, this abstract computational view provides an overarching apex from which varying HF/usability practices and domains can be subsumed.



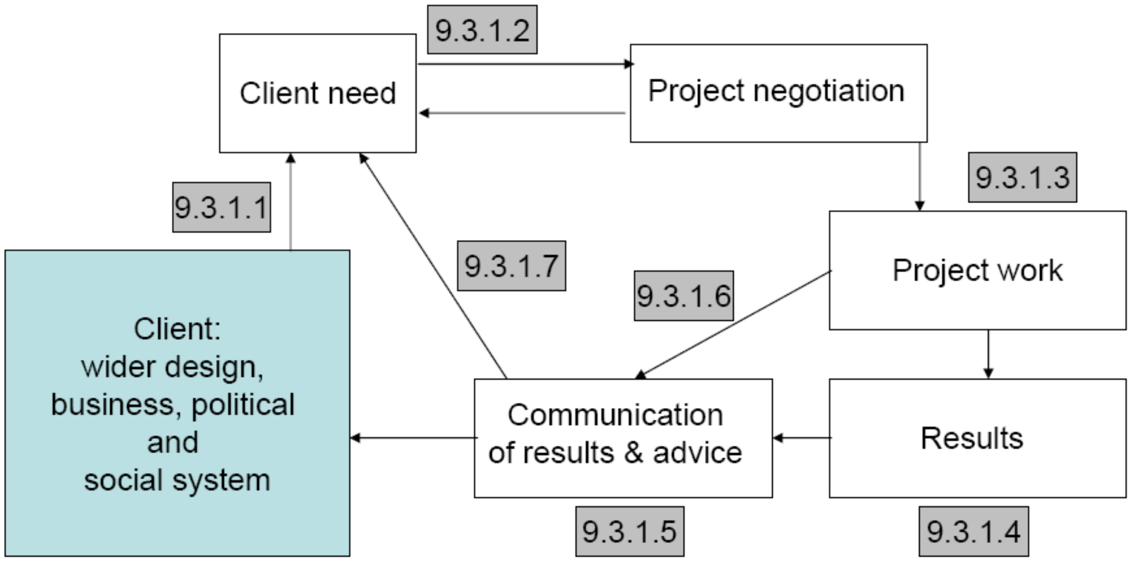
9.3 Information Flow Model: Marr's Representational Level (Level 2)

9.3.1 Theory

Marr's second level expands on the first by making further commitments to how the different computational elements of the system are coordinated (1982, cited in Hutchins, 1995a, p. 50). Figure 9.3 represents computational elements of HF practice at the representational level. The numbers in grey correspond to the section numbers below which describe those parts of the figure.

These descriptions contain explicit reference to the Resource Model as the coordination of abstract resources proved appropriate at this level of analysis: i.e. before the computational system is instantiated further at the implementational level. For example, we reflect on the formation of goals and plans, and how these are coordinated with affordances and action-effects in the computation of the system.

Figure 9.3. Computational elements of HF practice at the representational level.



The numbers in the figure correspond to the sections below:

9.3.1.1 The wider client system develops a need

9.3.1.1.1 SUMMARY

The wider client system develops some sort of need. This might be a wider need which Human Factors practice can contribute to, e.g. the clients might wish to design a new product line, or regulators of their industry say the client requires HF input into a process or problem.

9.3.1.1.2 DETAIL

Human Factors and usability are normally only part of, or servicing a much bigger system. Clients, which pertain to those parties which use HF services both internally within a company and externally through consultancy services, vary tremendously. They are organisations that have technical, social, business and political agendas, some of which might be contentious between different parts of the same organisation.

The client need might not be a well formed HF issue.

The client may use HF services regularly, the client may have heard of HF and be exploring what HF could do for them, or the client may have never heard of HF before their regulator said they must get HF input.

The client need is not always about money or revenue generation directly. For example, it may be about meeting safety standards in transport, complying with regulators in the nuclear industry, maximising performance of weapon systems, selecting the most appropriate product to buy for the Navy, seeking input into wider decisions such as allocating budgets on product development, improving the design of a control panel, making customers feel more satisfied on an ecommerce site, reducing personnel on an oil rig, or providing evidence that a particular DVD system is the easiest to use on the market.

9.3.1.1.3 RESOURCE MODEL

In terms of the Resource Model this part of the process is about goal formation in terms of the interaction between a client and HF practice. The client's need is generated by comparing a current state to some future state which they wish to achieve.

From the client perspective they might construct a plan and follow this plan to achieve their wider goal, e.g. to increase revenue by 10% in this financial year. In terms of the client's wider goals and plans, the HF practice might only be aware of and contribute to a small part. So the interaction strategy the HF practice follows in this case would be goal matching from the client's perspective.

From the HF perspective the client's goal might only be met by plan construction and plan following in project work.

Collaborative interactions coordinate resources in different ways depending on their roles, goals and plans, e.g. someone's simple goal might be another person's accumulative output from complicated plans.

9.3.1.2 A project is negotiated to meet the client need

9.3.1.2.1 SUMMARY

The client does not always know what they want from a HF practice, and so one of the first jobs is negotiating what they actually need. This negotiation might involve translating a business problem into a HF issue, appropriately scoping the client's needs into manageable HF issues, and organising appropriate time and budget to be available to do the work.

9.3.1.2.2 DETAIL

The client will have a need that they wish to satisfy. This may or may not be a well specified HF issue. Negotiation between HF practice and the client will need to take place to come to a common understanding about the need, perhaps translating into a HF issue, scoping what HF can provide, and to negotiate what resources would be available to do the work. For example, the client may not have, or not want to spend, the money for a full user test when they might be happy with a heuristic evaluation.

The project work can be offered as a series of work packages so that the client has some control over what they select to fund rather than it being one big offering.

9.3.1.2.3 RESOURCE MODEL

In terms of the Resource Model the plan construction interaction strategy is key to this stage, which involves coordinating goals, the current state, affordances and action effects.

The goal of the client might not be the same as the goals of the HF practice but they will need to coordinate.

The HF practitioner will use their expertise to interpret the client's need, and then use their internal knowledge of affordances of what to do in such a situation, matching their capabilities to the client's issue. They will also coordinate this with their experience of action-effects, i.e. use their experience of different practices, methods and template solutions to increase the likelihood of reaching a satisfactory solution for the client.

By this interpretation the action-effect resource seems related to the history resource. A history of previous actions and states, and how these fit together, give an indication of the likely effect from an action. For example, a history of projects where user testing has been successful might impact on the decision to select this action given it has proved successful in the past.

Beyond the technical implementation clients and practitioners will have their own prejudices of what should be done in a situation (action-effect, and affordance) given the past experiences that have and have not worked (history). This may mean that clients and practitioners prefer working with people, methods and practices they know and are used to. This relates to the ‘history selection and elimination’ strategy whereby past project experiences and working relationships are brought into coordination to influence future ones.

9.3.1.3 The project work is carried out

9.3.1.3.1 SUMMARY

Once there is agreement and commitment to a plan of work it can then be carried out.

9.3.1.3.2 DETAIL

Once there is a commitment to the plan then the planned work can be carried out. This will be a set of deliverables to a specific time and budget. The instantiation of how this project work is carried out will vary tremendously between different projects, practitioners and industries.

9.3.1.3.3 RESOURCE MODEL

In terms of the Resource Model the plan following interaction strategy seems most appropriate here. However, depending on the coordination and knowledge of the people in the project goal matching might be more appropriate.

Plan following involves the coordination of the plan that was agreed and a history of what has been done on the plan. The goals will be the steps in the plan and the current state might be needed if there are conditions in the plan, e.g. user testing cannot be performed until the participants have been booked, the tasks have been written and the prototype is ready for use.

Goal matching might be appropriate if the person doing the work does not know how it fits into the wider plan. For example, they may be a junior member of the HF team and be told what tasks to do on a task by task basis. Hence they will complete goals at a more local level but do not know how this contributes to the wider plan.

9.3.1.4 Results and recommendations are written from the project output

9.3.1.4.1 SUMMARY

The HF practitioner will need to distil results, recommendations and advice that were gleaned from the work phase of the project (Section 9.4.1.3).

9.3.1.4.2 DETAIL

Generally, any HF work will result in some sort of tangible output, e.g. a redesign of an interface, a Word report, a PowerPoint presentation and some video footage of user tests. These results have to be distilled in such a way that they have the desired effect on the audience.

9.3.1.4.3 RESOURCE MODEL

If we consider this step as a translation of the results into a form amenable to the client this summative step does not appear to have much relevance to the Resource Model as it focuses on resources for action. However, this should have relevance because the results and recommendations should not be written as just a summary but as a resource for action. The project report should provide clients with information of the current state of some interface, goals for improvement, and plans of how to best achieve this.

9.3.1.5 Results and advice are communicated to the client

9.3.1.5.1 SUMMARY

This is heavily related to, but separate from writing the results and recommendations because (1) results and advice can be communicated outside the official reporting channel, sometimes deliberately and sometimes informally; and (2) the report does not always equate to the communication between the parties and so this step deserves significance of its own.

9.3.1.5.2 DETAIL

(1) Practitioners reported encouraging clients to observe user tests first hand when they could as this carried some influential weight that could not be communicated in prose (Section 9.3.1.6).

(2) The report is normally a document written by the HF practitioner. However, what they wish the client to 'see' in the document, and what they actually 'see' are different things.

The report is normally accompanied by a presentation to the clients to summarise and explain their findings but this is not always the case. This goes some way to bridging the gap reported in (2). The HF practitioner has a variety of different modes of communicating to the client including meetings, presentations, reports, video clips, quotations from users, statistics, graphs, diagrams, and models.

9.3.1.5.3 RESOURCE MODEL

Again, there is a choice of how to instantiate this process and this will be affected by the different ways the practitioner can see to communicate (affordance), what effect these different ways of communicating are likely to have (action-effect), and the experience of how they normally communicate and what success these actions have had in the past (history selection and elimination – interaction strategy).

9.3.1.6 Project work can be communicated without a results stage

9.3.1.6.1 SUMMARY

Communication of results can happen directly from the project work if the HF work is observed or integrated into the client's own work.

9.3.1.6.2 DETAIL

The communication of some results can happen directly from the project work. One way this can happen is if the HF work is observed by the client, e.g. some practitioners reported encouraging clients to observe user tests because it carried some special influential weight that a report could not; other methods one could imagine having a similar role are panel discussions, focus groups and workshops. Project work can also be communicated informally if there is a close working relationship between HF practitioner and client. More formally the work of the HF practitioner might be closely integrated with the client, i.e. they might have an advisory role on a committee or team where the communication actually forms the project work.

9.3.1.6.3 RESOURCE MODEL

Again, the Resource Model does not at first seem to have immediate relevance from the HF perspective as this can be viewed as an output stage. However, from the wider system view we can see that this output should provide resources for action for the client, e.g. information on the current state, goals and plans.

9.3.1.7 Some results and advice lead to client need

9.3.1.7.1 SUMMARY

The output of a project might raise new questions or identify potential research areas that were outside the scope of the study undertaken.

9.3.1.7.2 DETAIL

A goal of HF work is to satisfy the client's need in terms of the agreed plan (Section 9.3.1.2). A wider HF goal will be to generate more work from the project so they can continue to do work and function as a business.

9.3.1.7.3 RESOURCE MODEL

Again, the communication should be seen as providing resources for action, not only in response to the client's need and a move toward that goal; but a resource for action that includes the potential for more HF work.

9.3.2 Support

This computational view of project need, negotiation, agreement, work, and communication was evident throughout the interviews. Three quotations have been selected that show support for the processes described in Sections 9.3.1:

Respondent S2 support for:

Section 9.3.1.1: The wider client system develops a need

Section 9.3.1.2: A project is negotiated to meet the client need

> "You start off and you try and talk to them about what their problem is, so it could be we have got this design and we want to find out this, this and this about it. Or it could be these kind of accidents keep happening and we want to know why they're happening or we want to know how to stop them happening, or we have this idea for stopping it and we want to know whether it works. So you'd start off with what their problem is and what they want to know. And then you'd use your experience to think about whether that is the right thing, because sometimes they think they want to know something and you might think from your experience that it isn't what they really need to know. And then you have that discussion and think about a suitable method based on their budget, time constraints

> and everything else. Sometimes they just have prejudices about what kind of methods they think are good and bad, and you have to usually fit into those as well, or you have to do a good selling job of your own idea." S2

Respondent W8 support for:

Section 9.3.1.3: The project work is carried out

Section 9.3.1.4: Results and recommendations are written from the project output

Section 9.3.1.5: Results and advice are communicated to the client

Section 9.3.1.6: Project work can be communicated without a results stage

> "If a methodology allows it we always encourage [clients] to come and watch, we think that they can learn much more from actually seeing users use a product than they can from actually reading a report." W8

Respondent S10 support for:

Section 9.3.1.7: Some results and advice lead to client need

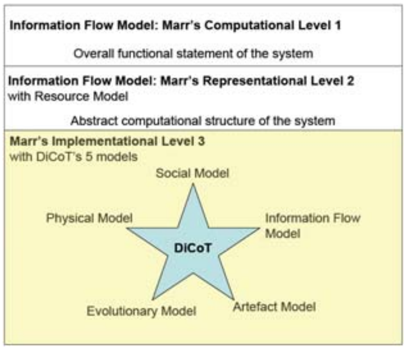
> "I will go 'I've got this error', as I did on a control room for a [Industry A], and my error related directly to the design of the graphical interface and then you start getting into arguments depending on how flexible you are with the client, the client may go, 'that's a really good point, I'll give you a little bit of extra money, can you do me an interface study?'" S10

9.3.3 Discussion

This representational perspective details computational parts of the HF practice system. Here, when looking at issues of method use, such as the adoption and adaptation of methods, we can see that computational effects on method use happen long before the project work stage, and these functionally affect the system long after the project work stage. Method use is just part of a wider computational system of HF practice. They are not an end in themselves but a means to help achieve the wider computational goal of the system; i.e. to provide HF input, feedback and advice to satisfy or exceed a client's need under constraints and finite resources.

By reflecting on this level of representation it is more apparent that interview questions were focused on trying to get generalities (at level 2), which were often met by answers starting with 'It depends…' because the instantiations vary (level 3). For example, a question such as, "What methods do you use?" or "How do you report your results to the client?" would be answered by referring to the variability and the specific dependencies of the context. The computational effects of some of these instantiations are discussed in the next sections which cover the implementational levels (level 3).

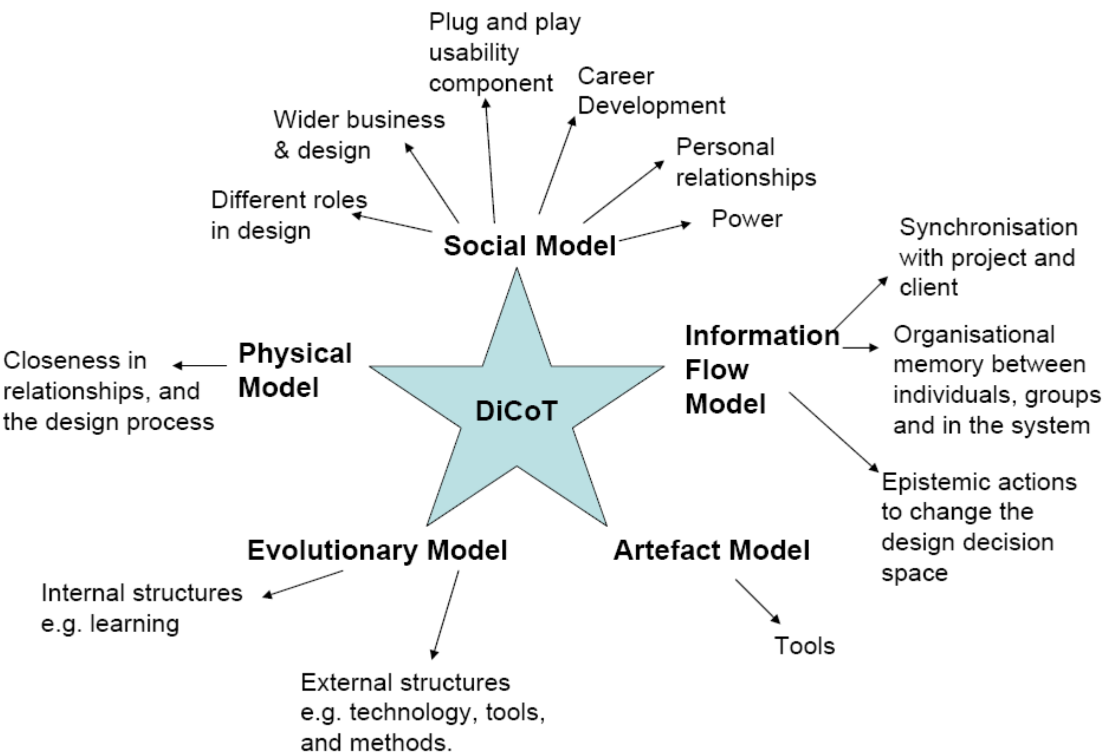
9.4 Marr’s Implementational Level (Level 3)



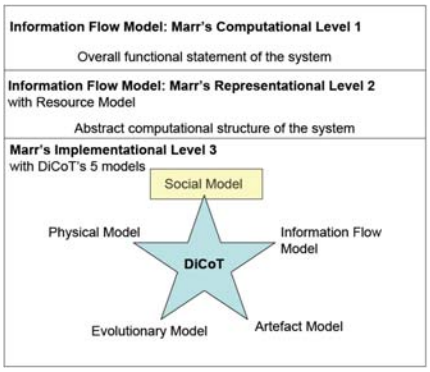
This level of analysis will be structured using the five models of DiCoT which address different parts of the complex cognitive system: social, information flow, artefact, evolutionary and physical models. This implementational level makes further commitments as to how the computational system is actually instantiated. However, these instantiations are still somewhat general as we abstract across different case studies and contexts.

Figure 9.4 indicates the different themes that are referred to in the different models of this level of analysis. These different themes make up the computational description of usability practice. We will reflect on what this description gives us for explaining the adoption and adaptation of methods in practice at the end of the chapter.

Figure 9.4. The themes described in the different models.



9.4.1 Social Model: Marr's Implementational Level (Level 3)



When work is distributed between people working together the computations of that system are socially distributed and are functionally affected by phenomena at the social and organisational level. This social model tells a story of how labour is distributed in HF and the wider social system within which it is embedded. In the subsections below we look at:

- the division of labour;
- the wider complex cognitive system;
- the unit of analysis being a plug and play usability component,
- the HF practitioner as a researcher;
- the career development of the HF practitioner,
- personal relationships in practice, and
- the functional influence of power.

9.4.1.1 Division of labour

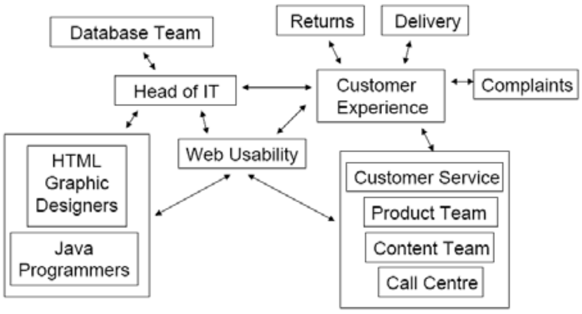
Practice will often involve different people working in different roles towards some common goal. The division of labour theme concerns itself with how tasks are split between people and how they integrate together. People will bring different skills and perspectives to their role, which can be a benefit or hindrance in terms of exploring alternatives, and so as the quotation below shows the collaboration needs to be managed. This applies to working in different projects and organisations:

> "It's a very collaborative world, you end up being almost a negotiating power between different groups in a company, if you're doing consultancy then you may be the negotiating power between what you know can be done and the client, and the client's desires, or if you're working internally for a company then you end up negotiating between I guess the designers, the artists, the technology people, the business people who want the product to do a certain thing or look a certain way." W2

9.4.1.2 The wider design and business process as a complex cognitive system

Processes in practice are often complicated and exceed the abilities of any one individual, meaning different people and roles need to be coordinated. The information processing metaphor lends itself well to conceptualizing the different component parts of the design and business process and how they integrate. Like different modules of the mind, or different chips in a computer, we are interested in what component parts there are, what each of them do, and how they come together to work as a system. Figure 9.5 shows a schematic diagram of how the components of a design and business process, referred to by one participant (W3), integrate to form a complex cognitive system. It is complex because it includes those personal, technical, social and organisational factors that functionally affect the system; it is cognitive because it expands on the information processing metaphor for the mind including demarking processing units with their connections to other processing units; and it is a system because it is integrative rather than reductionist. In this example 'web usability' performs a computational role within the wider system of the organisation.

Figure 9.5. How web usability integrates with the wider design and business processes (W3).



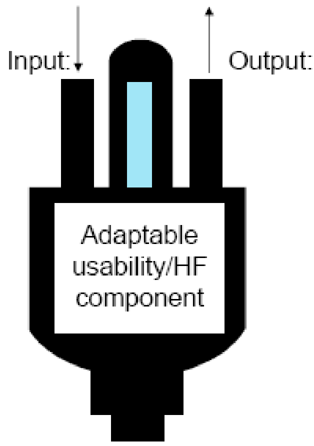
9.4.1.3 The unit of analysis

As discussed in the background section DC allows flexibility in what can be considered its unit of analysis. Here we introduce two potential units of analysis in the system. The first is more abstract and considered the HF/usability component as a plug and play technology. The second is more tangible in that it considers the HF practitioner as a component in the system that performs research. Both units of analysis integrate; however, they are at different levels of abstraction and have different consequences for analysis.

(1) The HF/usability component as a plug and play technology

For the purposes of our research we are interested in the HF/usability component of the design and business process. Our analysis suggests the usability component can be considered a plug and play technology, following the information processing metaphor of DC. Figure 9.6 provides an illustration of this metaphor.

Figure 9.6. The HF/usability component as a plug and play technology.



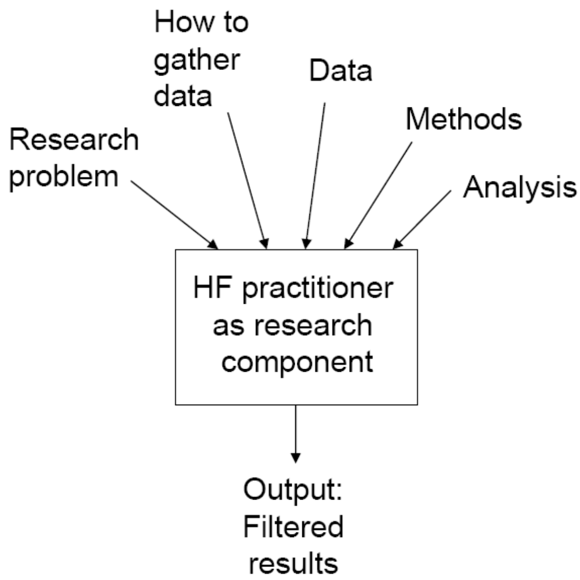
Just as plug and play hardware/software adapts to the system it is to integrate with, so the usability component adapts to ‘fit’ the business processes, constraints and research goals of the project that proposes its involvement. It is the job of the skilled practitioner to see how the usability component can best be organized to meet the business and research needs of a project (Section 9.3.1.2), and this may not always be in accordance with an idealized usability process. For example, one participant discusses trying to design effective projects, which are also feasible for the client; considering method, timing and budget:

> “It was kind of difficult to do some ethnographic research or anything like that […] it was just not feasible for our clients... It meant that we were limited in the methodologies that we were going to use, we just had to focus on two or three key points of the project that we could actually get involved in actually making a difference […] so it's obviously getting involved as early as we possibly could […] before everything’s got too far down the road otherwise you put recommendations in that are not achievable within their timescales” W6

(2) The HF practitioner as a research component in the system

HF practitioners can be viewed as research components who make decisions about how to go about tackling a research problem, what data to gather and how to gather it, how to analyse this data, and what should be filtered back to the client depending on their research interests (Figure 9.7 illustrates these processes). Their decisions are made under a pragmatic guise in that all methods have pros and cons, and the context will have its own limitations in terms of the time, budget, and the data that is available. Taken together the HF practitioner performs a complex set of coordinating actions for HF work.

Figure 9.7. The HF practitioner as a research component, coordinating research activities and filtering to clients.



Sometimes traditional HF methods might not be applicable for some data and research questions and so the practitioner must reflect on the situation using their experience and propose a way forward, whilst being mindful of practical, ethical and validity requirements. The quotation below refers to a large research project which involves the processing of different types of data, which falls outside the scope of traditional HF methods; also noteworthy is the practitioner's opinion about drawing these strands together whilst valuing some types of analyses more than others:

> "I've just done [a] big piece of work […] dealing with […] work place fatalities, including all industries […] they collected the accident data over the last five years […] several hundred accident investigation reports to go through […]. I [did] some field work, interviews with investigators and professionals, talking through the issues and getting some opinions about why they've happened. It's all about pulling things together, you need to process it, take people's opinions and process it, but most importantly, to use the technical analysis, the stats to analyse the trend, make sure if anything happens it is statistically significant and not by chance, so you need a testing method for the data. If you just use the graph, it may show a trend, but this can just be by chance, and it can be misleading." S9

Here we see that the HF/usability component and the practitioner component form part of a subsystem which can reconfigure themselves to perform the required computations demanded by the wider system; i.e. they will reconfigure to provide HF input, feedback and advice to satisfy or exceed a client's need under constraints and finite resources in different contexts. Both of these components perform a role in bringing various resources into coordination to affect information propagation and transformation of the computational system. They provide a mapping from the client's need to some HF advice or solution that should hopefully satisfy that need. In this respect the client can use HF/usability services as a smart interface, where the client can give them a problem and expect a solution without actually getting involved in the detail.

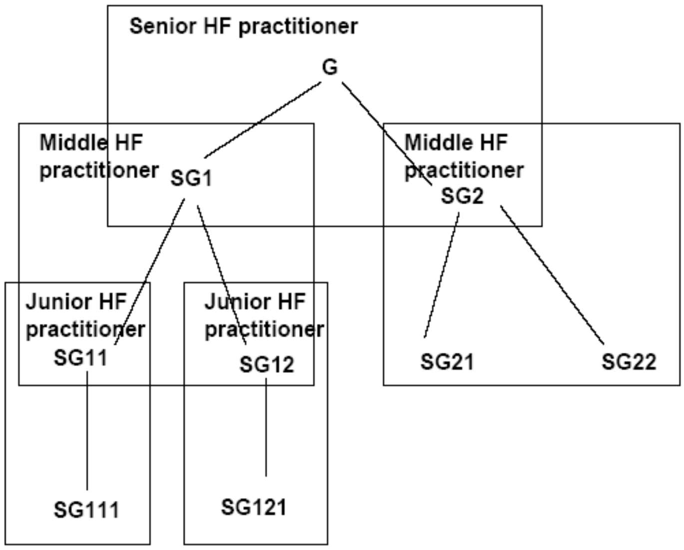
9.4.1.4 Career development – the maturing practitioner

There are different levels of seniority in HF practice. This can affect the computation of the system as more senior practitioners might tackle more complex tasks and be involved in planning and negotiation with clients, whereas more junior members might be managed as resources to perform project tasks. Respondent S12 describes the hierarchy of career levels in their company and outlines some differences in roles:

> "[Tier A] is students, [Tier B] is admin staff and so on, [Tier C] is graduate, [Tier D] is graduate with experience or possibly MSc […]. The sort of job description for a [Tier C] would be: do what you're told and do good work, the job description for a [Tier D] would be do what you are told, produce good work, write the odd bit, make the odd customer contact, make a presentation, bring something back from the customer and work with the team to develop it, that sort of thing. My job role would probably be described as all of the above plus actively pursues contact with customers and go out and solve their problems for them […]. As you get to [Tier F] and [G] you tend to take on much more team leadership generally rather than just on a project by project basis.
>
> I: More strategic?
>
> R: Yeah and being involved in the strategy development, absolutely." S12

As a practitioner progresses in their HF career they develop experience, skills and gain more responsibility. The less experienced members of staff will be managed and supported by more senior members. Here, the lower levels of a staff hierarchy become resources to be nurtured and coordinated to perform the work of the organisation. Referring back to the Resource Model we might expect novices to be involved in goal matching and plan following (Section 9.3.1.3 and 9.3.1.4); whereas more senior members of staff would also be involved in plan construction (Section 9.3.1.2 through to 9.3.1.5). This appears to fit the Hutchins (1995a, p.203) diagram showing how social structure can be superimposed on goal structure (Figure 9.8, which is explained further in Appendix B). Here it shows that more senior members higher up the hierarchy have a broader picture of how goals fit together whereas those at the bottom have a quite detached view of the tasks they complete. This is shown by the goal, 'G', being split into sub-goals lower down the hierarchy, SG1 and SG2, and these being further divided. The boxes represent people's different areas of responsibility.

Figure 9.8: Goal Hierarchy and Distribution of Responsibility (adapted from Hutchins (1995a) pp 203)



In terms of the coordinating resources the two biggest resources that a novice might lack are affordances, i.e. knowing what can be done with a given issue, and action-effect, i.e. knowing the likelihood of effects given possible actions. Once someone has gained sufficient experience the choice of methods might almost seem trivial when an appropriate grasp of the problem has been reached. By our interpretation, after a series of questions about the use and merits of different methods respondent S5 queries this line of questioning because unlike the interviewer the methods have a very clear and specific application that makes the line of questioning trivial, i.e. the method's affordance and action-effect are transparent to them:

> "I: […] what do you think about checklists, guidelines, standards?
>
> P: I don't know why people, this is an incredible academic discussion, what use is a checklist, you know, it stops people having to think for themselves, thank god! Why are we debating this!? Standards, if standards are bad or out of date, I've been writing guidelines and standards and checklists for twenty years! I really don't understand why people might debate these things." S5

The above quotation alludes to a change in computation within the practitioner through experience. Respondent S11 conjectures that there is a restructuring of knowledge from a modular based organisation as might be developed at university, to a solution based organisation that is developed through practice. Here the knowledge is structured to tackle problems as they are presented in the world, and these knowledge structures fit together as they are used in the world, rather than how they are categorised in a course text book or academic curriculum:

> "When I interviewed experts in the building industry, I interviewed a heating and ventilation specialist. I asked him to categorise his knowledge, and I was surprised by his answer. I said, 'I expected you to divide it into heating, ventilation, etc.' and he said, 'No,

> that's the way you learn it at university, that's not the way you use it. Nobody comes to me saying I've got a heating problem, or I've got a ventilation problem, they say - I've got a building that is boiling hot in summer and freezing cold in winter. What can you do to help me? - And it is up to you to find out whether it's an air conditioning problem or a heating problem'. I realised then that expertise is structured differently from how the subject is taught at university. Take medicine as an example. Two doctors might have the same degree, but if one's gone into GP work here in the UK, and one's gone to do voluntary work in Africa, after two years their knowledge structure is very different. It has been reorganised for use. Expertise is solution-based, rather than problem-based." S11

Here it appears that experts' knowledge is restructured through experience so potential solutions are more apparent. This seems to move away from abstract knowledge of methods and more toward an understanding of methods in-use (where real problems map to particular methods more directly).

In this section we have seen that practitioners at different levels of seniority have different computational abilities, they have different roles in the systems and different expertise. With this knowledge in mind less experienced practitioners are given smaller discrete packets of work, and given wider roles and responsibilities as they mature. We have seen it suggested that this is due to a reorganisation of knowledge; this may make affordances and action-effects more immediate and apparent to experienced people: so the mappings between real world problems and solutions are more direct and transparent.

9.4.1.5 Personal relationships

Relationships are important in practice as they can establish trust and confidence that the working practices of different parties will synchronize well. Dumas (Redish et al., 2002) claims that the most important factor for developers responding positively to usability findings, in the long term, is their relationship with usability professionals. Trust and confidence should aid the flow of recommendations. In this quotation respondent W8 gives us an impression of the need to manage relationships both inside and outside of the company to facilitate working relationships:

> "But we also include positive findings from our study, there are a couple of reasons for that, just as we try and treat our consultants like human beings we try and treat our clients like human beings as well, [some] people often work months or years on a product and how dispiriting it is to have someone to come along and evaluate it and only point out the parts that aren't working well." W8

This management of rapport and relationships can have a computational effect on the system, as people may be more or less likely to take comments on board, or work the extra hour to do a good job. W8 stresses that this does not mean they make up or exaggerate the positives just to spare people's feelings but to acknowledge where there is legitimate success. Respondent S11 emphasises the importance of working relationships and reputation in their industry as good working relationships can allow that person more freedom:

> "… as you build up relations with people, you know who will deliver on time, give added value, show real interest in the problem. Once you are confident about their expertise, you can give them much more freedom to do the job. The problem comes with unknown quantities. I had a problem managing a new consultant. I realised after a few weeks that he had not done what I expected, and I had to take over. " S11

The idea of uncertainty in working relationships is bad when wanting to coordinate resources to reliably perform a function well. In terms of the Resource Model we might relate this to history and action-effect: i.e. a person's reputation will illustrate the history of how they have performed in the past which might make their choice more or less likely in the future; and if we select a person to do a job we want to know that the action of selecting them for this job will have the desired effect. We want to reduce uncertainty and risk of components that would lead to the project failing.

9.4.1.6 Power

Within a social system there are likely to be people with different roles, and groups with different social structures. Within this some people will have more power than others. In terms of the computation of the system these people will be able to influence decisions more, e.g., where resources are placed, and how subsystems are organised and interact. Understanding the effect of power in the computational system becomes important because it impacts on the behaviour of the system. Power should be recognised and managed effectively to affect the computation of the system.

The concept of power has been recognised in both the website design study and the safety-critical system development study. This was most obviously in the form of the client's influence on what work was done, how it was done, and what was done with the work after. Indeed, one practitioner in the safety-critical development study stated that the client was at the top of the food chain because of their influence.

The client-practitioner relationship is an example of external power, but there are also internal power structures within a company. In HF practice this relates to career development whereby more senior members have more responsibilities and take on more complex work than junior members (see Section 9.4.1.4).

Something which emerged in the safety study, which did not come through in the website study, was the practice of regulation. This could be in the form of a legalised regulator enforcing safety standards. Here, there is a more superior power than the client which forces them to comply with accepted standards.

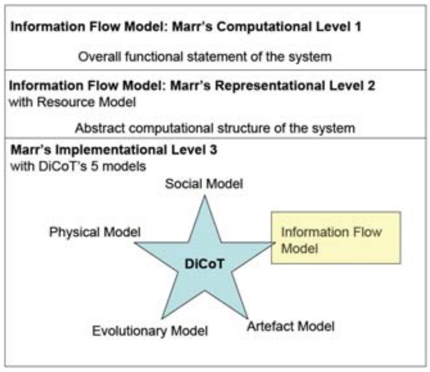
The safety domain also involved HF practices auditing the quality of each others work; here, power lies with the HF practice that is in the auditing role.

This project is not about power, but the above examples show that power influences different parts of the system. A brief reference to the literature reveals that 'power' is a concept with different origins and categories (Table 9.1). Regulators and clients have powers which are more akin to position power; whereas HF practitioners must rely more on personal power. Regulators have legitimate and coercive power as it is their official role to enforce safety standards and take action against individuals and organisations that do not meet these. Clients appear to have legitimate and reward power as they control the allocation of resources in the client-practitioner relationship. HF practitioners rely heavily on their expertise because they are specialists, but also on softer personal factors such as reference, charisma, and persuasive power which relates to the maintenance of relationships above (see Section 9.4.1.5). These powers will influence what work is done, how, and what is listened to.

Table 9.1. Position and personal power and their subcategories (adapted from Furnham, 1997, p. 368).

	Subcategories
Position Power (formal position)	**Legitimate:** based on the belief that the individual has the recognized authority to control others by virtue of his or her organizational power (i.e. a high ranking corporate official).
	Reward: ability to control valued organizational rewards and resources (e.g. pay, information).
	Coercive: control over punishments (e.g. suspensions, formal reprimands).
	Information: extent to which a supervisor provides a subordinate with information to do the job.
Personal Power (individual qualities)	**Expert**: based on the accepted belief that the individual has a valued skill or ability (e.g. expert medical skills).
	Reference: based on liking of the power-holder by subordinates (e.g. the superior is friends with the subordinate). Allegiance to the relationship.
	Persuasive: ability to use facts and logic to represent a case persuasively.
	Charisma: attitude of enthusiasm and optimism that is contagious.

9.4.2 Information Flow Model: Marr's Implementational Level (Level 3)



Information flow is a central theme to DC, which concerns itself with the propagation and transformation of information in complex cognitive systems. The different models overlap with each other in this analysis because they are about information flow. However, this model is most central because of its theme, with more potential to overlap with all the other models. This is of little concern because we should not be precious about what is included in each model, but what they explain together.

Here we elaborate on:

- how the usability component synchronizes into the wider complex cognitive system,
- the coordination of organisational memory and expertise in usability practice, and
- epistemic actions.

9.4.2.1 How the usability component adapts with the wider system

The previous section (Section 9.4.1.3) recognised usability practice as a plug and play component. This metaphor captures how it adapts to different clients and project contexts, and 'fits' with this context. Here we use the term 'synchronise' rather than 'fits' as it suggests an active process whereby one component couples to another, rather than it just being a convenient match. We concentrate on five themes that influence synchronisation in this subsection:

- Language
- Relationships
- Reporting – communication channel
- Timing – window of opportunity
- Timing – reporting

9.4.2.1.(1) Language

Language was recognised as an important aspect in both domains. It was recognised that to effectively synchronise with a client, HF jargon should be reduced and effort should be made to talk to the client in their own terms. This also included defining usability and HF, i.e. a tactic was to use terms which the client used when communicating with them rather than debating the differences between HF and usability. Practitioners might also need to learn the jargon of their clients to engage with them effectively; for example, respondent S12 recognises the importance of being able to speak the language to engage with different industries:

> "we are a multi-sector consultancy, but we certainly have people within the company who are focused in a certain area […]
>
> I: […] You could be someone that other people turn to for advice if they so needed in that sort of domain.
>
> R: Yeah, particularly in the domains where just speaking the lingo is a huge benefit. I know when I first started in [Industry A] and [Industry B] it was just a multitude of acronyms […] and just being able to know what an acronym is and speak a bit of lingo and appear to be, I'm not saying I'm a [specialised] engineer, but I just touch things on top level." S12

9.4.2.1.(2) Relationships

Good working relationships can facilitate synchronisation as the different parties that come together know each other's styles and preferences, trust each other, have confidence in each other and can rely on them meeting expectations (See Section 9.4.1.5). Good working relationships can also encourage more freedom and leeway between parties so they can get on and do their work with less doubt and questions.

9.4.2.1.(3) Reporting - Communication channel

Different channels exist to communicate results, e.g. Word reports, PowerPoint reports, presentations, screen shots, quotations, video clips, etc. There is often a recognition that these have to be suited to the clients' needs and be timely. Special value was placed on high-bandwidth communication, i.e. talking to the clients and getting them to watch usability tests where appropriate.

9.4.2.1.(4) Timing - Window of opportunity

It was recognised that some projects might have a window of opportunity to allow more funding and flexibility in HF work, e.g. if there was a recent accident or if a company wanted a gold standard project then they might allocate more funds for work, making synchronisation more flexible.

9.4.2.1.(5) Timing - Reporting

Design and business processes are dynamic and usability issues should be fed into the process so they can be acted upon in a timely manner. The consequences of being out of synchronisation in this respect may mean that usability issues become dated and irrelevant, which reduces not only their value in the short term but the perceived value of usability input in the longer term. This affects project design and reporting.

Synchronisation is important for accomplishing the computational goal to provide HF input, feedback and advice to satisfy or exceed a client's need under constraints and finite resources. These five factors affect how well HF synchronises with the client and the project. Poor synchronisation will affect information and value transfer for the project in the short term, and the perception that company has for HF in the long term.

9.4.2.2 Organisational Memory or Expertise

A re-examination of organisational memory was referred to in Section 8.3 whereby Ackerman and Halverson (2000) expanded the concept to be considered as an object and process; as a phenomenon that can have many representational states such as an individual's notes or a standard group procedure for handling calls; that these phenomena are complexly distributed, interwoven and overlaid; and that as memory crosses between groups and across times it gets de-contextualised and re-contextualised. We concentrate on four aspects of organisational memory that have presented themselves in the data:

9.4.2.2.(1) Boundary objects

The concept of a boundary object was introduced in Section 8.3. These are objects that are shared between communities of practice whereby the objects are robust enough to carry some shared meaning, but will inevitably be read differently because the communities have different perspectives.

In terms of the process of exchange between clients and practitioners we can tell a story of different boundary objects that facilitate the process. We take a loose definition of boundary objects here which do not have to be physically instantiated, but may be a distinguishable item transferred between two communities which requires interpretation. The first boundary object is the problem or client need; here the client may have a safety or business issue that needs to be clarified as a HF or usability issue so that it can be addressed by these services. The second boundary object flows from the first and is the plan or contract between the two communities; here the HF practitioners and client negotiate what programme of work will be done to address the need. This programme of work will contain an outline of the methods used which are also boundary objects; for example it was observed that the detail of different methods was actually masked by their labels – so the client could identify and understand what was going on but did not need to know the exact details. Then finally the most obvious case for a boundary object is the final report; here it was observed that some practitioners recognised that the report should be written with its audience in mind and a report would serve multiple communities, e.g. the regulators might check the method, the directors would want the solution, and the developers would want to know the finer grained details of the implementation.

In these instances the boundary object serves as a vehicle to facilitate communication and translation between two or more communities with different backgrounds, interests and understanding. At a finer grained level there was also evidence of boundary objects used in design, where written design requirements, a wire frame, a plan for a new control room, prototype, or proposal could be used to facilitate different stakeholder input, e.g. from users, HF practitioners and others. It was commented that in the earlier stages of a design process feedback on designs could be limited by the maturity of the idea, e.g. if a boundary object was not developed then people would have less idea about what to respond to.

9.4.2.2.(2) Reuse of System Knowledge: Organizational Expertise

Companies build up their expertise in more and less tangible ways. The less tangible is perhaps most obvious: through staff training, group communication and practice. The more tangible is, conversely, less obvious, but manifests itself through the development of processes, methods, tools, templates and artefacts produced through work, e.g. presentation slides and reports can be adapted for similar projects. From this perspective the effective coordination of company expertise in individuals, between individuals and in artefacts is very important. Both forms of organisational expertise impact on the capability, reputation and track record of the company.

This respondent expresses the expertise of the individual through the use of a metaphor with the medical domain, where a doctor learns the subtleties and realities of the job whilst working:

> "Yeah, seven years of practice, it's like anything else it's not that a new doctor just having graduated from medical school has any necessarily less knowledge or the ability to have as much knowledge as someone who's been working in the field for ten years, and

it's just that the doctor working in the field has seen the cold for ten years and can probably diagnose a cold within three seconds of seeing the patient.... it's just repetition, repetition, repetition and it just builds up." W2

This respondent refers to the knowledge built up through experience in the individual but also how a company would spend time gathering information and preparing material to capture this knowledge, e.g. in slides for presentation:

> "usability consultancies have a lot of experience at applying this knowledge and they actually have slides that are prepared about information scent and whatever … they spend …time gathering all this research that's been done by … researchers and say OK they work for three or four retail sites and they basically apply the same principles to each site" W3

9.4.2.2.(3) Perceiving partial solutions as potential routes

Usability specialists seem adept at noticing patterns in interfaces, as interface fragments (Chapter 4). For example, one participant recognizes these fragments and refers to their expected use, which is also an example of knowledge reuse:

> "You'd tend to have that thing, like on Amazon where they say 'people who looked at this looked at that.' So, I think there would be an expectation to applying that even to say a newspaper site, where you know people who thought that article was interesting, you might think this article was interesting." W7

In another example a practitioner shows their ability to rapidly and effortlessly offer a programme of relevant work-packages for a client wanting to design a control room. In both cases they are chunking knowledge so it can be recalled for similar but novel problems. Through experience they develop a wealth of partial solutions for planning and problem solving that can be reapplied in new situations.

In Section 8.2.4 we were introduced to the parable of the ant, and how the ant's seemingly advanced internal decisions are actually an interplay between itself and its environment. Here we can see how the mature HF practitioner builds up an internal network of partial routes so they are more easily able to tackle similar but novel problems in the future. Just as the ant makes use of its environment, so people assimilate and transfer good partial solutions (e.g. processes, solutions, and methods) to fresh domains, so new designs are built on the foundations of their contemporaries. These fragments provide scaffolding by which usability specialists think about website designs, safety processes and recommendations. For example, one practitioner notes a trend to use Goal Structuring Notation which appears to be becoming a standard in the rail industry but now might be used for safety cases in their HF work across industries, including some adaptation and the development of tool support (S7).

9.4.2.2.(4) Clients' education process

Clients of usability services often educate themselves about usability through interaction with usability project work and practitioners (Chapter 4). For example, one participant refers to this education process:

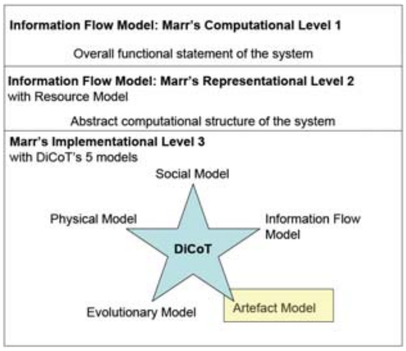
> "There's an education process definitely, I remember 4 or 5 years ago at [company A] trying to explain just the very basics, why you should do usability testing at all during the process never mind the different techniques […]"
>
> I: "Do you think that's changed now?"
>
> R: "[…] It's a lot better, it got to a point at [company A] where clients were actually coming in and say we want testing at this point, this point, this point." W6

This education process reflects the incremental journey of the ants in the parable: in the sense that clients are learning about the methods, costs, timescales and potentials of usability research they are internalising partial solutions. Through interaction with usability work they can progress from being completely naïve to having some understanding about when and where particular HF methods and processes would provide useful input for them – so they are better placed to think about the possibilities themselves.

9.4.2.3 Epistemic Actions

Epistemic actions were defined as actions which do not explicitly move an agent closer to their goal but change the cognitive space to make actions and decisions more reliable. The actions of making moves to change the cognitive space to make decisions more reliable can be related to HF and usability as they provide advice and input to make systems safer and more user friendly: i.e. they inform designs and decisions. Clients employ HF services because they provide information which changes the cognitive space for their decisions. There was evidence to suggest HF services were sometimes employed on politically motivated grounds where an external independent report would carry weight to shape decisions at a senior level which an internal voice could not. Here the client has taken an epistemic action to change the cognitive decision space of their seniors to achieve some wider goal (for example Respondents W4 and S11).

9.4.3 Artefact Model: Marr's Implementational Level (Level 3)



The interview data that was collected does not support a detailed analysis of artefacts; i.e. we have reference to artefacts at the more abstract level rather than examples of specific artefacts that are used in the HF process so detailed analyses about their structure and computational affordances are not possible. Such an analysis would be a different project and perhaps a fruitful one given the rich environment of artefacts that HF practitioners inhabit.

We have already discussed artefacts in terms of boundary objects in Section 9.4.2.2 whereby they are used as vehicles for communication throughout the HF process between the client and practitioner: i.e. as problem statements, as work-packages, as methods and as reports.

One group of artefacts that has had less attention in this analysis thus far, and is more to do with the internal computations of HF practice rather than facilitating communication with the client is tools. The work done by tools generally seems to be related to the manipulation of information, helping to map information from one form into another. The effectiveness and efficiency of this manipulation can either aid or hinder the wider computation of the system. For example, one practitioner thought editing video footage was too time consuming; another wanted software to help make drawing diagrams easier; and another said that since advances in tool support he could now do what used to take him weeks in a couple of hours:

> "Now I can do one of these work load assessments in a couple of hours because all I'm doing is inputting raw data and the computer does the rest" S10

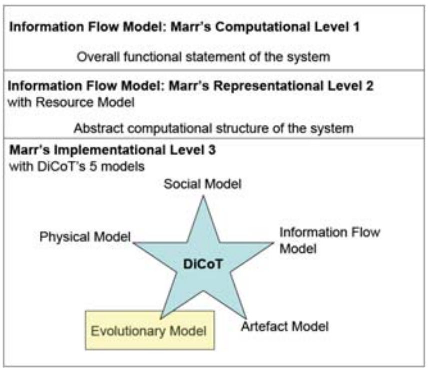
These tools not only affect computation locally but also the wider system. For example, the potential to do several weeks of work in one day would make that option much cheaper and more convenient for the client and so more likely to be resourced. Contrarily, if editing video footage is too time consuming then a practitioner may avoid this line of practice in their work. Hence the ease of transformation of different information will affect how structures are coordinated, which may have consequent effects, e.g. the video footage might actually be more persuasive than a normal report. If we picture the HF practitioner as an ant that makes choices, they will have more or less well travelled routes depending on their own experience and the people around them. These routes will be affected by their costs and potentials. So, the computational costs and potentials of subcomponents will affect their coordination in, and effect on, the wider system.

In terms of the complexity of the transformation, tools should allow practitioners to do the things they are good at, e.g. recognising patterns (Hutchins, 1995a, p. 155) and support them in tasks which they are not good at or can be automated, e.g. generating diagrams, editing video, and performing calculations. Hutchins (1995a, p. 171) reminds us that the power of computation can come from relatively simple processes rather than complex ones. For example, an abacus can be used to perform quick and complicated math but its actual operation is quite simple; here the cognitive interaction of the abacus does not equate to the cognitive task of the calculation it performs: i.e. interacting with the tool is simpler than the cognitive task it performs.

Similar comments could be made of usability evaluation methods and tools, i.e. they should support those tasks which the practitioner finds difficult or tedious; and allow them to concentrate on the things they are good at in ways they are good at. For example, a practitioner's time is better spent analysing consequences of a task analysis than struggling to arrange the diagram into a coherent representation. Tools should not be overly complex in performing the tasks they are designed for, e.g. having to learn and use a complicated notation for a tool or method is likely to be a hindrance and must give a computational reward for such costs. The use of the tool should be simpler than the cognitive task it performs, and certainly not vice versa. Tools may also provide support for activities that have not been conceived of yet, e.g. analysing usability metrics via brain scanning, and activities which someone might find impossible to do without the tool, e.g. eye tracking. In sum the cost of the tool should not outweigh its benefits in the short or long term.

Here we have seen that tools perform transformations, and that the cost and potentials of these transformations will affect their use. Tools should support practitioners by helping in things they are not good at or they find tedious, and allow them to concentrate on things they are good at like pattern matching.

9.4.4 Evolutionary Model: Marr's Implementational Level (Level 3)



The 'parable of the ant' (Section 8.2.4) was used to explain how human thinking and behaviour is influenced and supported by internal and external artificial environments which have been built up over generations. This applies to usability where we build on designs, methods, and technologies that we have inherited from previous generations.

The evolution of internal artificial structures is evident in individuals; and the evolution of external artificial structures is evident in the technologies, methods, artefacts and processes that change over time. Hutchins (1995a, p. 374) believes these sorts of changes make cognition a fundamentally cultural process as the social, material and conceptual aspects of practice change through social interaction and inheritance.

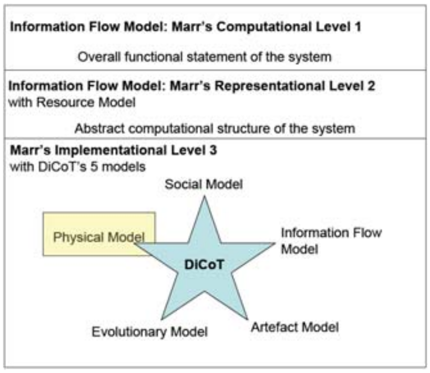
Sections 9.4.2.2***.(3)*** and 9.4.2.2***.(4)*** refer to how the internal structures of individuals change over time to support thinking about usability, both in terms of how practitioners learn partial solutions and how clients become more familiar with usability practice.

Section 9.4.3 refers to how the external structure of tools can have a computational influence on practice and we might envision a developing repertoire of tools providing practitioners with more computational power over time:

> "just a five minute search on the Internet came up with this new tool called Morae, so it was basically, ok, we'll order that, learn how to use it and use it on this project. Once you've used it once, it's there and you can use it on other projects. It tends to be more a requirement of a particular project where you use it, and tools that you find are really useful end up going into the repertoire of the tools you've already got." S13

A full evolutionary model is outside the scope of this project, as it would involve analysing how usability and HF practice has changed over years, which would include tools, methods, technological changes, with industry standards and market forces.

9.4.5 Physical Model: Marr's Implementational Level (Level 3)



Analysis and insight for the physical model is limited by our data, as it would require a more observational form of analysis or questions relating to the room and desk layouts which were not included in our interview scripts.

The idea of room and desk layouts did not seem pertinent for the purposes of our analysis, but comments about the effects of the 'closeness' of working relationships did reveal themselves in the course of the interviews which relate to this model. For example, one practitioner commented on the ability to 'ask the office' questions and advice about different projects; another commented that it is best to be sat with, and working closely with, the design team; and another commented on the need to maintain barriers between the design process and the evaluative process so claims to independent assessment could be maintained:

> "we can act as a customer friend in evaluating things as well as acting as a, potentially as a supplier although there are various business issues associated with that so for example we have to have firewalls in place between supply side and customer side because if one part of [Company A] is trying to sell some technology to a customer and another part is evaluating all the technologies for a customer, we need to make sure this team don't know anything about this team, because there could be conflict of interest there." S12

It is apparent that the physicality of co-workers, the design team and the design process has a computational effect on the system which is recognised and managed in some instances, e.g. the maintenance of firewalls between design and independent review.

9.5 Discussion

We have shown that usability and HF practice can be analyzed in Distributed Cognition (DC) terms, as a complex cognitive system. It is complex because it involves different facets that affect its computation, e.g. social influences, information processes, the role of artefacts, physical layouts, and the system history; it is cognitive because it is concerned with the informational flow in the system; and it is a system because it is non-reductionist but focused on the functional properties of the system.

The analysis was developed and structured iteratively using a combination of Marr's three levels of computation, the Resource Model, DiCoT and DC themes that have been referred to in the literature. Due to the nature of the data gathered some areas have more analytical power than others, e.g. the interviews covered areas such as expertise and communication, but observations were not made of HF offices and artefacts were not collected for analysis. This is because DC has been used as a theoretical leverage on interview data and analysis developed during grounded theory and so it was not the main focus of the study. Indeed, the applicability of DC in describing the context only became apparent during the grounded theory process, and the leverage it provides has only become apparent after the analysis described in this chapter.

This analysis has been focused on building up a computational view of HF practice whereby the high level, computational purpose of the system was: to provide HF input, feedback and advice to satisfy or exceed a client's need under constraints and finite resources. This computational purpose was then broken down into more structure in the representational view (with reference to the Resource Model) and then further elaborated on in the implementational view (with reference to the five DiCoT models). This discussion will focus on the implications for the adoption and adaptation of methods given the wider computational perspective developed in this chapter.

The representational view showed the different computational elements that are involved in HF work, from the client developing a need to the output of the results. Through this process we can see that the issue of method adoption and adaptation is not confined to when methods are implemented. Instead, the issue of method adoption and adaptation is involved in the project negotiation phase – because the client need has to fit the technical capability, the availability of resources, the practitioner's experience, and other constraints on the context. Here a plan is made about what methods to adopt and adapt. The implementation of the method also has consequences further along the process. For example, practitioners may encourage clients to watch user tests in which case they will receive feedback directly, and separate from an official report. Methods might also influence project reporting, e.g. whether video clips are used, whether wire frames are suggested or whether statistics and graphs are presented. In all, methods are only part of a wider computational system that have consequences and effects before and after their actual implementation. So, we should be aware of how they fit into achieving the wider computational goal of the system and refrain from taking a reductionist view by focussing on methods at the implementation stage alone.

The implementational view made further commitments as to how the computational view of the HF/usability system was coordinated and structured. In the social model we saw how work is socially distributed and how social factors can strongly influence the computation of the system. For example the picture that was described in this model was one where there were many people with different skills that come together to do work; and the HF/usability component fits into wider social, business and political issues. The HF/usability component provides a mapping between a client need and the client solution. This component adopts and adapts methods where necessary to achieve this mapping. The social factors of rapport and power also play a role in the adoption and adaptation of methods, and how successfully they are received. For example, people with higher power will have a greater influence on what happens and how it happens; and a better rapport and working relationship with people in power can allow more freedom and flexibility in choices. This happens externally with clients and internally within consultancies. Senior members of consultancies will not only have more power than junior members, but have more computational experience, contact with clients, responsibility to plan and manage projects and nurture more junior members of the HF profession. So, it follows that more senior members will have a larger influence on the adoption and adaptation of methods in practice, and they will pass on these practices to other members of their teams.

The information flow model showed factors which affected the synchronisation of the usability component with the client system. Once again this has implications for method adoption and adaptation as it will impact on communication, the resources, the risk, and the timing of the project. Preferably a HF practitioner would want to synchronise well by offering a technical solution that could be communicated well, be done on time, was proven to be reliable and fell within the allowed budget. Most of these synchronisation issues are tackled in the project negotiation phase, where the practitioner creates a programme of work suitable for the client. From the client's perspective we may see them as using the practitioner as an intelligent interface that will reconfigure its subsystems, including methods, so it can meet the client's needs.

Another significant area covered by the information flow model was that of organisational memory. This affects the computation of the system in a more fine grained way than has been discussed thus far. Here methods can be seen as boundary objects and as partial solutions that can be employed in appropriate circumstances. As boundary objects, methods need to be easy to understand at a high level so non-specialists can be at least somewhat satisfied that they know what is going on. As partial solutions those methods which have proven to be successful and useful in the past are likely to be employed again in suitable circumstances. This acts as a reinforcement as the more they are employed the more familiar they become, making their retrieval and use more likely still. This behaviour reduces the risk which is apparent if a novel method which had not been tested is used. Like the parable of the ant: following the scent on the beach relates to well trodden paths that will be less risky and more likely to lead to where you want to go. As partial solutions, methods can be adopted and combined to achieve appropriate research goals, e.g. interviews, questionnaires and user tests can be used together. These partial solutions are not only internally coordinated in experience and expertise, but are externally coordinated in the system in documents, shared plans, processes and procedures. Clients will also form their own partial solutions for their issues which may mean a preference for certain methods, a preference for HF input at a particular stage in the design cycle, or a preference to work with a particular practitioner or company if they have a good working relationship.

A more discrete analysis of how methods are adopted, which abstracts HF/usability issues away from real projects, would miss system level influences which are prevalent in practice. Method adoption does not involve an exhaustive evaluation of the total set of methods that might apply to a particular issue. Quite often the chosen method will be one the practitioner has experience in, is competent in applying, and has confidence in. More widely this appears to give inertia to method adoption, with widely used methods being used more, and less widely used and novel methods used less. This however, also makes the system inherently more stable and reliable, and arguably more efficient. This is because the cost of regularly learning new methods, which might not add a significant benefit to, or worse upset, the wider computation of the system, would be very detrimental.

The artefact model focused on tool use in practice and the effect of their transformations on the computation of the system. It was noted that the use of these transformations depended on their power and their efficiency of use. For example, one practitioner thought video clips of user tests for clients was good but the editing involved was too time consuming and so they withdrew from this practice. Another practitioner described the evolution of a tool which had reduced his workload assessments from weeks to days could now do the same work with much less effort. Another practitioner really wanted tool support in automating diagram drawing, so things like a task analysis diagram could be automated from a table view, and so that small changes in the structure did not mean hours of redrawing. It is clear that tools have an important role to play in the transformations that practitioners make, the more powerful and efficient these transformations then the more effective they can be in their work, e.g. they could potentially do more technical computations, communicate results better, and do the work faster at a cheaper cost to the client. Here tool support and method use become entwined as we can imagine that the right tool support for a method could greatly facilitate its use.

The evolutionary model commented on the rich cultural heritage of developing HF and usability practices. Practitioners work in a fundamentally cultural process, whereby their thoughts and behaviours are in some sense a product of the evolving methods, procedures, theories, tools, technologies and practices of generations that have gone before. Locally they coordinate partial solutions for designs, tools and methods into an evolving repertoire of potential actions. More globally these are passed on to people around them, and more globally still they become trends and standards in industry. Here we begin to get a picture of the part methods play in this shifting cultural heritage at local and global levels.

The physical model concentrated on the dimension of closeness and its computational effects on the system. Methods might facilitate a closer working relationship whereby a greater understanding can be communicated, e.g. clients observing user tests; or the situation might require that formal boundaries are maintained between design and evaluation so that claims to independence can be preserved. These computational effects will affect method adoption and adaptation in different circumstances. For example, a situation where a client appears sceptical about usability work might encourage the practitioner to use more persuasive methods such as observations and video clips of user tests.

An explanation of method adoption and adaptation benefits from such a view because it accounts for different system factors that affect their use. A reductionist view that does not account for these system level elements remains impoverished. The computational view has been shaped by the DC literature, which covers the system level elements at a high level. Pockets of this model could be expanded in future research, e.g. HF and usability practice artefacts could be collected and studied and a finer level of analysis, and the idea of boundary objects in communities of practice could be explored more. These are fruitful areas of research, but remain outside the scope of the current chapter. This chapter has served its purpose by providing leverage for understanding this project's data in a new light. By doing this we have established a computational system view of usability practice, which provides explanatory power for how methods are adopted and adapted in practice.

9.6 Conclusion

This analysis highlights important system level elements of usability practice, which might otherwise be ignored from a finer grained analysis. It presents these elements synergistically under the DC theoretical framework. This theoretical foundation adds coherence to the different system facets that make up usability practice (i.e. that it can be viewed as a complex cognitive system) and so helps researchers trying to gain a more holistic view.

The complex cognitive system view gives us an overarching abstract computational goal which provides the apex for many different HF and usability services: to provide HF input, feedback and advice to satisfy or exceed a client's need under constraints and finite resources. It also gives us a framework for conceiving how this computational system operates by first helping to divide it into subcomponents, processes and structures; and then by the way it integrates social influences, information processes, the role of artefacts, physical layouts, and the system history.

This analysis has shown that DC has potential to explain a system of usability practice with different functional influences. The issue of method adoption and adaptation in practice is understood within this system, as they are influenced by, and have influence on, wider computational elements in the system.

Chapter 10: Resilience Engineering literature review

10.1 Introducing the Resilience Engineering Perspective: Preparation for using it as leverage

This chapter orientates the reader to the Resilience Engineering (RE) area, and Chapter 11 develops a theoretical bridge from the literature to the data. The aim of this data treatment is to gain new insight into the data from a pre-established perspective: to ‘see’ the data in a new way. Although we use RE as leverage for thinking about HF/usability practice, it was originally developed as a new way of thinking about safety.

10.1.1 Self-reflection on the selection of RE

Unlike the DC analysis the analyst had no previous experience in the conceptual area of RE before this research project. Whereas DC was ‘ready to hand’ throughout the research project because of the analyst’s prior work related to this area, RE was encountered part way through the interviews with HF practitioners in the safety-critical system development domain. The events which contributed to encountering the RE area included: doing the safety-critical system literature review (Chapter 5) which moved toward a system safety perspective (Leveson, 1995); seeing preliminary links with usability practitioner interview data in terms of building an explanation of usability practice as a system; having a colleague direct the analyst to the RE literature when he mentioned Leveson’s (1995) ideas; and attending a symposium on RE with that colleague and seeing further links with interviewee data and the grounded holistic approach to my research. Unashamedly, this shows that using RE as leverage is not the result of an exhaustive search of theoretical frameworks (the pragmatics of which are somewhat hard to fathom), but is dependent on the analyst’s experience, context and interest; and in this case has some role for serendipity. Importantly these leverages are chosen for their potential for exploring the data, they are not selected randomly and they are not the first option. These leverages resonate with aspects of the data, and show potential to conceptually add to the analysis.

RE was selected as a theoretical leverage as connections to the theory were evident to the analyst, for example:

- The analyst had identified and was interested in building a systemic explanation of usability practice and RE builds systemic explanations of accidents;
- The analyst had identified that it was important for usability practice to operate under constrained resources and RE talks about systems operating under constrained resources;
- The analyst had identified the importance of the plug and play usability component adapting to the context of the project and client and adaptation to different demands is a central tenet of RE;
- The analyst had been interviewing practitioners about their normal work and RE concerns itself with learning about normal work as well as when failures occur;
- The analyst had been responding and trying to account for what the practitioners found interesting and important through the grounded theory process, similarly RE focuses on building descriptions from the operator's perspective and understanding the decisions they make in their own terms.

These have proven to be significant in the data and heavily relate to the RE perspective.

The following sections introduce the concept of 'normal accidents' (Sections 10.2); review definitions for RE (Section 10.3); and explore RE studies and concepts in further detail (Section 10.4) before showing how this systemic understanding differs from other accident models (Section 10.5). This will provide a theoretical grounding and vocabulary to move on to the analysis in Chapter 11, where our interview data, insights from the data, and theory are coordinated together.

10.2 'Normal Accidents'

Perrow (1999) provides foundational work for RE in his book, *Normal Accidents*, which was first published in 1984. Part of the message of his book is that accidents in systems are inevitable as events will fluctuate and conspire in unanticipated ways to cause failure. Here we come to the idea of 'normal accidents': these are so called not because of the frequency of their occurrence but because they are a result of multiple failures that are not in direct operational sequence, which interact in anticipated ways (Perrow, 1999, p.23). Here, the concept of an 'open system' is foundational as these systems do not have hard conceptual boundaries but constantly interact with their environment.

This allows for seemingly unimportant phenomena that may not have played a part in the system description to have important unanticipated roles in that same system.

Perrow (1999, p. 5-9) gives an example of a normal accident whereby someone misses a job interview, due to a set of unfortunate interacting incidents. The person gets up and gets dressed. They find that the coffee pot has cracked because it has been left on the heater. So they find another coffee maker, make some coffee, but in their haste they leave the house without their house and car keys, which are left inside. They normally have spare house keys hidden outside but they lent them to someone just two days ago. They go to their neighbour who is retired and has a car they do not use but it just so happens that it is being fixed that day. They think about ordering a taxi but the neighbour tells them that there is a bus driver strike so there is not any public transport which also means all the taxis are busy.

Perrow (1999, p. 7) asks us to reflect on what caused the accident: was it human error for leaving the keys, a design fault for being able to leave the coffee pot long enough on the heater for it to crack, a mechanical fault because the car engine did not work, or an environmental fault because of the bus driver strike? He maintains that it is more accurate to say that none of these are sufficient causes on their own and that the fault lies with the system. On their own the failures are annoying and trivial, we might even expect them to happen in normal operation because nothing is perfect, but together they led to a substantial system failure.

Using the concept of inevitable normal accidents as a foundation he develops an explanation of accidents in different sorts of systems. He defines systems across two dimensions: ‘complex-linear’ and ‘tight-loose’. The former is about the comprehensibility of interactions in the system; the latter concerns itself with the coupling between different actions and consequences within the system. Table 10.1 shows that these dimensions provide different system characteristics, which can provide a classification scheme for modern systems. Perrow (1999) warns of the dangers of tight-complex systems (the upper right quadrant in Table 10.1) where their operation often surpasses the comprehensibility of the designers and operators, and where there is little time to assess and recover from errors.

Table 10.1. Characteristics of different systems

	Linear	Complex
Tight	These systems are comprehensible but actions will have immediate and direct knock-on effects, e.g. rail transport.	These systems are incomprehensible and actions will have immediate and direct knock-on effects, e.g. nuclear plants.
Loose	These systems are comprehensible and will have delays and indirect consequences from actions, e.g. most manufacturing.	These systems are incomprehensible but will have delays and indirect consequences on actions, e.g. universities.

The idea of accidents happening due to unanticipated interactions in complex systems is a central part of RE. RE also covers how these systems respond and cope with unanticipated demands.

10.3 Definitions for RE

RE is a new perspective and consequently has no firmly agreed definition. In fact, the community have been quite open about the fact that there is not a definite understanding of the area, that it is fine to be in an exploratory mode, but, importantly, there is enough participation and interest in the perspective to continue its intellectual investigation and development (RE symposium, 2006). In Section 10.3 we offer three quotations about resilient systems and reflect on what they show.

The first quotation emphasises the fact that resilient systems must cope with changing demands made on them, even when those demands exceed what they are designed for:

> "Success belongs to organisations, groups and individuals who are resilient in the sense that they recognise, adapt to and absorb variations, changes, disturbances, disruptions, and surprises – especially disruptions that fall outside of the set of disturbances the system was designed to handle." (Woods & Hollnagel, 2006, p. 3)

The second quotation emphasises that a resilient system will hope to cope with demands from inside and outside of itself:

> "We adopt a simple working definition of resilience as an organisation's ability to adjust successfully to the compounded impact of internal and external events over a significant time period." (Sundström & Hollnagel, 2006, p. 235)

The last quotation further elaborates the concept of adaptation by emphasising that resilient systems will have adaptive boundaries concerning the type and amount demanded of it:

> "The adaptive capacity of any system is usually assessed by observing how it responds to disruptions or challenges. Adaptive capacity has limits or boundary conditions, and disruptions provide information about where those boundaries lie and how the system behaves when events push it near or over those boundaries. Resilience in particular is concerned with understanding how well the system adapts and to what range or sources

> of variation. This allows one to detect undesirable drops in adaptive capacity and to intervene to increase aspects of adaptive capacity." (Woods & Cook, 2006, p. 69)

In sum, these quotations show that: Resilient systems are systems that adapt and cope to internal and external demands/disruptions, which may or may not lie within the type and amount of demand/disruption the system has been designed to cope with.

10.4 RE studies and concepts: further detail

This section expands on the background to RE by summarising some issues and points of interest in the domain.

10.4.1 Normal vs abnormal performance: how and when do we distinguish between these?

When we move away from traditional approaches to human error, which take a more black and white view of when things are OK and when they have gone wrong, we have the problem of recognising shades of grey. In the systemic view, systems constantly change under demand and many different factors interplay and contribute to their performance. It is obvious when things have gone wrong but it is not so obvious when things are going right comfortably, going right under strain, and going right but on the verge of failure, i.e. unless the system is extremely brittle it will make local adaptations to compensate and cope.

10.4.2 Studying the banality

RE is interested in what happens during normal performance and near normal performance. Dekker (2005, p. 30) emphasises the need to study the normal to understand conditions for when it might turn abnormal:

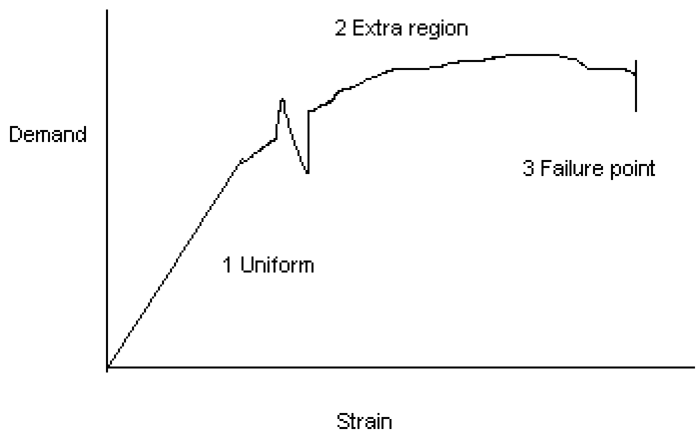
> "To understand safety, an organisation needs to capture the dynamics in the banality of its organisational life and begin to see how the emergent collective moves toward the boundaries of safe performance." (Dekker, 2005, p. 30)

Examples of this focus include Le Coze and Dupré (2006) who look at resilience in the chemical industry and look at accidents as well as what happens normally, i.e. when nothing significant appears to be happening; and Carvalho, dos Santos and Vidal (2005) who look at microincidents which are small incidents that rupture normal working and lead to adaptive behaviour by the operators which may not be considered as an accident or near miss. Here we are interested in how the system performs and adapts in 'normal' operation, where strain might show and how we can maintain a buffering capacity that can cope with the variance that the internal and external environment will throw at it.

10.4.3 Langewiesche (1998) said that “Murphy’s law is wrong: Everything that can go wrong usually goes right, and then we draw the wrong conclusion.” (Dekker, 2005, p. 26)

This refers to the normal adaptations again. Under strain the system changes and copes so where things might go wrong they actually go right. This compensation then goes unnoticed and becomes part of the normal operation of the system. Resilience can be seen as the ability of a system to adapt and cope in the face of high demand, constraints and pressures. Here adaptability and flexibility are key properties. Woods, Wreathall and Anders (2006) introduce an analogy from engineering to elaborate the concept of resilience: that of a stress and strain plot of a spring. Figure 10.1 illustrates how increasing demand puts added strain on the system. In region 1 the system can cope with the demand and is not deformed in any way, in region 2 the demand is such that the strain deforms and changes system, region 3 represents where the demand is too great and the system breaks or fails.

Figure 10.1. An illustrative example of a demand-strain plot



The analogy is useful in that it highlights that in the face of increasing demand the system will change to try to cope with that demand. There is not just a normal mode of working out of which appears the odd failure, but there is an ongoing interaction between what the system can do and the demands made upon it. The performance of the system is dependent upon this interaction. The better a system can adapt and cope in the face of increasing demands, the better its survivability and the more resilient it is.

10.4.4 Drift into failure (failures happen by people performing normally)

This refers to the local adaptations of the system that stretch the system's integrity, which almost go unnoticed as the system seems to cope. For example, Wears et al. (2006) report a case study of an Emergency Department whereby the department comes under increasing sustained pressure as more resources are not given to the increasing demand. Instead, staff make local adaptations to cope with their conditions (e.g. putting patients in chairs rather than stretchers because they had run out) which erodes the capacity for the system to cope with more pressure. It has drifted closer to failure as its normal resilience has become eroded.

10.4.5 Dynamic not static

Traditional approaches to human error have looked at almost decontextualised factors that have some sort of significant impact on error, e.g. Li (2006). These factors are isolated and fairly static for the sake of controlled experimentation. In the systemic approach, factors are heavily related and embedded within each other, and variability is a natural occurrence as the systems are more 'open'. From this perspective the rich picture of contextually-dependent varying factors influencing each other is the interesting thing, and better reflects real phenomena. The RE perspective generally errs with the philosophy that the whole is greater than the sum of its parts and so the analysis of static individual components remains lacking.

10.4.6 Expansion of the unit of analysis

Moving from reductionist approaches of isolating and testing components toward looking at mutually dependent dynamic factors we need methods able to cope with this added complexity. Following this Dekker (2005, p. xiii) points to the failings of traditional approaches to human factors, which focus on the components of systems, and he suggests an expansion in the unit of analysis to notice the significant interactions which affect the performance of the system in a more holistic manner.

10.4.7 Insider accounts not outsider ones (Emic not Etic)

This is to focus on creating a description of the system that is based on the understanding and vocabulary of the people that work within that system (an emic view), and not imposing a description that is led by the researcher (etic view). This is important for engagement with actors' local rationality, explained below.

10.4.8 Local rationality – context

To introduce this concept we first refer to Perrow's (1999, p. 323) discussion of three perspectives on rationality i.e. the way people think:

- absolute rationality is narrow, quantitative and precise where people perform calculations for optimum decisions;
- bounded rationality accounts for people's limited cognitive capacities and how they use rules of thumb and have biases; and
- social and cultural rationality emphasises the diversity in people's abilities and thinking. These diverse and sometimes specialist abilities then work together to achieve higher goals, e.g. a carpenter, plumber and electrician might come together to install a kitchen which they could not separately.

Here we see that there are different assumptions made about the way people think and rationalise. From thinking that people make precise calculations, to thinking they do the best they can in their limited view of the world, to thinking of individuals' diverse expertise and abilities which can be utilised effectively in group collaboration.

Local rationality emphasises a person's thinking from their own perspective by referring to the decision making at a local level, i.e. local in time and in place. These decisions may appear perfectly rational at the local level but may seem rash or irrational when considered away from that context (Dekker, 2005, p. 60). For example, it may seem perfectly rational for a mechanic to simply replace an aircraft's bolts by comparing them with the bolts they remove without checking their official size, particularly in the context of working efficiently and wanting to go home early, but they may be replacing 'wrong' with 'wrong' and this may be a breach of a safety barrier. Local rationality considers the context as understood by the actor.

10.4.9 Blind in foresight, 20-20 vision in hindsight

This relates to inability to recognise where and when the system may be drifting into failure. It is only when a failure occurs that a causal chain that led to the error can be identified. It is in the wake of an accident that personal, management, organisational and technical issues are drawn out and laid in front of everyone. The explanation of the causal chain may satisfy our thirst for certainty, but it may be a simplified or inadequate explanation of the interacting events that produced the failure (Hollnagel, 2004, p. 36).

10.4.10 Managing rigid procedures and allowing people freedom

Grote (2006, p. 120) attends to the issue of flexibility and rigidity of procedures in practice, i.e. when people should be following rules and when they should be thinking on their own. There are two types of problems in this area: the first is where rule following persists despite there being a need for adaptations, and the second is where unsuccessful adaptations are made when there is incomplete knowledge or lack of guidance (Grote, 2006, p. 120). Grote (2006, p. 116) refers to loose coupling to address this balance between rigidity and freedom, i.e. it is not just a case of having one or the other, but it is more a case of doing the right thing in the right circumstance.

10.4.11 Divergent local practices can become standard

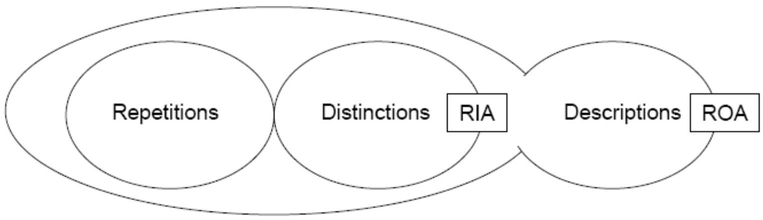
Practice can be viewed as a process of constant negotiation and renegotiation rather than as a repetitious activity. People may work in slightly different ways, may have different styles, may have to tackle work that is slightly different, or may find a different way of doing things. This is particularly the case where we have reflective practice. When new ways of working are found they can become standard through continued practice – these might be better ways of doing things, or they may not: they may also be more dangerous or have unexpected impacts elsewhere in the system.

10.4.12 The Repetition-Distinction-Description (RDD) Model

Schön (1987) describes two types of reflection: reflection-in-action and reflection-on-action. The former takes place as events unfold, where the participant will perceive the situation as new but implicitly compare it to prior experience, situate possibilities for new actions and carry out experiments to decide a course of action. The latter happens further away from the event temporally, where the participant will formalize the situation and actions so they can evaluate and think about the situation. For example, a footballer will be reflecting-in-action during the game by responding to opportunities presented to him by his team mates and the opposition; during the half time break the team's coach will facilitate reflection-on-action by describing what was good, what could be improved, and how to change their tactics.

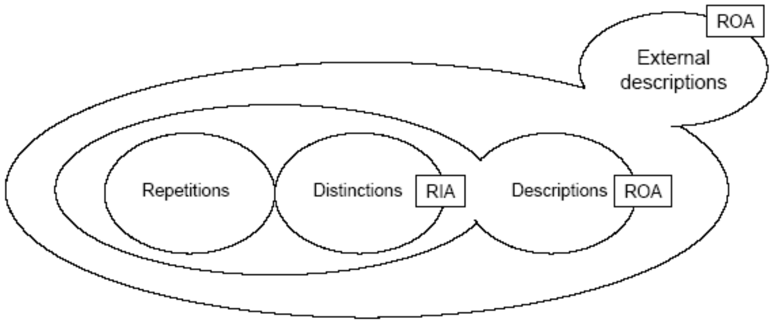
The Repetitions-Distinctions-Descriptions (RDD) Model (Nathanael & Marmaras, 2006) provides a graphical illustration of how reflection-in-action is distinguished from reflection-on-action. Figure 10.2 shows an abstracted version of the RDD model presented by Nathanael and Marmaras (2006, p. 233). Here repetitions account for the normal routine actions of individuals, where these are abnormal or there is opportunity to try something different then a 'distinction' in the normal routine can be made and the participant reflects-in-action (RIA) to alter their practice, this altered practice can then be absorbed in normal routine if appropriate. Reflection-on-action (ROA) occurs in detached moments where participants may formalise new understandings of their situation for action; i.e. the situation is not only distinguished but described and reflected upon away from the event which could be forced if there is a breakdown in understanding.

Figure 10.2. The Repetitions, Distinction and Descriptions (RDD) Model adapted from Nathanael and Marmaras (2006, p. 233). RIA = Reflection-in-action; ROA = Reflection-on-action



Furthermore Nathanael and Marmaras (in their conference presentation, 2006) added a further cycle of reflection that could be used to describe how external descriptions, by external observers, are incorporated into the reflective system. Figure 10.3 illustrates this external descriptive cycle. This could include management observations or researcher descriptions much like the current thesis looks at the work of HF and usability practitioners from an external point of view. The resultant explanation may then be incorporated into the reflective cycle to affect inside descriptions, inside distinctions and normal practice.

Figure 10.3. The RDD Model with an external reflection-on-action (ROA) circle. (Adaptation from Nathanael & Marmaras slides (in their conference presentation, 2006))

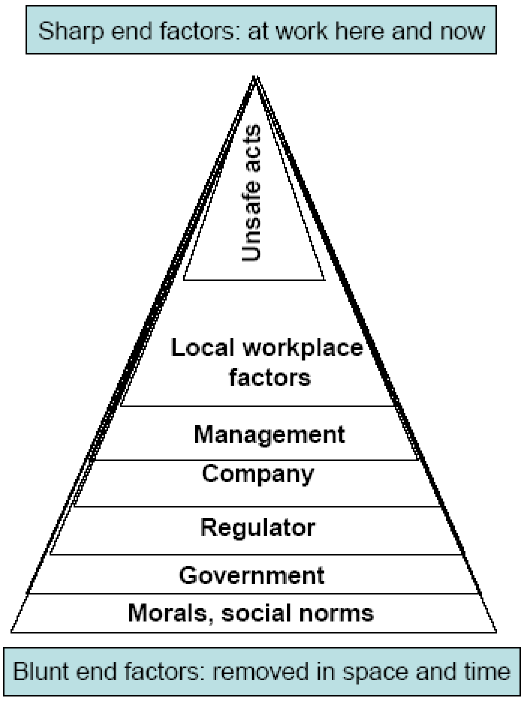


Explanations of how a system works is important as this can help or hinder reflective cycles and learning. For example, people pay a lot of money for coaches to teach them strategies and skills to raise their game in sport, e.g. compared to novices golfing experts will have a greater explanation open to them with regard to specific courses, holding the club, the swing, etc. to reflect on and develop a persons play. This is the same reason why experienced pundits are employed to comment on their field of expertise. We could also envisage management reflecting on how they think their staff perform rather than how they actually perform, and designers reflecting on they think their design will perform rather than how it would actually perform, because the explanations of these systems are inaccurate and not grounded enough. A better understanding will facilitate better reflection and adaptation.

10.4.13 Sharp-end / blunt-end distinction

Figure 10.4 shows a graphic representation of the sharp-end/ blunt-end distinction. At the sharp end you have acts performed by the operator. This is housed within ever increasing locality of contexts, e.g. from the local workplace, to management, to the company, and so forth. Each level works within the context and conditions of the levels closer to the blunt end and influences the context and conditions for the levels closer to the sharp end. In terms of accidents the sharp end includes the pilots, operators and controllers who interact with the hazardous process, but the actual failure may be affected by people at a different time and a different place e.g. the designer's poor design of controls, and the decision of managers to cut staff and training budgets.

Figure 10.4. The sharp-end / blunt-end distinction (Adapted from Hollnagel, 2004, p. 63)



Hollnagel (2004, p. 64) also points out the relativity of the sharp-end / blunt-end distinction in that someone's sharp-end will be someone else's blunt-end. For example, the operators of a car at the sharp-end will have blunt-end contexts which include the car's design; but this blunt-end will actually be the car designers' sharp-end. He also stresses that an analysis does not need to expand all the blunt-end levels; it will depend on the context but local working conditions will normally suffice.

We now refer to Hollnagel's (2004) introduction of systemic accident models and FRAM to show the development of RE from, and differences to, other accident models.

10.5 A comparison of Accident Models and FRAM

Hollnagel (2004) introduces systemic accident models which account for more complexity than the sequential and epidemiological models that have gone before. Systemic accident models rely less on reducing the explanations of accidents to linear sequences of events and instead stress the performance variation between different functional couplings in the system. We will discuss each in turn (this material has been summarised from Chapter 2 of Hollnagel (2004)). Accident models are important because they will affect the explanation and understanding of the accident: i.e. the models' assumptions affect what we 'see'.

10.5.1 Sequential accident models

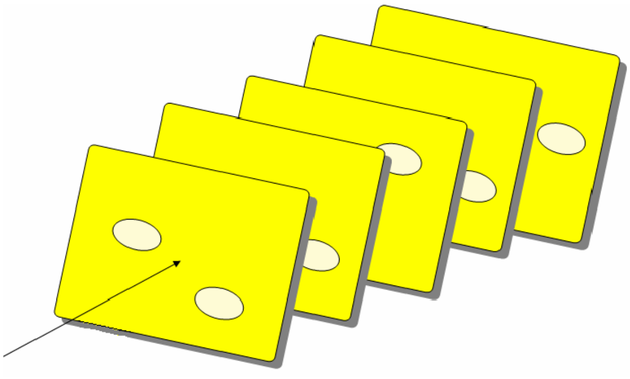
This is the simplest form of accident model. It presumes that a linear sequence of events can be identified that led to the accident. Here there are cause-effect links that move from one step in the chain to another. Because of this process the metaphor of dominos has been used to describe this model, i.e. a sequence of dominos can be identified that caused the accident, as one domino hits another in each stage. Once the causal chain has been identified then the events in the chain can be isolated and changed to prevent the sequence happening again. This model is associated with fault trees and finding the root cause of the analysis, i.e. looking at the sequence of causes from an accident and finding the cause that started the sequence of unwanted events. 'Human error' has often been associated with the reasoning related to this model as operators have been found to have used equipment inappropriately or have not responded to warnings which has been found to be the root cause of the event. The advantage of this model is that it is easy to understand and it can often provide a cause, e.g. blaming the operator, which satisfies the politics in a blaming culture. A disadvantage is that it is often too simplistic to capture the complexity in accidents.

10.5.2 Epidemiological accident models

Epidemiological models inherit their name from an analogy with the spreading of disease, i.e. the outcome is based on different interacting factors: some are latent and do not have an active role in triggering the disease but influence the effects of other active triggering factors. Hollnagel (2004, p. 54-56) outlines four main ways in which this model is different to sequential models:

- Performance deviation: this concept gradually replaced human error, it does not specify its subject and refers to a deviation in normal performance rather than a different class of action, e.g. error.
- Environmental conditions: this is a more open look at the conditions that led to the performance deviation compared to the rather succinct root cause analysis.
- Barriers: these can potentially stop the spread of unwanted events.
- Latent conditions: these are present in the system before the accident and are separate from the local triggering factors that actually start the accident. For example, they could be dormant in ineffective management procedures, communication, design, manufacturing and maintenance which could provide conditions to make an accident more likely to occur, or make the effects of an accident worse once it has occurred.
- The metaphor that is typically used to describe this model is Reason's (1997) Swiss Cheese Model. The metaphor involves slices of Swiss cheese lined up side-by-side. Each slice of cheese represents a barrier to an unwanted event occurring. However, there are holes in each slice, which means that these barriers have potential weaknesses. The more holes in each slice, and the bigger the holes, the more likely unwanted events will occur, i.e. the events will get through all the barriers. Figure 10.5 shows an arrow (on the left of the slices) trying to get through the slices, this represents a potential chain of unwanted events trying to get through the barriers.

Figure 10.5. A representation of the Swiss Cheese Model (Reason, 1997)



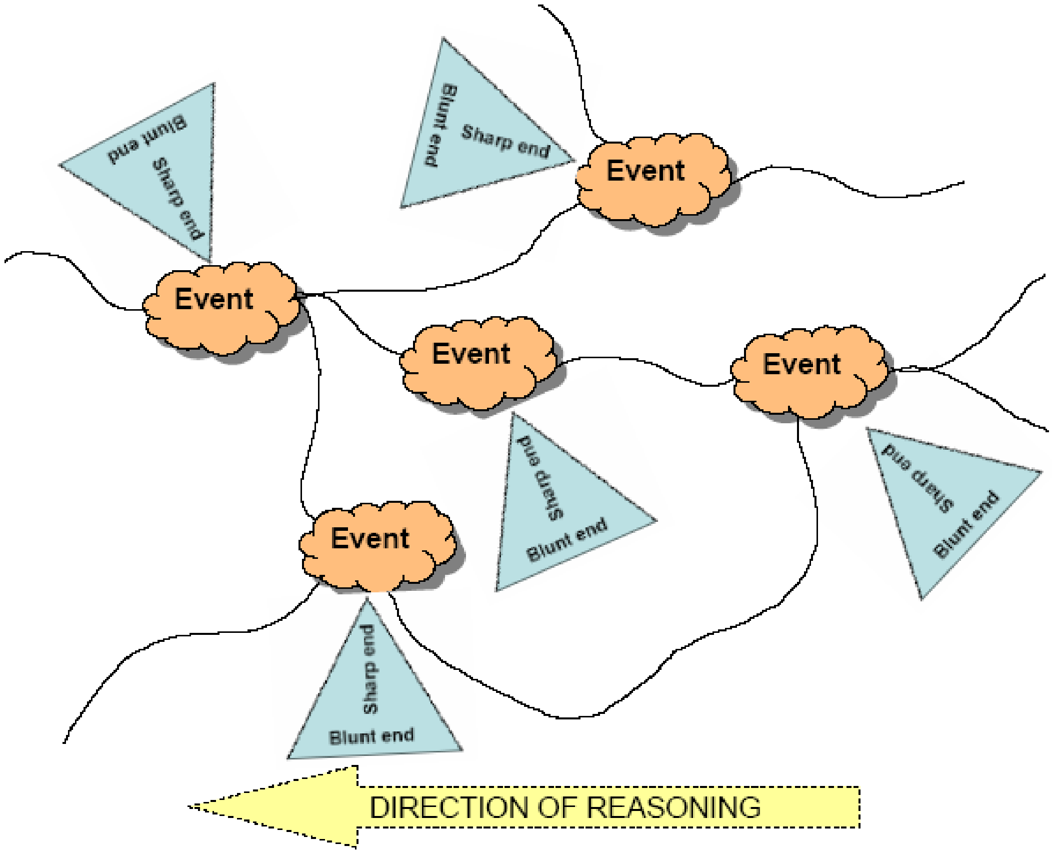
- Epidemiological models are able to cope with more complexity than the sequential models but they still search for causal linear sequences to explain accidents. They focus their search on carriers, which can promote accidents, and look at the general ‘health’ of the system which is the likelihood that an accident will occur. This can lead to removing the carrier or erecting further barriers to prevent the accident or prevent its effects from spreading.

10.5.3 Systemic accident models

Systemic models focus on the emergent properties of the system rather than decomposing the system into structural components and then looking at their associated functions. Systemic models lose the arrow which promotes a causal linear analysis, e.g. the arrow in the Swiss Cheese Model. Indeed, accidents still happen for a reason but the systemic model allows for events to be preceded by several events, and have several consequences that may be causally or temporally ordered. Also, each event will have a ‘sharp end,’ this is where the event actually takes place, e.g. an operator pressing a button; and a ‘blunt end,’ this is the context which influences the sharp end, e.g. the local working conditions, management, design and industry. This model focuses on interactions as parts of a whole rather than as separate events in a sequential chain. The emergent behaviour of the whole is hard to predict because small events, and interactions between small events, can have large consequences.

Figure 10.6 shows events as visualised in a systemic accident model. This figure shows that although there is the same direction of reasoning from an accident as in the sequential models the events involved in the accident might not be sequentially related, e.g. in Perrow’s example of missing the job interview in Section 10.2.1.1 the contributing events were not sequentially related: the coffee pot was left on the heater for too long, the design of the pot did not tolerate such mistake, the spare key was missing, the neighbour's car was broken, there was a bus strike and all the taxis were busy.

Figure 10.6. Events in a systemic accident model (adapted from Hollnagel, 2004, p. 60)



Systemic accident models emphasise the functional characteristics of the system and so move away from pre-prescribed structures which would shape the analysis, e.g. linear causal chains, information flow processes and failure pathways. Systemic models focus on unusual dependencies and common conditions that are associated with accidents. They allow that there is always variability in the system and that this variability is not always bad; for example variance can help the system learn and develop. So, systemic accident models concern themselves with monitoring, and the management of, inevitable performance variability in socio-technical systems: accidents occur when performance variability becomes uncontrollable. Hollnagel (2004) proposes FRAM as a method for engaging with a systemic analysis, which we discuss in the next section (Section 10.5.3.1).

10.5.3.1 FRAM (Functional Resonance Accident Model)

This section will introduce FRAM (Hollnagel, 2004), which follows from the discussion of systemic accident models. We will first discuss the idea of functional resonance, show how functional resonance can be visualised in a graph and then describe the steps for doing a FRAM analysis. These will be integral parts of the analysis in Chapter 11.

Resonance plays a central part in FRAM. An example of resonance common to most people's experiences is a playground swing (Hollnagel, 2004, p. 160). Children soon learn that they have to apply energy at the right moment in the swing to carry the energy through and amplify the swing. In this sense the applied energy 'resonates' with the swing. Children might also decrease the amplitude of the swing by applying energy against its natural frequency of oscillation. Hollnagel (2004, p. 165) then discusses stochastic resonance, which can be described as noise in a system that can be quite unpredictable and enhance or decrease signals depending on its variance, e.g. a freak wave can be very rare and large and can be understood in terms of a number of random unknown variables resonating together. Unlike stochastic resonance, functional resonance "does not depend on an unknown source but is a consequence of the functional couplings in the system" (Hollnagel, 2004, p. 170). Functional couplings functionally affect each other in a system but may not be sequentially related, e.g. in Perrow's (1999) example of missing the interview (Section 10.2) the cracked coffee pot and the bus driver strike were not sequentially related but are functionally coupled with regard to travelling to the interview.

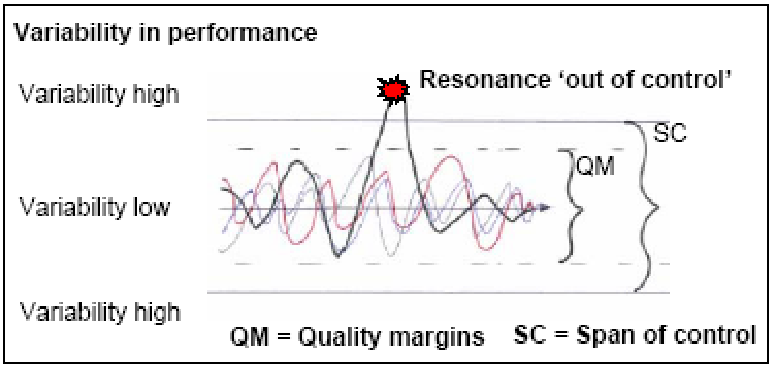
The FRAM model takes a systemic view of accident prevention by examining the functional resonance between different parts of a system, and looking for critical variances of that system that might resonate in unwanted ways. In this conception of functional resonance, the safe functioning of a system should lie within a certain threshold so it does not become uncontrollable. Variance is inevitable in open systems, some resonance will be beneficial because the system can learn and adapt from the variance. Generally, however, if functional parts of the system have variances that resonate together then the activity can go over the threshold and the system can fail. Such resonance is therefore generally unwanted. The resonance that FRAM concentrates on is performance variability, so if the variability is too high it is approaching the bounds of control, beyond which the system cannot cope.

If we reflect on the idea of normal accidents (Section 10.2) and how this relates to functional resonance, seemingly normal system behaviours may functionally resonate together leading to high variability outside of which the system cannot cope.

Individually, events such as forgetting your keys, a neighbour's car being fixed, and a bus driver strike may be inconsequential and considered normal; together they can lead to a system failure.

Figure 10.7 shows a graphic representation of functional couplings resonating out of control. The different lines in the graph represent the variability in functional performance of part of the system. The closer these lines are to the middle zero axis the less variability they have, the further away from the line the more variability they have. The areas closest to the middle axis are bounded by quality margins, the area outside of this is the span of control. The lines can affect system performance by functionally affecting each other. For example, seemingly detached events can functionally resonate together, make the variance exceed the quality margins and then exceed the span of control; thereby meaning the system is out of control and a failure may be pending.

Figure 10.7. A representation of functional couplings resonating out of control (adapted from Hollnagel, 2004, cited in Dijkstra, 2006, p. 97)



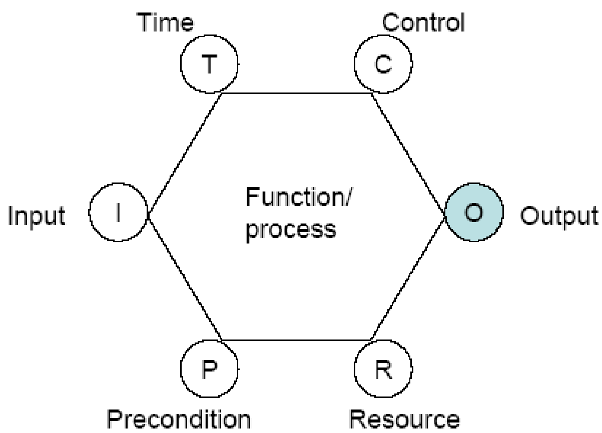
FRAM focuses on analysing what functional couplings have potential to lead to failure in a system and how these might be managed to prevent such failure. One of the differences and strengths of this approach is the prospect of recognising sequentially remote events which are closely functionally coupled in a system, which sequential and epidemiological models miss. These can be thought of as an unfortunate set of coincidences.

Hollnagel (2004, p. 186- 200) describes four main steps for performing a FRAM analysis, which are summarised below:

STEP (1) "Identify and characterise essential system functions; the characterisation can be based on the six connectors of the hexagonal representation" (Hollnagel, 2004, p. 186).

This step looks at the functions and goals which interact so the system can achieve its main purpose. These can be found by performing a task analysis but such a process can restrict the possibilities for finding what functionally affects a system. Hollnagel (2004, p. 188) instead proposes a hexagonal representation for functional components which do not need to define their relationship upfront like a task analysis would, i.e. the lines between the hexagonal components can be defined later in the analysis. The six connectors are represented in Figure 10.8. They provide the potential for linking with other hexagons in different ways in the analysis (see step 3 in the analysis). Briefly these connectors are: the input (I) which represents the necessary conditions to perform that function; the output (O) which represents what is produced by the function; the time (T) which represents the required time for the function; the control (C) which represents constraints in the system in terms of physical laws and supervisory systems; the preconditions (P) which represent conditions that need to be fulfilled before the input is processed, e.g. permission to act; and the resource (R) which represents the resources that are needed for the function.

Figure 10.8. The hexagonal function representation (reproduced from Hollnagel, 2004, p. 126).



STEP (2) "Characterise the (context dependent) potential for variability using a checklist" (Hollnagel, 2004, p. 186).

This step in the analysis is to identify the type of variance of each of the functions in the analysis in terms of variance, and the volatility of that variance. Hollnagel (2004, p. 191-192) elaborates on, and proposes, a checklist which originates from CREAM (Cognitive Reliability and Error Analysis) (Hollnagel, 1998), but not all the items in the checklist will be applicable to all the functions, i.e. some have more emphasis on either the human (M), technology (T) or organisational context (O). We list the items in the checklist here for reference, which the reader may wish to browse:

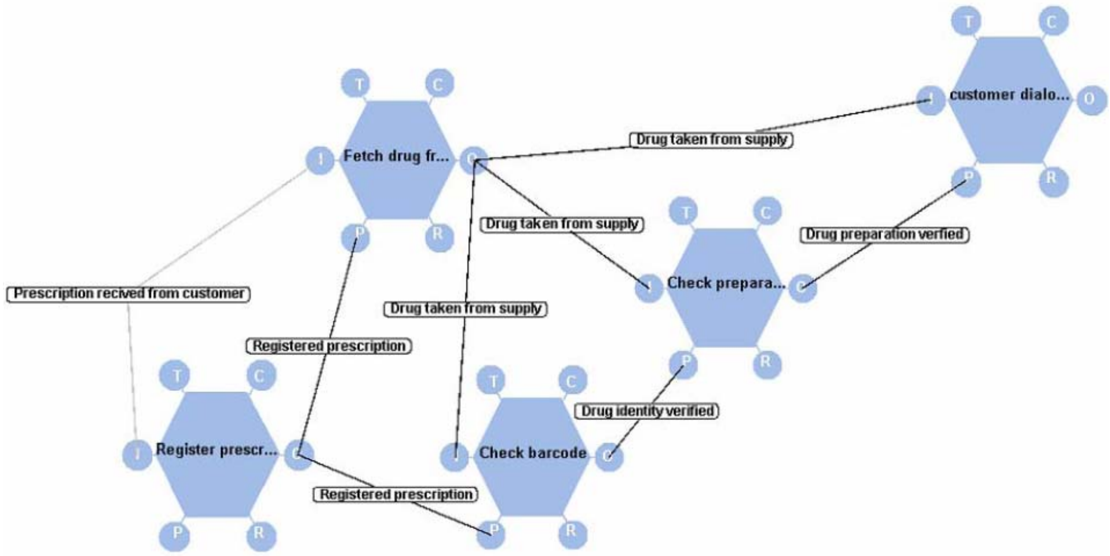
- *“Availability of resources* (M, T). Adequate resources are necessary for stable performance, and a lack of resources increases variability. The resources primarily comprise personnel and material.
- *Training and experience* (M). The level of quality of training, together with the operational experience, determines how well prepared people are for various situations, hence how variable their performance will be.
- *Quality of communication* (M, T). Another important condition is the efficiency of communication, both in terms of timeliness and adequacy. This refers both to the technological aspects (equipment, bandwidth) and the human and social aspects.
- *HMI and operational support* (T). This refers to the human-machine interaction in general, including interface design and various forms of operational support. The HMI is known to have a significant influence on performance variability.
- *Access to procedures and methods* (M). The availability of procedures and plans (operating and emergency procedures), routine patterns of response, etc., also affect variability of performance. This can create a synergistic effect with training and experience.
- *Conditions of work* (T, O). The nature of the physical working conditions such as ambient lighting, glare on screens, noise, temperature, interruptions from task, etc. Working conditions may range from the advantageous to the detrimental.
- *Number of goals and conflict resolution* (M, O). The number of tasks a person must normally attend to and the rules of the principles (criteria) for conflict resolution. Clear rules for conflict resolution may significantly reduce performance variability.
- *Availability time (time pressure)* (M). The time available to carry out a task; this may depend on the synchronisation between task and execution and process dynamics. Lack of time, even subjective, is likely to increase performance variability. Lack of time may be due to too many goals, but can also occur for other reasons.
- *Circadian rhythm* (M). Whether or not a person is adjusted to the current time (circadian rhythm). Lack of sleep or asynchronism can seriously disrupt performance.
- *Crew collaboration quality* (M). The quality of collaboration amongst crew members, including the overlap between the official and unofficial structure, level of trust, and general social climate. This comprises the effects of crew resource management, as well as people’s enthusiasm for work.
- *Quality and support of organisation* (O). The quality of the role and responsibilities of team members, safety culture, safety management systems, instructions and guidelines for externally oriented activities, role of external agencies, etc.” (Hollnagel, 2004, p. 191-192)

STEP (3) “Define functional resonance based on identified dependencies among functions” (Hollnagel, 2004, p. 186).

This step aims to identify the expected and unexpected functional dependencies in the system. Because unexpected interactions are sought the normal process for performing the task should not be the only thing to construct the dependencies. Dependencies may exist where they should not under unusual circumstances. Functions are related if an output of one function contributes to at least one input of another function (i.e. input, time, control, precondition, and resource). All the functional dependencies in a system should be recognised and labelled. The model can then be tested to see the effects of one functional failure and groups of functional failure.

Hollnagel (2004, p. 196) gives the example of the procedure for giving a customer their prescribed drugs. Figure 10.9 shows an illustration of the FRAM functional network for this example. The inputs, outputs and the preconditions have been mapped. The system can then be tested to see what effect there will be if the preconditions, which constitute checks in this case, fail. For example, all of these checks could fail if the operator is under too much time pressure to carry them out properly.

Figure 10.9. An illustration for a FRAM network (reproduced from Hollnagel, 2004, p. 196).



STEP (4) "Identify barriers for variability (damping factors) and specify required performance monitoring" (Hollnagel, 2004, p. 186).

This step in the process considers placing barriers in the system to prevent and mitigate unwanted events and unwanted resonance. Barriers can prevent material, information, energy and other variables. The consideration of barriers will have to include their cost, their effect on the system, and their added variability and weaknesses they bring. For example, in the provision of prescribed drugs (above) the system could be organised so that the monetary transaction cannot be started until the bar code has been scanned into the till, meaning that it could not be overlooked. However, this might reduce manual checking, the bar code may not be readable, or the scanner might fail all causing further issues.

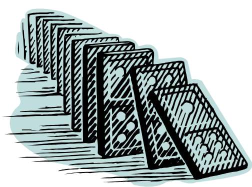
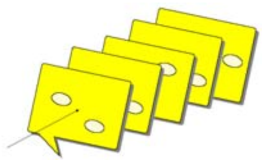
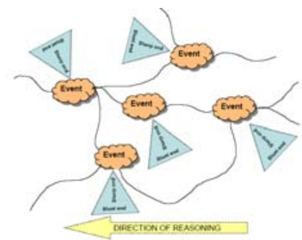
Section 10.5 has given a comparison of three different types of accident model, with a focus on systemic accident models and the introduction of FRAM. FRAM's four steps of analysis have been outlined here. Further detail can be found in Hollnagel (2004). It is still a very new method and so there are few published papers that describe its application. The leverage that FRAM can provide for insight into method use in practice is explored in Chapter 11.

10.6 Conclusion

This chapter has covered background material related to Resilience Engineering to lay the foundation for our qualitative analysis: this theory will be used as leverage to frame the interview data.

As a summary we first introduced the concept of 'normal accidents' (Sections 10.2); we then reviewed definitions for RE (Section 10.3); then explored RE studies and concepts in further detail (Section 10.4) before showing how this systemic understanding differs from other accident models (Section 10.5), including an introduction to the FRAM method which is applied in Chapter 11. Table 10.2 shows a summary of the different accident models to remind us of the focus of RE and how this has changed from previous explanations of accidents.

Table 10.2. A summary of differences between accident models (adapted from Hollnagel, 2004, p. 66 and Dijkstra, 2006, p. 96)

Accident model	Sequential	Epidemiological	Systemic
Description	Accident development is deterministic (cause-effect links)	Accidents have both triggering and latent causes.	Variability is inevitable and can be helpful as well as disruptive.
Characteristics	Decomposable, simple linear	Decomposable, complex linear	Non-decomposable, non-linear
Metaphor	Domino 	Swiss Cheese 	Functional resonance 
Analysis goals	Eliminate or contain causes	Make defences and barriers stronger	Monitor and control performance variability

The RE perspective presented in this section has given a view of events, and socio-technical systems that are based on functional couplings, coincidences and non-linear links. This conception allows for explanations of systems that are non-linear and where seemingly unrelated functions have an influence on each other. The explanations then encourage a move away from the most central process in the system toward those elements in the system which have important functional couplings, e.g. away from the design as a process, from design brief through to a solution, and toward those functional elements that contribute to the performance of design such as the designer's experience, the methods used, the clarity of the problem, and the communication of solutions.

Chevreau (2006) reflects on Hale and Heijer's (2006, p.40) suggestion that Resilience Engineering can be considered as part existing terminology related to high reliability systems if it is to do with staying within a safe envelope and avoiding accidents. Chevreau believes it can be considered as part of having a good safety culture. However, others assign more novelty to the approach; for example Hollnagel and Woods (2006, p. 2) write that RE is a 'completely new way of thinking about safety' which could be similar to a paradigm shift.

We believe that RE has mileage in giving dedicated thought to the resilience of systems. There may be other terms that have traditionally encompassed it, but there is a difference between just being covered compared to being the sole focus of intellectual investigation and development. If these issues are important in practice, which they appear to be, then it is worth developing a paradigm that can capture the complexity of resilient systems so eventually we can understand these properties better and consequently have some control over them.

Chapter 11: Resilience Engineering analysis

11.1 A Resilience Engineering View of HF/Usability Practice: the case for a positive resonance model

This analysis builds a theoretical bridge from the RE literature presented in Chapter 10 and the data from the website domain (Chapter 4) and the safety-critical development domain (Chapter 6). The analysis highlights system characteristics of HF/usability practice and the way that methods fit within this system. We see that the context has a large influence on the outcome of events, and that variances within the internal and external parts of the system are inevitable and need to be accounted for. We introduce the case for a positive resonance model where practitioners choose actions and methods to maximise their performance under constrained resources, and we develop a functional network diagram through a FRAM analysis which provides a representation of the functional couplings in a HF/usability practice system. This shows the non-linear dependencies involved with method adoption and adaptation in practice.

This chapter shows that RE can be used as a useful leverage for conceiving method use in HF/usability practice. It reveals characteristics that would not have been so apparent without this conceptual leverage.

11.2 Method

This analysis is similar to the Distributed Cognition inspired analysis of the data reported in Chapter 9. It uses pre-established theory as leverage for understanding the data in a new light. The data that we seek to frame includes that collected from the website and safety-critical system development domains, and the qualitative analyses that have been conducted thus far.

RE literature was only encountered part way through the second domain of study, but from the outset this project has unwittingly had resonance with recommended approaches for engaging with safety analyses in a systemic way. For example, the grounded theory approach seeks to engage with the context in a bottom-up manner from data provided by practitioners, and the analysis captured those aspects of the system that were important to the practitioners: importantly where things have gone right rather than where they have gone wrong, e.g. how methods are selected and used successfully rather than why they fail to transfer. Similarly, Dekker (2005) recommends that analyses of systems engage with the operators' local rationality by engaging with an understanding from their perspective, and engaging with the banality of their normal practices rather than just where the systems fail. RE is inherently about the system as a whole, and about noticing those functional couplings that have a significant impact on system performance. With hindsight this approach resonates with the grounded theory data gathering and analysis performed in this project.

Like the task of relating DC theory to the data, the task of relating RE theory to the data begs the question: how? Like the DC case there is not an obvious *a priori* approach that can be followed. From an abstract level this analysis involves first engaging with the data and establishing an internal understanding of it, then familiarising oneself with the theoretical literature to be applied, then combing the two to gain insight. The RE theoretical lens was selected because it showed potential to highlight and crystallise patterns in the data. The analyst has to coordinate: the data, explicit insights from the data, their impression of the data, what they understand of RE, explicit RE theory, and proposed RE methodology to gain insights between the data and the theory.

To explore the leverage RE can give to the data, the analysis has been divided into three subsections: Section 11.3 explores how Resilience Engineering themes resonate with patterns in the data; Section 11.4 relates the different accident models to models for understanding method transfer from research to practice; and Section 11.5 reports a FRAM inspired analysis of the adoption and adaptation of methods in usability practice.

11.3 Links with Resilience Engineering Themes

Seven Resilience Engineering themes have been identified in the RE inspired analysis of the data on HF/usability consultancy practice. Each theme is discussed with relation to its theory, supporting data and discussion.

11.3.1 Goal Conflicts: Efficiency-thoroughness trade-off (ETTO).

11.3.1.1 Theory

Hollnagel (2004, p. 152) and Dekker (2005, p. 144) both quote NASA's "Faster, Better, Cheaper" organizational philosophy to illustrate the problem of multiple competing goals in a system. Like the law of conservation of mass in physics that states that mass remains constant in a closed system, efficiency-thoroughness trade-off (ETTO) is like a law of conservation of resource: if one element goes up then another should have to come down, e.g. if you increase a system's speed and quality it should cost more. Of course, this is dependent on the definitions of quality and better, as one could argue that it is possible to increase all three. However, the underlying point of goal conflict and pressure to optimise remains and is captured succinctly by Hollnagel (2004, p 159): "If anything is unreasonable, it is the requirement to be both efficient and thorough at the same time." For example, this goal conflict pans out in business' interest in being cost-effective and safety's interest in being relentlessly thorough.

11.3.1.2 Support

This is evident in HF/usability consultancy practice. For example, one interviewee recognized that a previous company would overwork her to win contracts so she left. She is now in a company that project manages more fairly without staff having to stretch and stretch. It is also evident that usability practitioners want to use more UEMs but are restricted by client budgets and willingness, i.e. they would like to do 'gold standard' projects which involve them from start to finish, but they are restricted by the resources clients will spend on usability and so have to be efficient and effective in their use of resources. Work-packages are offered to clients so they can choose the services they are willing to invest in.

11.3.1.3 Discussion

HF/usability practice functions in a market, and emphasis must be made on how this context permeates their behaviour, including the use and demand for different methods and practices, i.e. the market place provides consumer forces that shape the services and methods offered. Clients will have choice in the standard, depth, speed, and cost of the projects and HF/usability services on offer. The project design phase is in a position of great importance as this is when options are discussed, plans made, and resources negotiated. Practitioners will be under pressure to be efficient and thorough at the same time to provide their clients with value: too much of one could be to the detriment of the other.

11.3.2 Values: Survivability and Different Dimensions of Resilience.

11.3.2.1 Theory

A theme from the 2nd Resilience Engineering Symposium was that different dimensions of resilience should be considered, e.g. survivability of an organization is a balance between not only resilience in safety, but also in economics so it can carry on as a business. This was most evident through discussion of Morel and Chauvin's (2006) paper on the sea fishing industry. Here it was recognised that to be a viable industry safety had to be balanced with ecological and economic considerations. This is similar to the theme of goal conflict above; however, it relates less to ETTO and more to the different values and dimensions people strive to achieve. Once again the right balance is context dependent.

11.3.2.2 Support

Experienced practitioners were aware that HF/usability was not the only dimension for product success as this quotation demonstrates: "one of the realities for commercial usability is that products that survive for a long time in a market place have to fulfil both the customers' needs and the business's […]." W8.
Experienced practitioners were also aware that different audiences in the design process will be motivated by different dimensions or values, and that these should be engaged with to get a good response as this quotation demonstrates:

> "it's knowing which people to talk to, because I could sit and talk to a mechanical engineer and I could say, what about this, it's a real risk if this person makes this mistake, [but] it's not his job, he doesn't care. […] he doesn't want to know about this risk because of the wellbeing so to speak […], he wants to know about that risk because he is going to have to spend x amount of time and money investing in a new design solution." S10.

11.3.2.3 Discussion

When considering survivability of a system one should consider the safety, HF/usability, and business case. Too much of a focus on one of these could lead to a detriment of the system overall. Tactics for integrating HF/usability recommendations for clients successfully include an understanding of this balance, and an understanding that people’s values need to be engaged with. This is more than just communicating well, which stops at getting people to understand what you are saying. Engaging with values also includes getting people to listen and react to what you are saying because it is something they are responsible for or care about.

11.3.3 Normal Adaptable Practice in Open Systems.

11.3.3.1 Theory

Open systems have variance in their normal operation, and this variance is absorbed and adapted to by resilient systems. This theme is reflected in Sundström and Hollnagel’s (2006, p. 253) definition of resilience: to “adjust effectively to the multifaceted impact of internal and external events over a significant time period.” In this quotation Hollnagel (2004, p. 181) moves further away from perspectives that view faulty behaviour, e.g. human error, in fixed systems as the issue to be investigated and instead toward perspectives where open systems’ variance can lead to unwanted performance: “the lesson to be learned one more time is that accidents are due to usual actions under unusual circumstances, rather than unusual actions under usual circumstances.”

11.3.3.2 Support

This was evident because practitioners would frequently say “it depends…” when questioned about their choice of methods. This alludes to the important contextual factors which affect UEM adoption and adaptation.

11.3.3.3 Discussion

Chapter 4 first stated that usability consultancy can usefully be considered as a ‘plug and play technology’ and Chapter 6 elaborated on factors that need to be considered for successfully synchronising this ‘plug and play technology’ with wider design and business processes. This is because services are flexible and adapt to the requirements of the project and the client. Usability practice, and wider business and design processes, form a complex open socio-technical system. Variance within this system is normal, and UEM adoption and adaptation is a negotiation between internal and external pressures. Local adaptations can lead to evolving practices in the long term as they become normalised in practitioners, organisations, and industries.

11.3.4 Reflection-in-action and reflection-on-action.

11.3.4.1 Theory

Schön's (1987) reflection-in-action and reflection-on-action were introduced above with respect to Nathanael and Marmas' (2006) Repetitions-Distinctions-Descriptions (RDD) Model (Section 10.4.12). Here, variations in the environment are recognized and practice adapts to cope. This can happen without description (i.e. in-action) or with description (i.e. on-action), the latter of which is more abstract from the action. Since variation is normal in open systems reflections should be common place.

11.3.4.2 Support

This quotation shows a practitioner's recognition that they have to develop new practices to synchronise with a new group of collaborators better. They recognise that there is a distinction in this work group, and reflect on how they can change their practices to compensate and cope:

> "[…] in the last two years we've done quite a lot of work with architects, […] they […] churn out so many designs a day […] we're slowly building up the relationship of how to work with architects, what's the best way, and how we can get them to understand what we do, and how we can understand what they do, working together and how we can produce something of benefit, of value, that's a good example of where you get requirements creep up at any time." S8.

This quotation shows a practitioner's conception of doing improvisational usability, where it appears they reflect-in-action in response to local conditions, and then reflect-on-action to check the quality of their practices, procedures and results are maintained:

> "Well you know music and you do improvisational jazz, well I do improvisational usability, because I've been doing it for that long and like a jazz musician has learnt all these scales and patterns and chords and cycles and riffs and knows what notes come after the next, when I do usability I'm doing the same thing, so if I'm running a user test I'm improvising a test a lot of the time, now I can see actually that I can see myself getting into very bad habits from doing that, which is why you have to step back and reflect, have quality controls and get other people watching your work from time to time to see and make sure, but I think a lot of the time it actually liberates you to get the more interesting bits." W5.

This quotation shows a practitioner's reflection on learning new lessons in coping with the variance provided by a new industry:

> "it's knowing which people to talk to […], so with the application in human factors, and we are still learning this within [Industry A] I feel it is knowing who to go to get the job done" S10.

11.3.4.3 Discussion

RE emphasises the variability in open socio-technical systems and this is evident in HF/usability practice. Practitioners constantly reflect in and on action to cope with normal and more abnormal variances. This also relates to why Murphy's Law does not always apply, i.e. because practitioners adapt and reflect to cope with the changing demands of the context to maintain performance levels. A practitioner's ability to reflect in and on action will depend in part on their experience which is discussed below.

11.3.5 Expertise.

11.3.5.1 Theory

Expertise was a theme of The Resilience Engineering Workshop, which took place in Vadstena, Sweden, in June 2007. Sydney Dekker's keynote included emphasis on expertise, he pointed out that it is no coincidence that people's experience is rewarded with high salaries because they are more likely to understand the system's behaviour and make sound judgements. The value of expertise can also be related to Hollnagel and Woods' (2006, p. 348) comment that stresses the importance of understanding the situation to remain in control: "In order to be in control it is necessary to know what has happened (the past), what happens (the present) and what may happen (the future), as well as knowing what to do and having the required resources to do." This ability to understand a complex situation and make sound judgements falls in line with Klein's (1998) work on expertise. This goes beyond conceptions of expertise in terms of, for example, a designer using a design tool well, to account for perceiving and responding to a complex situation. For example, a designer gets a feeling that a client is discontent with a proposal even though it meets the brief they were given. They believe that the reason may be due to underlying political conflicts within the client organisation. From previous experience of similar situations they know that a good tactic is to win a friend on the client side who might enlighten them on the situation, and so they proceed in this manner.

11.3.5.2 Support

This issue of expertise has been evident in previous analyses: e.g., in Chapter 6 in talking about how years of consultancy experience enhance practitioners' thoughts and behaviours such as recognising and reapplying patterns in interfaces; in Chapter 9 in talking about career development and how more experienced practitioners have more management and mentoring responsibility, how more experienced practitioners can identify options in different circumstances and can predict the effect of different actions (this was explained with the ‘affordance’ and ‘action-effect’ resources in the Resource Model (Wright et al., 2000) where affordance is the potential to recognise options and action-effect is the potential to predict the effects of actions), and that their knowledge may restructure to be solution based rather than modular based which would more closely resemble the structure of an academic textbook or course.

11.3.5.3 Discussion

An increased level of experience and expertise will mean that a greater amount of complexity will be understood. People will be more aware of what has happened in the past, aware of their options in the present, and be in a better position to predict the likely effects of their actions in the future. This is why expertise is rewarded with higher salaries and more responsibilities: experts are able to perceive the critical points in a situation or context and respond appropriately. This was referred to in Chapter 4 with reference to the way expert chess players chunk patterns of pieces (Chase & Simon, 1973). Just as chess experts quickly perceive patterns and critical points when playing chess, expert HF/usability practitioners will perceive patterns in interfaces and in project work. For example, an experienced HF/usability practitioner might quickly deduce that an apparent usability problem is less a consequence of the interface and more to do with the website’s underlying business proposition.

Expertise is central to RE and is evident in the performance of HF/usability practitioners. Essentially this is because the environment is constantly varying and these practitioners can perceive this variance and know how to respond appropriately. Where novices ‘see’ noise in the context, in evaluating the situation and their options, experts ‘see’ greater clarity in the past, the present and what will happen in the future. For example, a novice might be confused by the bewildering array of methods available to support them doing a control room design, but a more experienced practitioner might immediately recognise three core activities that need to be performed with an optional four more key activities depending on the budget and circumstances of the project.

The observation that we can sometimes be blind in foresight, but have twenty-twenty vision with hindsight, was discussed above as a theme relevant to RE. We suggest that an essential characteristic of expertise is that experts are not blind in foresight. Experts are able to evaluate options in relation to likely outcomes. The 'blind in foresight' rhetoric is at an extreme to illustrate the point that the role events play in causing some accidents is only obvious after the failure. By sticking to vision as a metaphor we might say that novices are short-sighted and experts have better eyesight to see into future potentials. Senior HF/usability practitioners are therefore in a strong position to manage and monitor projects, and to intervene and problem solve at critical points where needed. HF/usability practice is prone to unexpected variances and has to cope with many uncertainties including research findings, people, politics, emotions, technologies, methods, decisions and ideas. Experts are in a better position to 'see' and manage this dynamic flux.

11.3.6 Sharp-end / blunt-end distinction.

11.3.6.1 Theory

The sharp-end / blunt-end distinction was introduced in Section 10.4.13 which made the point that the actual events that functionally contribute to failure take place within their own receding contexts, such as, their local working conditions, management, company, etc.

11.3.6.2 Support

From the first qualitative analysis of this project (reported in Chapter 4) it was evident that method use would need to be explained in context because it is this context which shaped how they are adopted and adapted in practice. This context has revealed itself at many different levels throughout the data such as practitioners' preference, expertise and skill; available tools and methods; the project and problem context; communication and persuasion; the clients needs; industry practices; and regulators.

Reflecting on the point-centric triangles which often represent the sharp-end / blunt-end distinction (see Figure 10.4 above) it appears that the blunt-end factors, which influence method use, should be represented in three different but overlapping triangles: the client's business context, the HF/usability practice context, and the academic context. Factors associated with these different contexts are represented in Figure 11.1 where the point-centric triangles have been removed in the sharp-end / blunt-end representation because the relationship between these blunt-end factors are not easily distinguishable between contexts. The relative distance that different blunt-end factors are from the sharp-end is estimated.

Figure 11.1. Figure to show a sharp-end / blunt-end representation of method use

11.3.6.3 Discussion

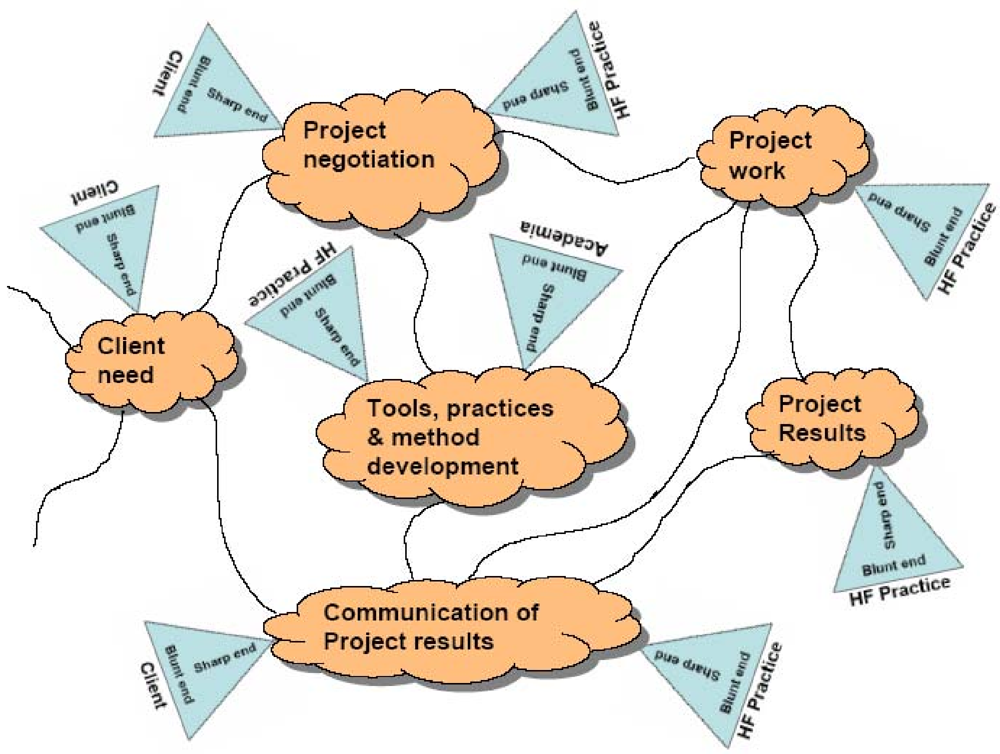
The sharp-end / blunt-end distinction allows an analytic structure that emphasises the different levels of abstracted context which influence method use. From our qualitative work it is evident that there are three main contexts at play: the client's business context, the HF/usability practice context, and the academic context. These contexts do not have a simple relationship but overlap in the demand and development of different tools, practices and methods.

To support the observation that different blunt-end factors influence method use we refer to Walker and Dearden's (2005) talk about different contexts which have influenced pockets of ICT design and use:

> "We can point to the well documented example of the Scandinavian trade unions contributing the development of participatory design of ICT (Bjerknes et al., 1987; Greenbaum and Kyng, 1991; Schuler and Namioka, 1993). Other, less well documented examples might include disability campaigners' influence over Web accessibility standards and the influence of green social and political organisations in establishing standards and regulation of technologies throughout their lifecycles." (Walker & Dearden, 2005, p. 4)

Here we see how parties with different motivations and interests can influence method development. Different processes affect the development and use of methods in practice, e.g. academia, HF/usability practice and clients affect the development, use and demand of methods. These might not be sequential but functionally affect each other. A representation of this relationship, inspired largely by the project process in the Distributed Cognition chapter (Chapter 9) is represented in Figure 11.2. It shows the different functions of project work and method development, the different groups involved, and their sharp-end / blunt-end distinctions. This figure is focused on the project cycle and its relation to method use as this was the focus of the interviews. The figure shows that some functions are affected by more than one context (triangle) directly, and that all the functions can functionally affect each other, e.g. the client will shape their project need which will impact on project results and potentially the demand and development of new tools, practices and methods in the long term. The advantage of this representation is that it shows functional relations between elements and the main contexts which are involved in them. Perhaps the more interesting elements are those which have more than one context (triangle) contributing to it because it involves an interaction between the two which could potentially have different vocabulary, pressures and values. For example, HF practice will involve working in a business like manner which will involve pragmatic solutions and short time scales for clients; in contrast academics have more flexibility, longer time scales, and their reward system will encourage publications rather than the development of pragmatic, industry-ready tools.

Figure 11.2. A systemic model of functions in a HF/usability project cycle and its relation to tools, practices and method development, with three main sharp-end / blunt-end contexts: client, HF practice and academia.



11.3.7 Tight and loose coupling.

11.3.7.1 Theory

Tight and loose coupling was first introduced with reference to Perrow's (1999) classification of systems in Section 10.2 whereby there is a time lag for intervention in loosely coupled systems. In Section 10.4 we saw how Grote (2006) moved on to apply this dimension to rule following in organisations, i.e. tightly coupled rule-following means that rules and procedures are strictly adhered to, loose rule-following means that there is flexibility for the operators to interpret rules, and think on their own. Grote's conception of loose coupling orientates the time lag for intervention more around the choice that an operator has in performing activities in a given situation. These conceptions are similar as they both relate to the ability of a system to have some freedom to deviate from their projected path – tightly coupled systems could not deviate from a projected path even if this path was undesirable. Problems occur where there is a mismatch tightly and loosely coupled situations: when people follow rules too strictly when they should have thought on their own, perhaps bending or breaking them; or when people thought on their own when in hindsight they should have really followed the rules and procedures. Grote (2006 p. 116) states that "a core requirement for resilience is to achieve an adequate balance between stability and flexibility in the functioning of an organization." The balance between stability and flexibility will be dependent on the characteristics of the organisations and contexts involved.

11.3.7.2 Support

In previous analyses we have identified how usability can be considered a plug and play component that synchronises with its project and client; this is a form of coupling. There are loose and tight aspects of this coupling, e.g. tight aspects might be in terms of the time and budget of the contract between the two parties, loose aspects will include the details of how the project is performed. There was evidence in the interviews that a good working relationship between the client and the usability practitioner can allow the practitioner more freedom, and so in RE terms we might consider that a trusting relationship has more potential to be a loose relationship, as the controlling party is happy to give the service provider more autonomy.

Loose coupling was evident in the labelling of techniques and methods. Here a core of the technique or method remains to make it distinguishable as that method, whilst it is adapted to suit the context. For example, Heuristic Evaluations (Nielsen, 1994) were reported to be used in an ad hoc manner to support design recommendations, explicitly used to evaluate and compare websites, implicitly used like an expert evaluation, and actual heuristics were sometimes adapted from "Nielsen's ten heuristics." The quotation below shows that this practitioner is aware of the need to adapt to the specific circumstances of the project in making bespoke recommendations but is also conscious that the client has to be managed so they understand and engage with what is going on:

> "We certainly have an internal catalogue of standard projects and if someone hasn't done usability work before its a good place to start, because if everything is up for negotiation it can feel overwhelming, I think my natural inclination is to do everything as a bespoke project but in fact that much choice for some clients is crazy. […] I suppose the most common thing to happen if they haven't come to us with a specific methodology in mind then we will start with several specific standard methodologies so they can hang their hat on it and then we query them as to whether that was what they needed, or if they needed it to be tinkered a little bit more." W8

11.3.7.3 Discussion

HF/usability practice has loose and tight characteristics and these can vary between different contexts. In Perrow's (1999) original terms design would be considered a loosely coupled system as there is slack and time for intervention, e.g. it is not like a nuclear power plant or manufacturing where knock-on effects are immediate and inevitable. Design is an uncertain area with many choices of where one should go, it is because of this that it can be hard to understand and why expertise is regarded so highly in the field. In a very uncertain context it can be hard to know appropriate options, confounded by subtle interactions that are foreign to novices: here experts are valued to lead the way.

It was also evident that the labels of methods perform an important role in stabilising the system as novices are able to 'hang their hats' on methods and prescriptions, meaning that their worlds can be simplified as they have some certainty to hold on to. Here labels and prescriptions protect the novice from complexity: from variances and details of the context they will not understand, do not need to know, or are not interested in.

We can relate the loose coupling of the method labels to the method practice to the concept of a boundary object (introduced in Section 8.3). The boundary object passes between two different communities and is interpreted differently by both as a consequence of their backgrounds, but it is robust enough to retain its core meaning between the communities. The same is true for methods. An expert may say that they are doing a user test to the client, and the client will acknowledge and understand that users will use the system and provide feedback on certain tasks, but the client might not know the detail: for example, the specific questions, that an interview will be done before to get expectations, that a questionnaire will be performed after for quantitative feedback, that some scenarios will be used to get users to engage with the task, and that the practitioner already has a hunch for what might be wrong with the interface.

Tight and loose coupling has been identified in the HF/usability context in two regards: 1) Planning: in keeping key aspects of the project definitive for the sake of collaborative work (e.g. time and budget), whilst allowing autonomy in the actual knowledge work of those professionals; and 2) Communication: bridging the gap between an abstract understanding of practice (e.g. method labels and prescriptions), compared to adaptability of the actual methods to the context.

In the RDD model discussed above (Section 10.4.12) the practitioner may make many repetitions and detailed distinctions, but the descriptions will be more abstract. For the purpose of communication it will be abstract enough for two groups to reflect on it appropriately. Not all members in collaborative work will know all the details to the same level and understanding, nor should they, as this undermines the autonomy and expertise of different groups and ignores the very basis for multidisciplinary working. This is also why HF practitioners are often employed to audit each others' work in the safety-critical context: they share a similar knowledge base that allows them to appropriately scrutinise the detail of the work, which someone without a detailed HF background would be unable to do.

11.3.8 Conclusion

This section has related seven RE themes to the data on HF/usability practice. In the RE tradition it paints a picture of a complex socio-technical system which has natural variances, with competing goals and value systems. It is because of this complexity that practitioners' expertise is valued as a commodity and reflection-in-action and reflections-on-action takes a central place in their work. Practitioners' local rationality has been engaged with to understand their context from their perspective. From this perspective it has been evident that the blunt-end of method use stretches across three main contexts: clients, HF/usability practice and academia. Lastly we covered how

HF/usability practice has tight and loose couplings for the sake of collaborative project work, and how method labels can be considered as loosely coupled to their practice to protect non-experts from detail and allow experts to adapt to the specifics of the context.

The links between RE themes and the data shows that HF/usability practice has resonance with characteristics of RE systems. This is despite the fact that the RE tradition is borne out of focusing on the prevention of accidents rather than HCI research. To extend the leverage of this area further we do two things: in the first we apply the rhetoric of how RE has developed from simpler versions of accident models, to how we can appreciate a similar transition for understanding the barriers and opportunities for UEMs practice; in the second we apply FRAM to the HF/usability context to determine the functional couplings in the system and give detail of their relation. These moves make further use of RE as a leverage for understanding the system of HF/usability practice and how UEMs fit into this.

11.4 A Case for a Positive Resonance Model

We now discuss consequences of applying different accident models to the issue of how we understand the opportunities for methods in practice. We apply three accident models in turn:

1) Sequential Model
2) Epidemiological Model
3) Systemic Model

In Section 10.5 we saw that the models shaped what was understood of the situation. In this section we will see that the different models also have different consequences for understanding the opportunities and challenges for methods in practice. There is a change from a sequential perspective which looks for simple causes for the non-transfer of methods from academia to practice; to an epidemiological perspective which looks at latent properties of models in practice which influence transfer; to a systemic perspective that looks at how methods are adopted and adapted in a system of usability practice. With each step we get a less predictable but more realistic and meaningful picture.

11.4.1 Sequential Model

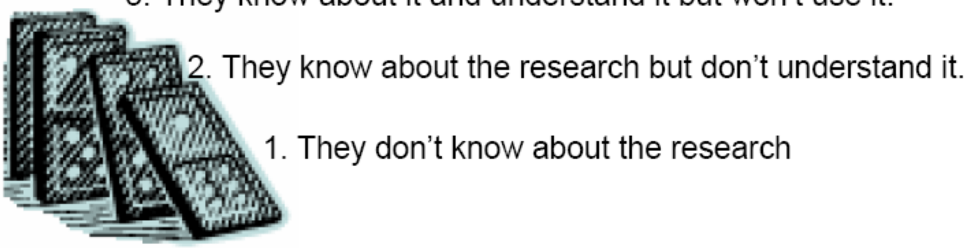
Sequential models assume that accidents can be explained by a sequential causal chain of events. Like dominos, one domino hits another, which hits another, and so on, in a line. This represents a linear chain of events with simple cause-effect relations. It is a simple model that is easy to understand which can lead to a cause for the sequence of events.

In playing the role of the devil's advocate early on in this research project, a professor in HCI, suggested that there were three reasons why practitioners do not use methods:

1. They do not know about the research.
2. They know about the research but do not understand it.
3. They know about it and understand it but won't use it. The reason they won't use it can then be explained because the research method will not give them the added value they need for adopting it.

This explanation for why methods are not used by practitioners fits the sequential model: the three reasons fall into a causal sequence and each one can be represented as a domino in that sequence (see Figure 11.3). Here, the dominos represent reasons why practitioners do not use methods, so the dominos are barriers to method adoption which must be overcome. They are causally sequential as 1 is a precondition for 2, and 2 is a precondition for 3. If practitioners know about the research, understand it and will get high added value then they will be likely to use it. As we referred to above, Hollnagel (2004, p. 36) says that explanations of this sort provide more certainty than meaning, i.e. they give a reason for what has happened but not a realistic understanding of the different factors which led to the situation. Our data suggests that an explanation of the opportunities and barriers for methods in practice cannot be adequately captured by this perspective.

Figure 11.3. A sequential model of possible reasons why practitioners do not use methods.



This model does provide a level of explanation, but it suffers from being too simplistic and focused on fixed methods which fail to transfer to practice. It does not account for why some methods are used and how they are used. The explanation of methods adding value is correct but it does not give any detail about what this means. Similar to explanations to accidents which stop at 'human error' it gives us a reason but no understanding of the detail which caused it. Being critical about these explanations, they actually mask the important systemic contributing factors that really work in shaping the performance of the system. Like Leveson's (1995, p. 108) call to stop talking about 'human error,' in the same way that we assigned terms like phlogiston to the history books, we should not dismiss the issue of method use as a decomposable problem which involves: the practitioner's understanding of the method, and whether the method adds value. The next two models start to unpack the issues further.

11.4.2 Epidemiological Model

The epidemiological perspective allows for more complexity than the sequential model: it allows for factors that influence the likelihood or impact of an accident but which do not have to be part of the sequential chain of cause-effect events that lead to it. For example, latent conditions can be present in the system before the accident actually occurs, such as poor management and poor training.

Although not described as such, Buckingham Shum and Hammond's (1994) research on the gulfs which influence model and design technique use in practice can be interpreted with this perspective. They identify four gulfs:

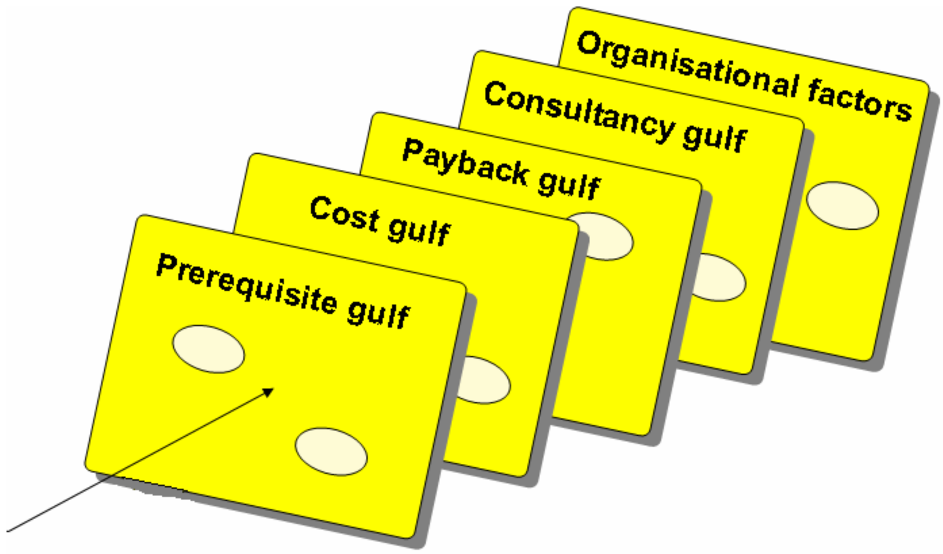
1. **Prerequisite gulf**: This is the extent to which an approach is sufficiently understood, and trusted by practitioners. If they do not understand a method and have not used it before then they will not have confidence that it will give them the results they need.
2. **Cost gulf**: This refers to the demand placed on the practitioner in using the method. For example, the process of using the method will necessarily involve intellectual effort, time and other resources in doing the necessary translations of the context into the method's notations, diagrams, sketches, etc.
3. **Payback gulf**: This refers to the potential benefits the method will give for design reasoning.
4. **Consultancy gulf**: This refers to the value that the method allows for the development of the design in practice. This goes beyond the payback gulf which

stops at giving insight to the design rationale to making sure that insights are useful and intelligible enough to carry through in to the development of the design in practice, e.g. so non-HF specialists can understand, appreciate and act on the issues.

Buckingham Shum and Hammond (1994) also refer to organisational issues affecting design technique uptake as it must fit with their current practices and not introduce excessive overheads. They state that 'design' had been treated as though it did not exist in an organisational context, and although raising this issue do not go much beyond recommending that design techniques 'fit' the organisational context.

Taken together the five gulfs, including the organisational gulf, can be interpreted in terms of the Swiss Cheese model. Figure 11.4 shows such an epidemiological model where each slice of the Swiss cheese represents a barrier to method transfer. Unlike the original conception of the accident model which seeks to erect and fortify barriers to reduce the likelihood of an accident occurring, this conception seeks to weaken barriers to method transfer so methods can get through to practice. These barriers are different from the dominos, as one is not strictly reliant on another, e.g. a method might be used because it has low cost (cost gulf) and is easy to communicate results (consultancy gulf) but it may not provide rigorous depth of insight (payback gulf).

Figure 11.4. An epidemiological perspective of possible barriers that affect practitioners' use of models in practice.



From this conception of Buckingham Shum and Hammond (1994) we interpret the gulfs as latent conditions which affect the use of models and design techniques in practice.

Like all epidemiological models the latent conditions are decomposable and have an additive effect on the sequence of events that may lead to an accident, i.e. the slices of Swiss cheese are largely independent and influence the likelihood and severity of the accident in a collective manner. Like the sequential model epidemiological models concern themselves with the propagation of unwanted events. However, in this case the propagation of events is desirable, through barriers, so that methods are adopted and positively contribute to practice.

Epidemiological models account for more complexity than sequential models by allowing for latent conditions that do not directly trigger the sequence of events, they affect the environment in which the events occur. This is also important for systemic explanations. However, they do not account for functional interactions between factors which lay outside the mere addition of identified factors; these functional interactions, couplings and coincidences are given emphasis in the systemic model discussed below (Section 11.4.3).

Buckingham Shum and Hammond (1994) document important insights but we suggest this is too focused on the method and practitioner. The systemic model offers an explanation of opportunities for method use in practice in terms of how they integrate with and affect the performance of the wider system. So, rather than giving an explanation of method use in terms of failure to make the grade for use in practice, we can give an explanation of method use in terms of system performance.

11.4.3 Systemic Model

Unlike the previous perspectives this perspective loses the emphasis on causal sequences of events. This is advantageous when accounting for functional interactions in a system which are not sequentially related. The exemplar of an accident which has such functional couplings that are not sequentially related is Perrow's (1999) story of someone missing their interview (Section 10.2); where amongst other things the design of a coffee machine, lending the spare set of house keys to a delivery driver, a neighbour having their car fixed and a bus driver strike conspire together to lead to the person missing the interview. This perspective accounts for functional interactions, couplings and coincidences that are not necessarily sequentially related, which the previous perspectives do not.

Unlike the previous perspectives it makes less sense to talk about why methods have gone wrong or failed to transfer to practice, and more sense to talk about how they are affected by and influence the performance of the system. Through this view we are not searching for root causes (Section 11.4.1) or dissolving barriers *per se* (Section 11.4.2), but rather seeking to understand performance variability of the system. The aim then is to identify those functional couplings that are important for method use in practice.

This also is more conducive to practitioners' own perspectives. According to our data they use methods as a means to an end, the end being the performance of usability practice in transferring knowledge, giving value to clients and operating as a business. They do not use methods as an end. This may seem trivial or obvious to some but it is worth reiterating as academics can become so engaged and immersed in method evaluation and development that they might be forgiven for forgetting that there are wider goals at stake in practice: not only on impacting design but in getting repeat business, building a reputation, etc.

The systemic model will be analysed using FRAM in the next section; however, we make the case for a positive resonance model here. Section 10.5.3.1 introduced FRAM and the concept of functional resonance. Briefly, resonance can be thought of in terms of a child's swing: when energy is applied to the swing in the right time and place the movement of the swing will be amplified. Here the application of energy resonates with the movement of the swing, i.e. they work together in such a way that they have a larger combined effect. In systems there exist couplings which functionally affect each other, e.g. a driver's vigilance may be affected by their attention, the amount of daylight, the weather, their eyesight, and the windscreen wipers: these are functionally coupled. If the driver is tired, it is getting dark, there is heavy rain, they are not wearing their glasses that correct their vision and the windscreen wipers are not well maintained, then these are functionally resonating to decrease performance. Resonance is a pattern of emergence in that it proposes that functional elements of a system interact in non-linear ways to affect an outcome, e.g. an alternative type of emergence might be a more additive model that discriminates less between the actual functional relations by suggesting that all the functional elements have a summative affect on an outcome.

Hollnagel (2004) says that performance variance is inevitable in open systems and that some of this is useful so systems can learn and adapt to what the environment might throw at it. However, performance variance is generally seen as bad, because increasing levels of variance may lead to an accident if it gets out of control: the more performance variance the more unpredictable the system becomes. An aim of systemic accident models is to monitor and control performance variance so it is kept within acceptable, manageable thresholds. Generally, if functional parts of the system have variance that resonates together then the activity can go over the threshold and the system can fail. Such resonance is therefore generally unwanted.

In keeping with the metaphor of resonance our data is best conceived from a perspective of positive resonance, i.e. the conception of a plug and play HF/usability component that adapts to fit the host company, people and project suggests that consultancy practices should aim to positively resonate with them. They should apply their resources at the time and place, and in such a way, that maximizes the push on the project with little wastage.

This distinction is made because unlike accident models HF/usability practitioners are not trying to absorb variance to prevent failure, but are adapting to variance to maximise their impact on design under constrained resources. For example, variance comes to practitioners internally in terms of staffing resource (time and expertise), and availability of methods and tools; and externally in terms of HF/usability problems, projects and clients. It is the practitioner's role to reconfigure resources and subsystems with the aim of not merely coping with this variance but offering a competitive solution so the client is left happy and their reputation benefits.

Importantly, there are qualitative differences from Hollnagel's (2004) conception of performance variance and the conception of variance in positive resonance. By making this change we are no longer talking about 'rare failures' due to variability, but the requirement for 'continuous quality'. This is a change in the frequency of the events and whether interactions lead to positive or negative outcomes. Mansfeld (personal communication, 2008) emphasised this difference in the frequency between the conceptions when commenting on this work: the small possibility with risk and the continuous requirement for quality. Positive resonance seems more about the value that is gained and transferred between interacting functional parts of a system. To capture the ongoing need for positive resonances we use the metaphor of an electrocardiogram below.

The conception of positive resonance is not complicated but nevertheless is useful as leverage for understanding HF/usability practitioners' choice and use of methods. By maximising the value transfer under constrained resources HF/usability consultancies have better survivability and resilience. Intelligent choices in method adoption and adaptation with respect to the specifics of the problem, project and client will lead to improved performance.

Figure 11.5 shows a positive resonance illustration which is adapted from the FRAM illustration presented in Section 10.5.3.1 (see Figure 10.7). Instead of quality margins and a span of control, it has satisfaction margins and a span of expectation. In this representation the practitioner seeks to improve the performance quality of their work by choosing and using a method that will positively resonate with other functional components to exceed the satisfaction margins and span of expectation under constrained resources. For example there may be a particular problem in convincing the client, so workshops and observations of usability tests are chosen for persuasive purposes. Alternatively there might be a safety-critical risk so checks and double checks are employed to make certain of the outcome even though it is resource intensive. In Figure 11.5 quality and success are defined in terms of the practitioner's aim to do work that satisfies the client under constrained resources – this will obviously depend on the nature of the context.

Figure 11.5. A **positive resonance model of method use in HF/usability practice.**

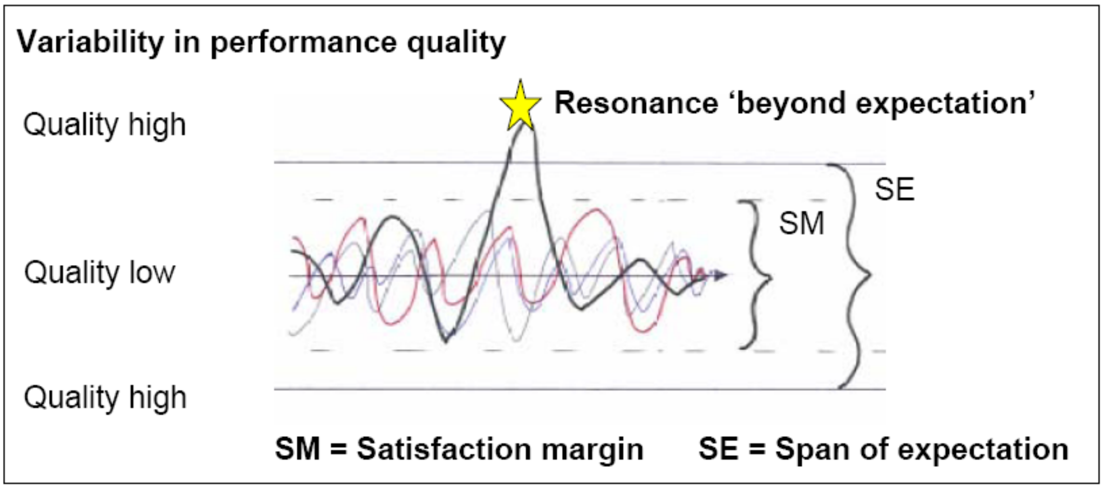


Figure 11.5 has been heavily inspired by Dijkstra (2006) (see Figure 10.7) which appears to originate from displays of oscillation frequencies and amplitudes which might be more common in maths and physics. This seems an appropriate representation

for displaying resonance as each individual line affects the amplitude of the resultant performance.

Similar to an electrocardiogram which measures the electrical activity of the heart, Figure 11.5 can metaphorically be seen as representing the health of a HF/usability project. The higher the amplitude, the more quality, and the better the health of a project. Similar to an electrocardiogram which can ‘flatline’ which shows that there is no electrical activity of the heart; a project could be considered to flatline when the quality is very low, unhealthy and it is close to going wrong. Each line is represented as a wave which passes through the central axis at each oscillation. What matters is the pattern and the amplitude of the waves. Experts who read electrocardiograms can spot irregular heart patterns, which might lead to problems in health should they remain untreated. In a similar sense one can consider practitioners ‘reading projects’ in similar way and treating them should they find unwanted patterns.

The success and health of a project is defined from the HF/usability practitioner’s perspective: to do work that satisfies the client under constrained resources – this will obviously depend on the nature of the context. Importantly, this is not just to pick up the cheque at the end of the project but to transfer value to the design process in HF/usability terms. This would be understanding the client’s need, doing usability work to meet that need, then communicating the results so the client is empowered to act appropriately on those recommendations.

It is important to realise that this graph has been established through the HF/usability practitioner’s perspective, and the graph remains focussed on that view. From this perspective, practitioners try to keep the state of the project as healthy as possible. If it were a representation to argue for earlier intervention of HF/usability work in projects then it might show a decreasing resonance the further along the project timeline we go – we do not make that argument or try to represent it here. The representation could also be expanded to other contexts which seek to maximise their performance under constrained resources, e.g. academics organising teaching, research agendas, students and funding proposals; and Formula One teams organising budgets, people, expertise, technical developments, drivers, and mechanical parts. We do not make these arguments here, but focus on HF/usability practice as this is what our data represents. In Section

11.5 our FRAM analysis elaborates on the functional parts of the HF/usability system where positive and negative resonance occurs.

11.4.4 Conclusion

This section has covered the consequences of applying different models for the understanding of the opportunities and challenges for methods in practice. This follows the same line of reasoning that Hollnagel (2004) uses for understanding accidents. As with understanding accidents, the models that we implicitly or explicitly apply to explain the opportunities and challenges for methods in practice will shape our explanation.

We have seen that sequential models can provide simple causes for methods not transferring to practice. We have seen that epidemiological models can account for the latent effects that will influence the likelihood that methods will be used by practitioners. Finally, we have seen that methods can be understood in terms of how they are affected by and functionally influence the performance of usability practice.

Positive resonance was introduced as a construct to explain how practitioners maximise their performance under constrained resources, i.e. they will select methods that will suit the internal and external variances of the context. The next section documents a FRAM analysis of our data which seeks to map out the functional couplings that are important for the performance of HF/usability practice and how methods fit into this.

With positive resonance, and with the recognition of the key functional couplings in the system, we are in a better position to reflect on strategies to tune the system to maximise positive resonance and erect barriers and monitor for negative resonance.

11.5 FRAM Analysis

In this section we highlight the last stages of the complete FRAM analysis for brevity. The full analysis can be found in Appendix C1 and C2. Readers are referred to Chapter 10, Section 10.5.3.1, for an introduction to FRAM (Functional Resonance Accident Model).

We outline how we have used the four steps of FRAM and highlight the results.

11.5.1 FRAM Step 1: Identify essential system functions

This step was focused on identifying the main goals and functions of the system. This step identified 29 different functions in the system of HF/usability work. These functional nodes are listed in Table 11.1.

Each functional node was elaborated according to their system function characteristics. Primarily this meant their main input and output. However, it also looked at whether there were preconditions for that function, the time needed, the required resources and what controls were in place. This step also identified whether the function was focused on human (M), technology (T), and organisational (O) factors.

All these details are contained within the template in parts A and B of Figure 11.6. For example the number and title of the functional node comprise Part A in Figure 11.6. The six connectors detailing input, output, precondition, time, resources and controls; and the MTO (human (M), technology (T), and organisational (O) factors) focus comprise Part B in Figure 11.6.

11.5.2 FRAM Step 2: Determine the potential for variability

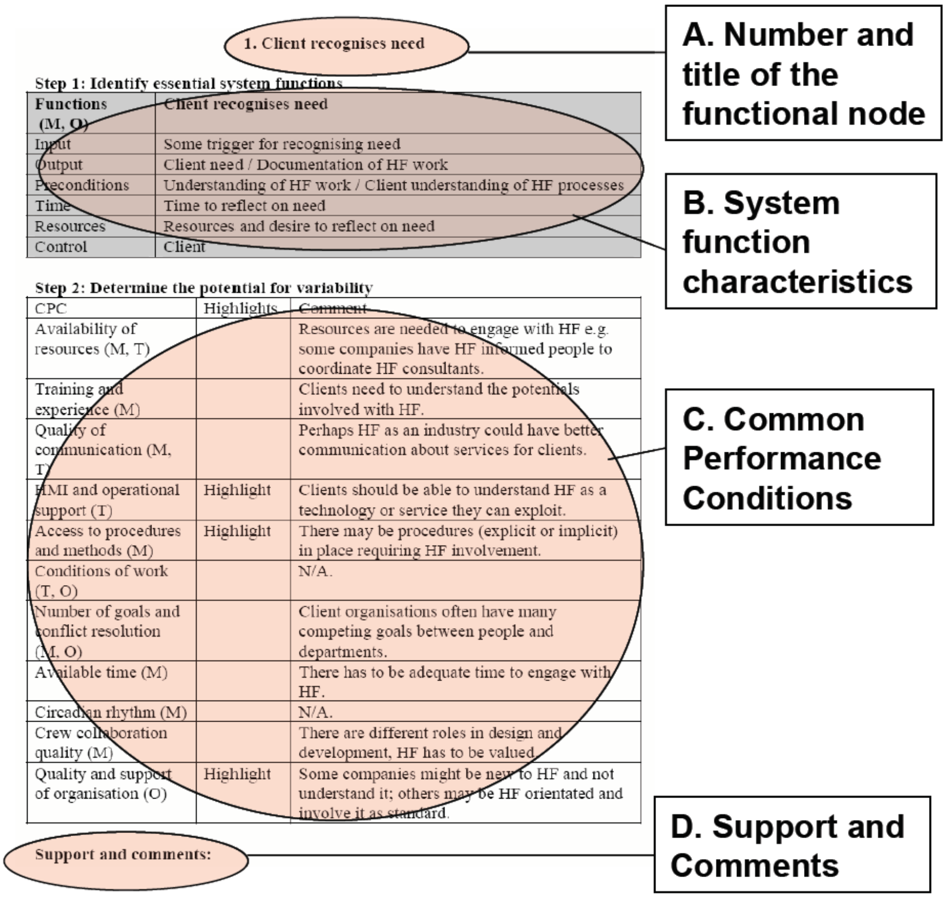
This step used the checklist proposed in Hollnagel (2004, p. 191) for identifying the context dependent common performance conditions (CPC) of the function. Instead of grading the variability of each condition the important conditions are highlighted as the analyst chose not to go to this level of granularity (represented in Part C of the template in Figure 11.6).

Steps 1 and 2 are further elaborated on by support and comments which appear in Part D of the template in Figure 11.6. The first node, ‘client recognises need’, is given as an example of this process in Figure 11.7. The goals and functions developed in these first two steps are integrated as nodes in the FRAM network in Step 3, which provides a graphical representation of their relationship.

Table 11.1 Different functional nodes of HF/usability work.

Functional Node Number	Functional Node Title
1	Client recognises need
2	HF understands client need
3	Work packages are developed
4	Project negotiated
5	Client understands HF processes
6	Resources allocated
7	Methods are developed
8	Select method
9	Tools are developed
10	Select tool
11	Staff are developed
12	Senior HF management
13	Project work performed
14	Development of paper trail
15	Persuade client
16	Reporting practices developed
17	Select reporting practice
18	Analysis of data
19	HF understands project issues
20	HF understands domain
21	Write report
22	Communicate to client
23	Client engages with results
24	Client understands results
25	Client considers results
26	Client acts on results
27	Build reputation
28	Build rapport
29	External audit

Figure 11.6: Sections of the template used for Steps 1 and 2 of the FRAM analysis



1. Client recognises need

Step 1: Identify essential system functions

Functions (M, O)	Client recognises need
Input	Some trigger for recognising need
Output	Client need / Documentation of HF work
Preconditions	Understanding of HF work / Client understanding of HF processes
Time	Time to reflect on need
Resources	Resources and desire to reflect on need
Control	Client

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Resources are needed to engage with HF e.g. some companies have HF informed people to coordinate HF consultants.
Training and experience (M)		Clients need to understand the potentials involved with HF.
Quality of communication (M, T)		Perhaps HF as an industry could have better communication about services for clients.
HMI and operational support (T)	Highlight	Clients should be able to understand HF as a technology or service they can exploit.
Access to procedures and methods (M)	Highlight	There may be procedures (explicit or implicit) in place requiring HF involvement.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)		Client organisations often have many competing goals between people and departments.
Available time (M)		There has to be adequate time to engage with HF.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		There are different roles in design and development, HF has to be valued.
Quality and support of organisation (O)	Highlight	Some companies might be new to HF and not understand it; others may be HF orientated and involve it as standard.

Support and comments:

As an example of how the template was used for all 29 functional nodes we include the first one in Figure 11.7. The others can be found in Appendix C1.

Figure 11.7: Step 1 and 2 of the first functional node

1. Client recognises need

Step 1: Identify essential system functions

Functions (M, O)	Client recognises need
Input	Some trigger for recognising need
Output	Client need / Documentation of HF work
Preconditions	Understanding of HF work / Client understanding of HF processes
Time	Time to reflect on need
Resources	Resources and desire to reflect on need
Control	Client

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Resources are needed to engage with HF, e.g. some companies have HF informed people to coordinate HF consultants.
Training and experience (M)		Clients need to understand the potentials involved with HF.
Quality of communication (M, T)		HF as an industry has varied communication about services for clients. Different clients find HF need in different ways.
HMI and operational support (T)	Highlight	Clients should be able to understand HF as a technology or service they can exploit.
Access to procedures and methods (M)	Highlight	There may be procedures (explicit or implicit) in place requiring HF involvement.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)		Client organisations often have many competing goals between people and departments.
Available time (M)		There has to be adequate time to engage with HF.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		There are different roles in design and development, HF has to be valued.
Quality and support of organisation (O)	Highlight	Some companies might be new to HF and not understand it; others may be HF orientated and involve it as standard.

Support and comments:

There are different reasons why clients use usability services. The quotation below shows that most are financially driven, some are driven by legislation and others adopted as a matter of course:

> "Probably some in the US are legislation driven. I'm trying to think of specific examples. Most of them are financially driven. Most of them believe that usability is going to do something in terms of returning on their investment. But some don't articulate it that way.

I'm thinking of one client in particular that just knows it's the right way to do it and doesn't question it." W9

Practitioners referred to a range of reasons to do with why clients sought usability services. Most identified this with some underlying motivation toward revenue generation. However, some specified examples that were not about money, e.g. to comply with legislation, to conform to their own internal procedures, to fulfil contractual obligations, as part of a media showcase, to improve safety and performance, to do the same as competitors, because it is fashionable to do so, and for political reasons like gathering independent evidence to support an argument.

The respondent below compares the maturity of how clients differ in their acceptance of HF/usability services to the maturity of safety cultures, where level five is very mature and accepting and level one is naïve:

> "R: The motivators tend to be that someone is pushing them to sort themselves out at the beginning... I think actually the safety culture is actually good way of describing it because you have different stages of safety culture. If a company is at the fifth stage which is like the top stage, then they will want to improve continuously, they're really high up, they have got very good safety but they can see that they can drive it further and further; and they would come and approach us on their own as part of some kind of programme because they're thinking let's try and do more in human factors. But if you've got someone who is at number one then, who is right at the other stage who doesn't even know that they've got a problem, just get on with it, do the job day to day, get things done, but don't really think about how they can change or improve, they're not going to come and try and find human factors help, but they are the type of company that's then going to have some accident and then the [regulator] is going to come along [and reprimand them]." S3

Companies will also carry out prospective work to try and generate business, i.e. they will try to encourage the client to recognise a need and acquire their services:

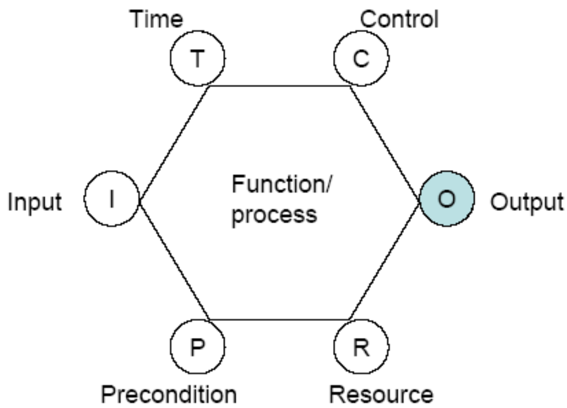
> "R: Erm yes... done heuristics […] it's more set criteria and that was more for driving sales opportunities I guess in terms of things like who's got poor accessibility, who's got poor usability, because if you can go to someone and say, we've evaluated a load of websites and yours frankly isn't as good as your competitors we can help you to improve this and improve that, again that can be quite a powerful means for getting your foot in the door. I did that for a number of sites, UK financial sites […]" W4

This commentary shows that different clients will recognise need for usability in different ways depending on their own maturity of acceptance toward HF/usability services, whether they can recognise a specific need themselves, or whether they are encouraged by others. These different needs will have to be understood and catered for by HF/usability practitioners.

11.5.3 FRAM Step 3: Define functional resonance

This step looked at the expected and unexpected dependencies among the 29 functional nodes. This was achieved by building up a FRAM network, which displays the nodes and links between them. The nodes represented in the FRAM network are hexagonal in shape and represent the input, output, preconditions, time, resources and control referred to in Part B of the template in Figure 11.6. The layout of these functional characteristics is displayed below in Figure 11.8. Many of the node's main links are via their input and output, although there are some links to time, controls, preconditions and resources.

Figure 11.8. The hexagonal function representation (reproduced from Hollnagel, 2004, p. 126).



We present two FRAM networks from our analysis here. The latter is a development of the former as it contains more information which we will move on to in due course. They are described in turn below.

The numbers and titles of the 29 functional nodes refer to the number and titles of the functions identified in Step 1 and 2 in Appendix C1.

Description of the Project Process (Figure 11.9)

Figure 11.9 highlights the central project process. The central process roughly includes: the client recognises a need, HF understand this need, work packages are developed to satisfy this need, a project is negotiated, work is performed, data is analysed, a report is written, results are communicated to the client, they consider the results and how to act on them. This flow is represented in a 'Z' shape so the input and output flow from left to right can be maintained, and the process is able to fit on to one page. The ability to fit the process on to a single page is an important requirement as some of the other nodes relate to more than one stage in the process. It also provides the reader with a single graphical representation for the system description.

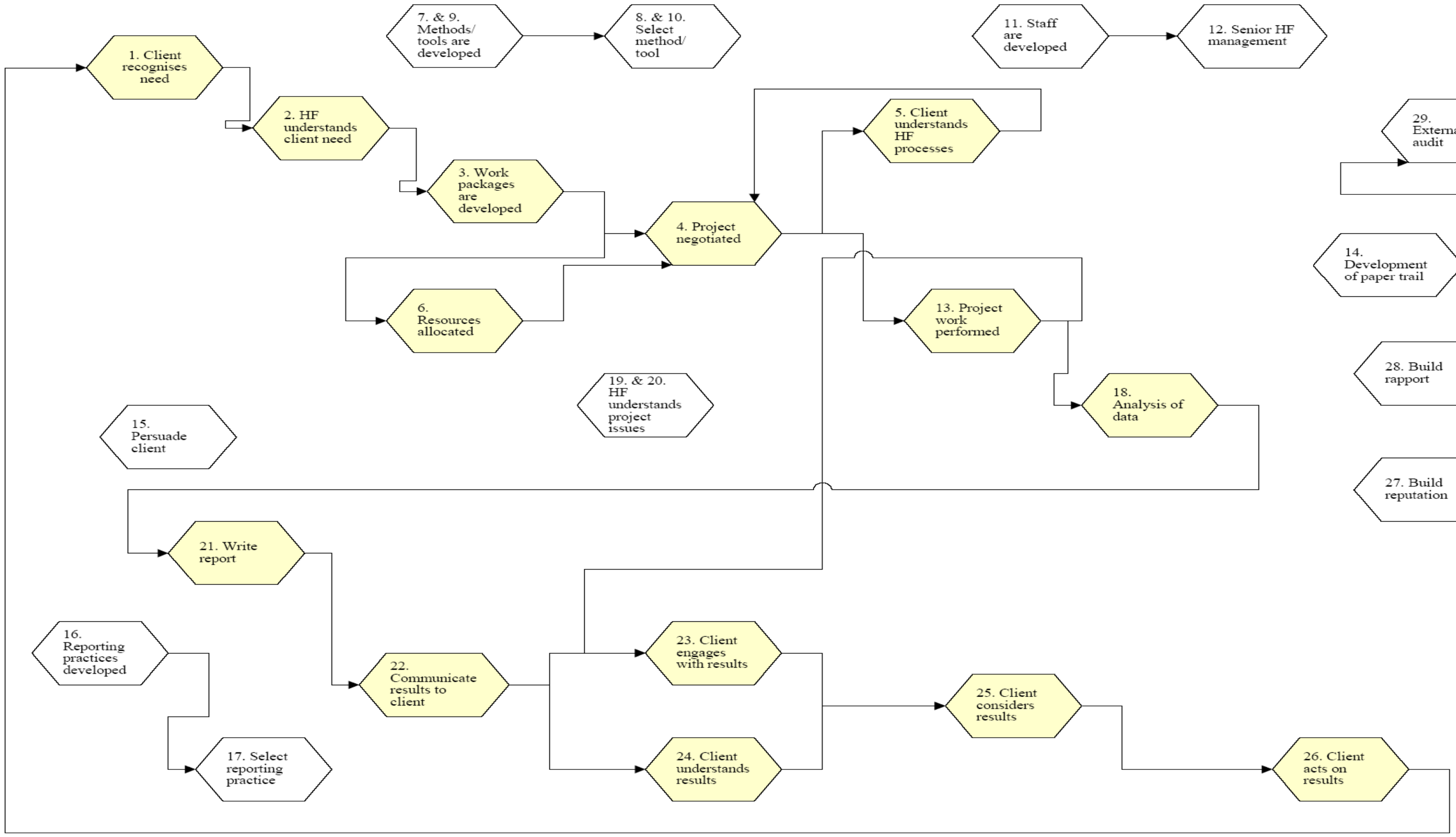
Those deviances from a single linear flow in this representation this flow include the processes surrounding function 4 to do with project negotiation; the fact that function 13 goes to function 23 and 24; and that there is a distinction between the parallel components of function 23 and 24; which are explained below.

The negotiation of the project work requires that the client understands, at least to some degree, what they are agreeing to. In the negotiation process the client will understand more about their options and so develop their understanding, this is why function 4 feeds into function 5. The clients understanding will then act as a control in the negotiation, this is why function 5 feeds back into the top of function 4. Important for both parties in the negotiation is that some set of resources will have been allocated to allow the potential for negotiation, this is why function 6 is a precondition for 4. From the HF/usability perspective this will be staff, time and equipment to do the work (which will be shaped by function 3); from the client side this is likely to be time and budget to pay for the work.

Function 13 feeds into 23 and 24 because some practitioners would encourage clients to observe user testing, or get them to speak to users, or watch an expert panel so they receive direct communication which is outside of the data analysis and project reporting process.

There is a distinction between function 23 and 24: 23 is to do with the client caring about and engaging with the issue, whereas 24 is more about the cognitive task of actually understanding what is said, e.g. people might fully understand but not care about what is communicated and vice versa.

Figure 11.9: The Project Process [No codes as this is the central process]



In the full report Figure 11.10 is built up through a series of seven FRAM network diagrams, each overlaying further links between the nodes (see Appendix C2). We now present the last of these diagrams which combines this information. If all the functional links were drawn it would make the representation unintelligible so to cope with this we hide the lines and represent the relations with a coding scheme. These codes have a letter and number. The letter signifies a different type of code and the numbers signify the direction: i.e. where 1 always goes to 2. Descriptions of these codes and couplings are listed in Table 11.2, and are realised in Figure 11.10.

Table 11.2. Coding scheme and description of the functional couplings.

Coupling	Description
A1-A2	The HF/usability practitioner gains a better understanding of the project issues.
B1-B2	A better understanding of the project issues informs further functions.
C1-C2	The client is further persuaded through knowledge, understanding, reputation and rapport.
D1-D2	Persuading the client impacts on the work performed and communicating the results.
E1-E2	Rapport is developed through client contact.
F1-F2	Reputation is developed through evaluation of HF/usability work and results.
G1-G2	Performing HF/usability project functions leads to the development of HF/usability staff.
H1-H2	HF/usability staff are a resource for HF/usability project functions.
J1-J2	Senior HF/usability manage and control HF/usability project functions.
K1-K2	Reporting and communicating results leads to development of practice.
L1-L2	Reporting practices are selected.
M1-M2	Project work leads to the development of methods and tools for practice.
N1-N2	Selections of methods, tools and reporting practices feed into the development of work packages at the start of the project.
P1-P2	Documents are produced at different stages of the project which lead to the development of a paper trail.

Description of the Combined FRAM network (Figure 11.10)

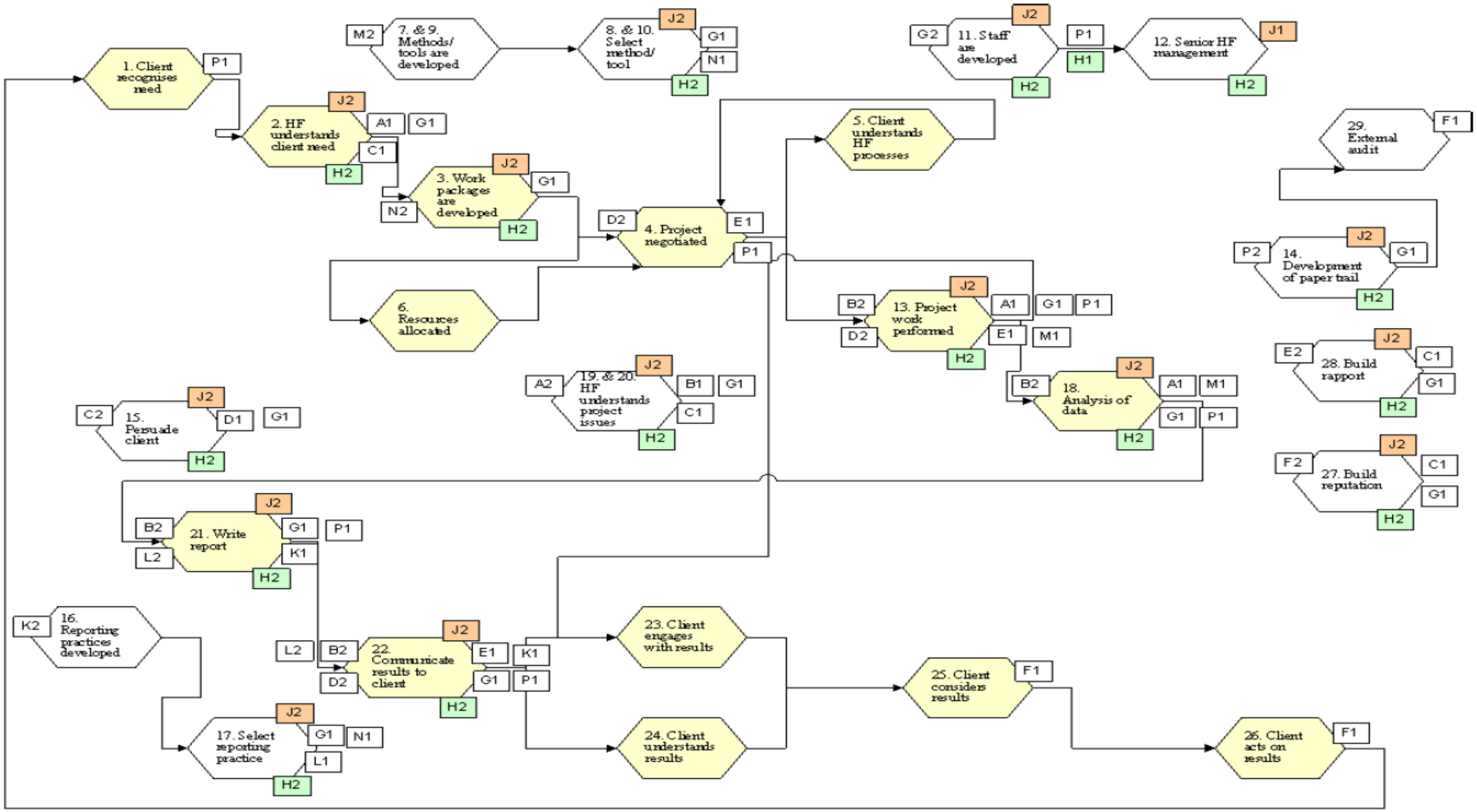
Figure 11.10 shows all the functional couplings in code form. It has the project process as its central core, which is in a 'Z' shape (described in Figure 11.9).

This representation allows us to have an overview of the system. For example, there is a central project process for project work; this has a softer element in persuasion, report and reputation which impacts at three main functional stages: 4, 13, and 22; HF/usability practitioner understanding plays a functional role in persuasion and is a central process itself with feedback loops with 13 and 18, and links to 2, 21, and 22. Staff are a critical resource throughout the project, and senior members monitor and manage project progress as a supervisory control (see J2 and H2). Tools, methods and reporting practices which are developed and selected for implementation in practice, are also developed in practice. However, there is external input in this development from academia. It was identified that the selection of tools, methods and practices was strongly based on previous experience to promote predictability, efficiency and effectiveness. There were also specific stages in the project process which would provide opportunity for more formal documentation which is a necessity in some contexts (see code P1 to P2).

The system of HF/usability practice is in constant flux, and needs to adapt itself to every project. Through this system description we can see how performance of the different parts of the system come together, adapt and bend so the whole stays in a healthy state. For example, staff are constantly developing in different areas, working on different projects and building their rapport and reputation; work packages are being proposed and negotiated with clients but with some opportunities lost to competitors; the company is developing their reputation and expertise through staff and completed project work; staff are being reflective on the tools, methods and reporting practices they use, some mindful of what academia is producing, but others are content that they have a set of well developed and successful practices already; resources are stretched on some projects and are quite flexible on others; and some clients come back for repeat business, other clients might be approaching the company for the first time. This list of variances is not exhaustive.

The variance which exists in the different parts of the system makes its performance complex, particularly when we consider many parallel projects taking place at the same time: some finishing, some starting, some going well and some with challenges. A big influence in managing and absorbing this complexity comes down to the HF practitioner and staff. Through experience senior HF staff are able to see the past, present and some of the future, to know when things are going right and when they require attention, and what to do to successfully absorb variance.

Figure 11.10: Combined FRAM network [Includes all codes: from A to P]



11.5.3.1 Positive and Negative Resonance

In the following section we reflect on steps 1, 2 and 3 of the FRAM analysis. Table 11.3 lists positive and negative resonance at a system level, which have come from respondent quotations.

Positive resonance is a state whereby system performance is having its maximum effect within the constraints and dynamics of the context. Where non-linear functional couplings coincide and reinforce each other to increase the likelihood of an outcome which surpasses normal performance.

Negative resonance is a state where unwanted outcomes and influence coincide and reinforce each other to increase the likelihood of an unwanted event occurring. To prevent unwanted resonance we can erect barriers and specify performance monitoring practices.

Table 11.3: **List of positive and negative resonance from respondent quotations, with comment**

Theme	Positive Resonance	Negative Resonance	Comment
Understanding client's need.	Respondent W8 spoke of helping the client understand their need, because they sometimes did not fully understand it themselves.	W5 satisfied his contacts' need but then found that his contacts' seniors had other concerns which nullified his contribution.	There should be a deep understanding of the client's need even when they do not know what it is.
Understanding project benefit.	W9 said that they would try to recognise and agree measurable improvements for the client as an outcome of proposed project.	Respondent S5 recognised that a client was unhappy because they did not feel they had received benefit from the work, which was exacerbated by the fact that they had not understood the benefits in the first instance.	The client and HF practitioner should be absolutely clear about what they both expect from the work.
Resource management.	Respondent W2 was satisfied with the way her current work place managed projects.	Respondent W2 left a place of work because they worked their employees too hard, trying to stretch times and budgets so they could make more money at the detriment of the staff.	Projects should be managed appropriately, respecting staff, client, project and business goals.
Methods suitability.	Numerous practitioners reported applying methods which gave successful results, which suited the problem and project constraints.	Respondents W1 and W6 wanted to use more methods but these were often not feasible for their clients' budgets and timescales.	Clients need to be convinced of the worth of doing a particular activity or method.

Theme	Positive Resonance	Negative Resonance	Comment
Practitioner proven track record and reputation.	Respondent S11, spoke of being accepted by her clients once they knew that she had connections to people they respected and were friends with, so they trusted her reputation by acquaintance. Respondents W8 and W9 found it easy to justify usability and had a wealth of practical experience and examples.	Respondent W1, found it hard to justify usability, had little practical experience, and used examples from text books.	HF practitioners with a proven track record are likely to be in a good position to justify their work through real case studies and command more influence than junior members because of this experience.
Formal communication.	Respondent S2 states that a lot of their communication is done via documentation and email thereby creating a paper trail for auditing purposes.	S3 reported trying to evaluate an interface specification from a group outside the UK and they had no documentation on how it was developed. This started a long struggle to get supporting evidence to prove it was suitable.	Communication should be formal and auditable where appropriate.
Frequency of communication.	Respondent W2, who was involved in design work, greatly valued their company's procedure for frequently communicating with the client, to make sure both parties understood each other, so the project could be corrected should it need to be.	Respondent W1 makes comment which contrasts with the way W2 refers to design, saying: "you design it, you ship it out to another team, either they're happy with or they're not, if they're not happy then you argue with them." This is not as communicative or collaborative.	You need the right level and frequency of communication to facilitate successful collaboration.
Respect and rapport.	S5 and S11 both remarked on the importance of building up rapport.	Respondent W1 talks about the degradation of rapport and collaboration within their company, which led to recommendations being ignored and people 'doing their own thing'.	Mutual respect and rapport should facilitate collaboration.
Group work.	Respondent S6 said that they can get work done a lot faster working in groups, and that access to other experts was a great resource.	Respondents W1, W3 and S3 made comment about the advantages of working in groups for idea generation, error checking and learning.	HF group work is preferred for idea generation, error checking and learning.
Tool support to extend abilities.	Some respondents had easy access to tools and technologies which enhanced their offering to clients; for example, testing in a simulator and the development of 3D walkthrough computer models of control rooms.	S7 reported budgetary pressures which prevent them from adopting tools that may not prove their worth in the long term.	Tools and technologies should be employed to extend what practitioners can offer.
Tool support to enhance abilities.	Respondent S10 remarked about the considerable time he could save since the development of a tool which helped him calculate work load analyses.	Respondents W4 and S7 both identified editing video to be a chore.	Tools should make tasks easier and more effortless.

Theme	Positive Resonance	Negative Resonance	Comment
The right message to the right people.	Respondent S10 stated that he had learnt and was still learning that results from reports needed to be filtered back to the right people in the client company that cared about the issues relevant to the recommendation. This was in contrast to clients that could understand the recommendation but would not care about that issue.	Respondent W5 recognised that they had done a project that met their needs of the client they had contact with, but not their higher management which made the decisions. The clients did not have a coherent view and understanding of their needs, so the project suffered.	The right person on the client side should be identified, who should understand and care about the HF issues.
Development of HF/usability output practices.	Respondent W5, was proud of the development work they had done on their reporting procedures. These developments made the reports faster to produce, gave the detail for the people that needed it, and a high level section for those that did not need it and are not interested in it. The development also included it being 'pretty' so it was more appealing and engaging as a product.	Respondent W1, did not feel like they had a suitable way of selecting issues to communicate to the client. There were processes in place but they had no support from senior management and so no one had confidence in them or the motivation to use them.	There should be a well developed and suitable reporting procedure.
Actionable HF/usability output.	Respondent S12 said that they wrote reports making it clear how to exploit the knowledge within them thereby facilitating the client's consideration and actions on results.	Respondent S5 recognised that a client was unhappy because they did not feel they had received benefit from the work, which was exacerbated by the fact that they had not understood the benefits in the first instance.	Consequences of HF work for the client should be made transparent to be acted upon, i.e. as a resource for action.

11.5.4 FRAM Step 4: Fine tuning and barriers

This section identifies bullet points for fine tuning the positive resonance in the system, and putting up barriers to prevent negative resonance in it. It has a focus on how methods fit into the system.

Fine tuning to enhance positive resonance

- The client's need should be properly understood, particularly in light of the fact that they might not know the need themselves or there may be different factions within the client organisation that communicate a different need. Methods should be selected to meet this need.
- Staff will be more competent at applying methods which they are experienced at. This will enhance how they see its application, their adaptation of it for the context, the speed and proficiency of its application, and their communication of what the method does and its results to the client. Experience is generally gained through a cycle of reinforcement, e.g. a method is selected and used, the experience gained then means it can be more easily selected and used in the future, this leads to further experience, and so on. There is risk in experimenting with unproven areas and this should be managed. New methods can be explored where opportunities arise, e.g. where a client will pay for a new method or where a project is non-critical, and new members of staff may come to the organisation with a different expertise to share with more established processes.
- Senior staff should plan projects with methods they are experienced at. This will allow them to monitor and supervise the project work better. It will also enhance how they see the project progressing, and their communication of what the method does and its results to the client.
- Time should be given to staff to adequately perform their tasks, monitor and support colleagues.
- Staff should reflect on their own practices so they can be developed and improved.
- The opportunities that particular methods afford such as enhancing persuasion, building rapport, documentation development, and facilitating communication should be exploited. This will include adopting and adapting methods for particular project contexts.
- Following on from methods, reporting processes should be quick, persuasive, clearly communicate crucial aspects, and make it clear how the client is to exploit

the results. Results should be tailored to the audience, or the audience should be tailored to the results, i.e. communicate to people who will care most about the consequences of these issues in a way they will understand.

- Appropriate tools should be employed to facilitate HF/usability work. This can differentiate offerings by adding something different (i.e. extend abilities), or speed up work and improve its quality thereby reducing its cost and improving the output for the client (i.e. enhancing abilities).
- Routine HF/usability practices should be developed so work is standardised and can be performed faster. Adaptations to the practice can then be made from this to suit the context.

Barriers to prevent negative resonance

- Novel and unpredictable methods should not be tried in important situations, which include most commercial projects where there is little slack. Methods can be tried and tested in academia or in situations where they are not project critical and unpredictable.
- Practitioners should have ample experience and resource to plan and monitor projects effectively, including the choice and use of methods. Experience is generally gained through a cycle of reinforcement: methods are used and experience is gained in them, these methods are more liable to be selected as they can be better applied, they are then used even more, and so on. This reinforcing cycle can be shifted; for example, by exploring new methods, by employing new staff, and through a client's request. This shifting can be strategic to gain a business vantage; however, the risk involved in exploring unproven areas has to be managed.
- Practitioners should pay close attention to the points in the process where client communication occurs, so any questions or concerns they have can be addressed to ensure they maintain confidence in the processes and people.
- Within any project the negotiation stage should be managed as a critical step as this is where the parties agree on the plan, resources, methods, goals, and priorities. This will have resonance throughout the project.
- Within and between different projects practitioners and organisations should take advantage of self-development opportunities to consolidate and diversify different skill sets. This will prepare practitioners and organisations for future projects with their own idiosyncrasies and variances.

11.5.5 Summary comments

Fine tuning and erecting barriers has to be context specific. Different practices often exist in different contexts for good reason. So those values and circumstances of the context have to be taken into account. A case in point is the amount of communication: for designing, it is a good idea to increase communication and collaboration, but from an independent evaluation perspective this is not a good idea as it might jeopardise their impartiality. Some companies try to manage both roles by erecting barriers between design and evaluative processes, or even using people that are unfamiliar with designs to get a fresh perspective.

From the explanation developed in the analysis it makes little sense to talk about what is the most effective or efficient system. In fact, we must remember that it is an industry and so market forces will play a role in determining what succeeds and what fails. There are likely to be places for different HF/usability systems in different domains: some companies will be cheap, some dear; some light-weight, some heavy-weight; some large and global, some local where individuals work alone; some new, some well established; some will have different emphasis on valuing staff, profit, and quality; some will be general consultancies, and some with expertise in specific methods and domains.

For success, what matters is that within any niche the HF/usability services develop and adapt practices to positively resonate with that market. This will include the technical, social, structural, communication and resources aspects of methods. Expertise is important to understand these resonances and use them intelligently. Predictability is important for clients and practitioners because they need to be able to reliably deliver to agreed standards and targets. The need for predictability encourages a cycle of reinforcement in methods, tools and procedures whereby current practices are repeated, learnt, and propagated from project to project and from practitioner to practitioner. This creates some inertia on the one hand and stability on the other.

In this system of functional resonance we have built an explanation where method selection, use and performance are inextricably linked to the performance of the wider system of HF/usability practice. Either directly or indirectly method use is affected by or affects every node in the FRAM network.

11.6 Conclusion

This section has used Resilience Engineering (RE) as leverage to explain the adoption and adaptation of methods in HF/usability practice.

We have seen how RE concepts relate to our data in Section 11.3, in terms of:
1) Goal conflicts: Efficiency-thoroughness trade-off (ETTO)
2) Values: Survivability and Different Dimensions of Resilience
3) Normal Adaptable Practice in Open System
4) Reflection-in-action or reflection-on-action
5) Expertise
6) Sharp-end / blunt-end distinction
7) Tight and loose coupling

In Section 11.4 we related different models for understanding accidents to explanations of method use in HF/usability practice. Following Hollnagel's (2004) line of reasoning we argued that sequential and epidemiological models have shortcomings for understanding the opportunities and barriers for method use in practice. We proposed a systemic model using functional resonance and outlined the case for a positive resonance model whereby practitioners maximise their performance under constrained resources, i.e. they will select methods that will suit the internal and external variances of the context. We used the metaphor of an electrocardiogram to relate 'continuous quality' to a healthy system.

In Section 11.5, we performed a FRAM analysis which has mapped out a functional model for HF/usability practice. This included a FRAM network representing the system, comment on positive and negative resonances and ways to fine tune the system. This section has given detail to the systemic model of methods in HF/usability practice proposed in Section 11.4. Here, we see that method use will be influenced by and affect many different aspects of the system, for example: from the short term project to long term reputation and expertise; from the beginning of the project in understanding the client need and winning the contract to the end in delivering results; from hard factors such as technical capability of the method to softer factors such as building rapport.

We have created an interpretive bridge between the qualitative analysis of HF/usability practice and the RE literature. This relates to Dekker's (2005, p. 192) statement that “validation emerges from the literature (what others have said about the same and similar contexts) and from interpretation (how theory and evidence make sense of this particular context).” We have shown how resilience engineering concepts are reflected in our data, proposed a positive resonance model, and detailed the functional components of this model. This captures the way usability consultancy services adapt and fit the host company, people and project to maximize their impact under constrained resources. This is inextricably linked to the opportunities and barriers of method use in practice.

Chapter 12: Validation

This chapter discusses validation of the thesis.

12.1 Grounded in data

The process of grounded theory encourages ongoing validation throughout the analysis. The data is gathered with a focus but the line of questioning is responsive to issues raised by the practitioner. As themes emerge in the interviews they are probed and analysed further. Themes are brought forward and tested with subsequent interviewees. The constant comparative method describes this constant grounding and testing of emerging themes in the data (described in Section 3.5.8).

12.2 Internal member checking of quotations

The analysis in this thesis has been grounded in interview transcripts. Quotations from the interviewees have been used to support the reporting of the analysis. These were passed back to the interviewees to achieve two purposes: the first is the ethical purpose of checking whether the practitioners are happy with the quotations used; the second is for them to check the accuracy of the interpretation of the quotation. This was done at three points in the thesis:

1) The first time was after the analysis of Chapter 4. Seven of the 8 practitioners in the website development domain reported that their quotations were used accurately; the other was non-contactable.
2) The second time was during the development of Chapter 6. Ten out of the 13 practitioners in the safety domain checked that their interview summaries were correct; the other 3 were non-contactable.
3) The third time was toward the end of the thesis, which included practitioners in both domains. Thirteen out of the 22 interviewees checked that the remainder of their quotations, used in the thesis and in the appendices were used accurately; the other 9 were non-contactable.

Feedback from the practitioners did include some minor clarifications but no significant misinterpretations. For example, S2 wanted to be clearer that they did not want to 'avoid' informal communication; instead formal communication is preferred so that a written record of communications and decisions are kept.

12.3 Internal and external member checking of the resonance model of HF/usability practice

Part of the output of Chapter 11, which used RE literature as leverage for understanding HF/usability practice, was a FRAM analysis. This showed the functional components and couplings in a resonance model of HF/usability practice. Feedback and validation packs were created which included a description of this model for HF/usability practitioners to check. The model was checked internally and externally. Internally: all 22 interviewees were sent the pack of which 10 responded having looked at the model (from those that did not give feedback 8 were non-contactable and 4 responded but did not look at the model, e.g. due to lack of time). Externally: 11 practitioners were sent the pack after accepting a request to participate, of which 8 responded. The identifying codes for anonymity, experience and job titles of all respondents are contained in Table 12.1. The external respondents were theoretically sampled to provide a breadth of experience and domain knowledge; e.g. including website, software and air traffic control HF/usability consultants with different levels of experience and responsibility.

Table 12.1: Respondents who looked at the resonance model of HF/usability practice

Type	Code	Job title	Years in experience
Internal - website	W1	Research Fellow	1
Internal - website	W2	Senior Users Experience Analyst	5
Internal - website	W3	Usability and Analysis manager	6
Internal - website	W7	Information Architect / Usability consultant	12
Internal - website	W9	Chief of Technical Staff	22
Internal – safety	S1	Senior Industrial Designer	30
Internal – safety	S2	Senior Human Factors Researcher	5
Internal – safety	S3	Senior Consultant	10
Internal – safety	S11	Independent Consultant	17
Internal – safety	S13	Senior HF Practitioner	11
External	E1	Senior Human Factors Consultant	7
External	E5	Usability Consultant and Information Architect	5
External	E6	Principal User Interface Designer	5
External	E9	Strategic Development Manager & Digital Media Consultant	5
External	E11	User experience consultant	6
External	E12	Director of a usability consultancy	12
External	E13	Human Factors Scientist	5
External	E14	Usability Consultant	3

In the packs the model was presented at three levels:

- Level 1: The 29 individual functional components
- Level 2: The six subsystems

  Subsystem 1: Project process

  Subsystem 2: HF/usability practitioner understanding

  Subsystem 3: Persuasion, rapport and reputation

  Subsystem 4: Staff development and management

  Subsystem 5: Tools, methods and reporting practices

  Subsystem 6: Auditing and documentation
- Level 3: The overall system

At each level statements were extracted from the model, explaining that part of the system. Participants were asked to say whether the statements were generally accurate, whether they were a significant part of their work, and to provide comment if they wished to clarify or add anything.

A pack, which collates all of the responses from the 18 participants and gives reflection on these comments to include potential model modifications, can be found in Appendix D. Rather than present an updated version of the model here, which is part of future work, we emphasise how respondents reacted to the model developed thus far. In general the respondents thought that the model was accurate. We summarise and reflect on the main points below:

12.3.1 The distinction between a model and its instantiations

A development in the FRAM notation since the analysis and network diagram developed in Chapter 11 has been the distinction between a model and its instantiations (Hollnagel, 2008, personal communication). The model is a map of the functional components that can come into play in the functional system without any relationships between these parts. Instantiations of this model include those ways that the functional parts of the system work together. So, from the same model there may be different instantiations.

This distinction helps us rationalise feedback from participants that have highlighted deviations from the explanation we presented (Appendix D). For example, S2 points out that not all clients are willing to enter into a negotiation process; some respondents indicated that developing a paper trail is not significant but others said it is very important; some said the hierarchical description of management and staff development did not apply whilst others said it was accurate; respondents indicated that the frequency of client communication is project dependent; and some practitioners preferred to be seen as facilitating and helping clients rather than selling services and persuading them. S2 also points out that a tool or method might be the stated objective of project work rather than a report and S1 says that their output often consists of designs; S2 points out that project records are strategically used to build the company's reputation and expertise whereas E9 says that project records are mainly kept for auditing purposes. These variations from the explanation presented to the participants, and the apparent contradictions between their practices indicate the variances between different projects and contexts. These variations can be rationalised through a general model, and then different instantiations of this depending on the practices at a local level.

This distinction between the model and its instantiations allows us to cope with the problem of abstraction across multiple cases. Abstracting across multiple cases with different practices is a genuine problem. Balance needs to be maintained between abstracting enough to capture the practices adequately, but maintaining enough detail so the abstractions are not vacuous. In the explanation we presented the majority of feedback indicates that it is generally accurate but some practitioners have pointed out variances with their practice. This variance is welcomed. The main contribution of the model is not rich detailed description but conceptual explanation: that there are functional components that can be recognised in a system, that these will vary between projects and contexts, and that these can be managed to enhance performance. This is a 'contingency theory' of projects and method use, which hold that the right way to organise depends on the circumstances and the contingencies of the situation (theories of this nature have been developed in the field of organisational management (Klein, 2005, p. 13-14)).

12.3.2 Scoping the model: Not enough detail and complexity versus too much detail and complexity

Participants have commented that the model is missing detail and complexity (e.g. E11) and that the model is overly complex (e.g. E14). Both of these are sustainable positions, and what is worth emphasising in response is balance. E9 correctly points out that there is more going on in the 'Persuasion, Rapport and Reputation' subsystem, along the lines of including theory from the domain of organisational psychology. A whole PhD could be devoted to this area alone and still not comprehensively account for the area – this is outside the scope of the current thesis. Again, we refer to the problem of abstraction mentioned in Section 12.3.2. We maintain that the explanation is adequately scoped for the purposes of its contribution. The model is not comprehensive but conveys functional influences from seemingly disparate areas of the same system, e.g. method development, staff management, building rapport, and project negotiation. In this instant we find it useful to refer to Box's (1979) observation that 'all models are wrong, but some are useful'.

12.3.3 Some parts are not unique to HF/usability practice

Some participants questioned whether parts of the model were really unique to HF/usability practice. For example, E6 says that every practitioner in business builds up a repertoire of practices; W1 says that senior managers generally monitor subordinates and that there has to be an adequate understanding of project issues to act appropriately; and E6 says that rapport and reputation will have a role in any profession. This is true. The explanation presented aimed to point out functional components that affect the performance of the system. In fact, it would be a surprise if a system description of HF/usability practice bore no resemblance to other professions and business practices. These parts have to be understood in the same way as those that are unique to HF/usability practice: their functional role and couplings should be understood in terms of their effect on system performance.

12.3.4 Differences in tone: Facilitating and helping versus persuading and selling

Interestingly, some practitioners reacted to the tone of the explanation, which was not a conscious creation when developing the model. For example, S2 prefers to see their work as collaborating with the client rather than persuading them, E11 preferred 'being friendly' rather than 'acting friendly', and E6 commented that the language seemed to suggest it was more of a consultancy product sales environment rather than a needs based environment. Here, we seem to have a difference in tone between facilitating and helping and persuading and selling (the latter of which emerged from the data). The tone that these practitioners have reacted to was unintentional and so this is surprising and interesting. We conclude that this is a difference in culture and also something that can differ between companies and projects e.g. sometimes practitioners and clients might not get on and so there will be a need to 'act' friendly. This implicit variation has now been made explicit through participant feedback and so should be reported in future versions of the model.

12.3.5 Using the model

E9 says there is not ‘a step’ where they recognise the potential for a successful intervention to aid the transfer from research to practice. What the model emphasises are the many dependencies at play in the system and so interventions are more systemic e.g. between critical functional couplings and across the system rather than at single steps. For example, strategies for building rapport through method use should be exploited, and improving staff development could have a significant and broad impact across the system. The main contribution of this model is describing the context in a way that reflects real decisions and dependencies in method use; it is more about understanding the gap between research and practice than bridging it (a similar argument is made by Ackerman, 2000 for CSCW). This is similar to Dourish’s (2006) argument regarding the difference between descriptions of contexts from ethnographic work and having specific implications for design from research. This research is more akin to the latter, which builds a better understanding of the research. This area is complex, and to offer steps to effectively bridge the transfer gap between research and practice, which has been around for so long seems overambitious. However, what this thesis argues is that if we have a better ecological understanding of issues in practice there is improved potential for more appropriate applied research.

12.4 Triangulation

Triangulation is where different samples, methods, perspectives and contexts are used to show that similar claims can be supported from different angles. Here we discuss how different samples, theories, literature and an alternative data set support the validity of our contributions.

12.4.1 Relating to different samples: people, projects, domains

The qualitative analysis has been developed from different people, projects and domains. The analysis has included 9 people in the website domain[2] and 13 people in the safety-critical development domain. The output includes emergent themes and

[2] Due to the timing of the ninth interview eight participants were included in the analysis in Chapter 4. The ninth’s data was included from Chapter 7 onwards.

connections that are triangulated across these different people, projects and domains. The thesis' picture has been built through triangulating across these multiple cases.

12.4.2 Relating to different theories: DC and RE

Distributed Cognition (DC) and Resilience Engineering (RE) were selected and used as leverage to explore the data and develop the qualitative analysis. They were selected because their conceptual frameworks resonated with emergent themes in the data. The thesis shows that the system of HF/usability practice can be conceived in terms of DC and RE. By successfully relating DC and RE to the data we gain support from these existing frameworks, i.e. characteristics that were evident in our data are also evident in other systems that have been described in DC and RE terms. For example, through DC we can see that coordination of people, artefacts and resources has computational influence on system performance in our data in similar ways that it has influence in control rooms (Furniss & Blandford, 2006), the bridge of a ship (Hutchins, 1995a), and agile software development contexts (Sharp et al., 2006). Also, through RE we see that we need to consider phenomena such as loose coupling, the sharp-end blunt-end distinction, goal conflicts, how systems respond to internal and external demand, and non-linear functional couplings in the HF/usability system in a similar way to how they have been considered in other RE systems.

12.4.3 Relating to different literature

We refer to other approaches and results in the literature which have a close relation to our perspective and concerns. This performs the important role of relating our results to the work of others, and highlights where similar issues have been identified thereby giving support for our own work. This section is divided into three subsections: corroborating with similar UEM research, corroborating with method use in information systems development, corroborating and shaping usability practice research more generally.

12.4.3.1 Corroborating with similar UEM research

Bellotti (1988) reviews whether commercial design satisfies the requirements for the successful application of HCI task analysis techniques. Four designers involved in user-system interface (USI) development from academia and four from commercial organisations were interviewed. The findings from the study are summarised below before we relate them to the current thesis:

- Design environments varied such that external influences like the availability of information about users and tasks might have unavoidable consequences on the project.
- Five categories of development activity were recognised that were defined by their goal and could occur in any particular order: commitment to requirement specification, conceptual specification, generation of a working prototype, testing, and finalisation. Design activities were found to be informal and did not involve HCI task analysis techniques. Furthermore, the finalisation of the project was frequently determined by external market pressures rather than internal design satisfaction.
- Various design problems were also elicited from the user system interface designers:

Low autonomy	Technological constraints
Small design team	Market pressures
Uncertainty about requirements	Poor communication
Poor access to user/task-information	Exclusion of users
Low affinity to HCI	Expanding task outlines
Highly inflexible design method	Lack of HCI guidelines and standards
Highly inflexible design team roles	Familiar solution application
Non-user orientated prototyping	Written software constraints
Unfamiliar application domain	Over-casual evaluation
Little USI design/HCI experience	Lack of performance metrics
Unstructured application domain	Inadequate resources

These findings support results of the current thesis, i.e. specific HCI methods were influenced by the process of development, technological, psychological and organisational constraints. Bellotti (1988) has focused on HCI task analysis techniques and the detailed development of specific projects. In contrast this thesis has taken a broader sample of practitioners, methods and projects. By doing this, this thesis adds a complementary view; for example, whereas Bellotti (1988) emphasises project specific details such as ‘expanding task outlines’ this thesis has more emphasis on client interactions, persuasion, rapport and communication. A large difference is that Bellotti (1988) investigates whether commercial design satisfies the requirements for the successful application of HCI task analysis techniques, whereas this thesis has investigated how methods are adopted and adapted in practice and influence system performance. The difference in research approach lies in the *a priori* status given to methods. Both show similar findings with regard to the role of contextual dependencies. Important developments in the current thesis include a narrative to argue the case for considering context in terms of downstream influence (Chapter 6), a description of HF/usability practice as a complex cognitive system (Chapter 9), representations to capture the different factors in a FRAM network (Chapter 11), and a new conceptualisation of method use in terms 'positive resonance' (Chapter 11).

Bansler and Bødker (1993) criticise quantitative studies which report that X% of companies use method Y as they do not tell us how they are used or whether they are used consistently within the same company. Our research shows that there is 'loose coupling' between method labels and method practice, so their criticism should not be taken lightly. To investigate how think-aloud (TA) testing is performed in practice Nørgaard and Hornbæk (2006) perform an observational study of seven usability companies. Their study is at a finer level of granularity than the present thesis, e.g. observing specific types of questions used, and observing how evaluators use tests to confirm assumptions. Their work is complementary to the broader level of this thesis. For example, they discuss some cases where the utility of the device is infrequently discussed and evidence from this thesis suggests that this may be context dependent i.e. that the early stages of the design of a new device might focus more on utility whereas the later stages of a design might focus more on ironing out usability issues. They also observe that tests are sometimes used to confirm assumptions and evidence from this thesis suggests that supporting evidence might be needed for persuasive and auditing purposes even when issues are known. They also question the utility of questions about "first impressions", and "what would you expect to be there [e.g., on the next page]" which might actually be performing the function of relaxing the user so they open up and start talking more about their own views and expectations. Nørgaard and Hornbæk (2006) successfully show that the same method, in their case TA studies, is practiced differently across different contexts, which is quite different from prescriptions in the literature. This sort of grounded understanding of the adoption and adaptation of methods in practice is what has driven the approach of this thesis.

12.4.3.2 Corroborating with method use in information systems development

Studies on methods in information systems development (Fitzgerald, 1996, 1998) and web design methods (Garzotto & Perrone, 2007) have resonance with the findings of this thesis, thereby providing support for its contribution. These studies focus more on the work of software developers rather than usability and human factors consultants.

Fitzgerald (1996) draws attention to the assumption that improvements in information system development practice can be achieved through more control and more widespread use of rigorous and formalised methodologies. He also presents arguments which question this assumption. The arguments for formalized methodologies include that they will simplify complex development processes, facilitate project management, and reduce risk and uncertainty. The arguments against their use include that contingencies in the situation need to be accounted for, the skills and experience of the practitioners need to be considered, the development process is complex and does not fit the simplicity proposed by formal methodologies, and that practitioners might get more fixated on adhering to the methodology rather than the actual project issues.

Fitzgerald (1998) develops this work into a framework for conceiving the information system development process. Figure 12.1 shows the elements in the framework whilst Table 12.2 outlines the properties of these elements. In this framework he distinguishes between originally prescribed methodologies and the methodologies-in-action, which corresponds to ‘loose coupling’ in this thesis. At a broad level the framework also shares the fact that people are a critical resource in the system and that psychological and environmental factors will play a role in what shapes practice. At a finer level Fitzgerald’s (1998) framework is visually simpler. It is fair to say that it has more detail in terms of the overt and covert roles of methodologies within the representation, whereas the current thesis has more detail on the management of HF/usability work, the auditing process, staff development processes, the role of reputation and rapport, the project negotiation, report writing and client engagement processes. It is perhaps unfair to make strong comparisons as the development of information systems, which involves developers building software, is very different to traditional HF/usability practices that engage with clients in consulting roles. However, there are striking similarities between the two; at the highest level, this is that a proper account of method use in practice must include the people using them, their skill and expertise, and the problem context.

Figure 12.1: Framework for the IS development process (adapted from Fitzgerald (1996, p. 107))

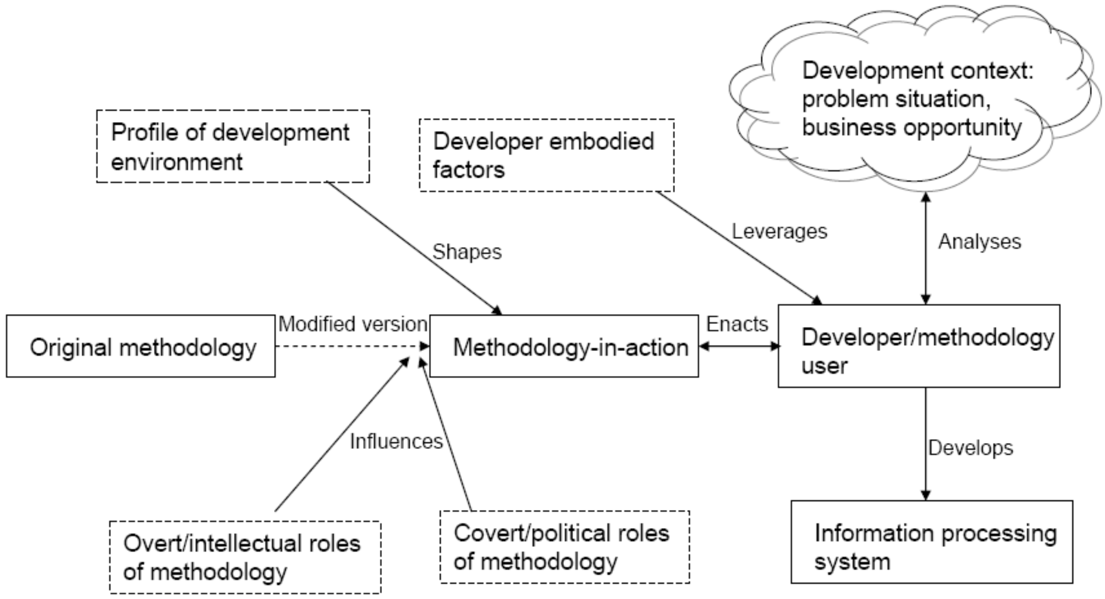


Table 12.2: Description of Figure 12.1

Element's name	Description
Original methodology	This is the methodology as prescribed.
Methodology-in-action	This is the methodology as used.
Developer/ methodology user	This is the person that performs the work. It is the people rather than methodologies that develop systems. The latter is merely a framework used by the people.
Information processing system	This is the system that is developed.
Development context: problem situation, business opportunity	This acknowledges the dynamic processes outside of the immediate problem which can influence the project.
Profile of development environment	This involved the size of the organisation, the length of projects and whether services were in-house or outsourced.
Developer embodied factors	This reflects the skills and experience of the developer and how these change over time. It also embodies trust in working relationships between people.
Overt/ intellectual roles of methodology	Methodologies facilitate project management by making processes structured and transparent, making resource allocation easier, and allowing an easier grasp of projects for novices and comparisons between projects for reflection.
Covert/ political roles of methodology	Methodologies are used for marketing, provide comfort in that 'proper' processes are being followed, enhance the perception of professionalism and facilitate the auditing process.

Garzotto and Perrone (2007) focus on developers' use of methods in the web design context. Like other studies referred to above they are motivated by the fact that academic methods do not seem to transfer to industry and pursue a qualitative and holistic approach to investigate why. Garzotto and Perrone (2007) put forward 10 lessons from their study:

1. A holistic view for design methods is needed
2. A design method should be easy to learn

3. A design method should compromise between richness and simplicity
4. A design method should be “multi-lingual”
5. A design method should be modular and scalable
6. A design method should be flexible and customizable
7. A design method should provide “patterns”
8. A design method should be complemented with high quality documentation
9. A design method should be complemented by various kinds of support tools
10. What kind of prototype better suits practitioners depends on what development phase it has to be used in

From an abstract perspective we relate Garzotto and Perrone’s (2007) lessons to our own work: conforming to their suggestion in Lesson 1, this thesis has developed a holistic description of method use in practice. This thesis also suggests that methods should be adaptable to different contexts and presented in such a way to make these adaptations more accessible to practitioners, which is in agreement with Lessons 2, 3, 5, 6 and 8. Their other lessons include communicating in multidisciplinary teams, Lesson 4; recognising patterns in problems and design work, Lesson 7; having tool support, Lesson 9; and having consideration for the stage of design the project is in, Lesson 10; which are referred to in this thesis. Despite the similarities there are fundamental differences in these studies which include what makes methods suitable for web development practice, to understanding how methods are used and affect performance of HF/usability practice.

There seems a contrast between Bellotti (1988) and Garzotto and Perrone (2007), which look at the requirements for methods to be used in practice, and Fitzgerald (1998) and this thesis, which develop explanations of how methods are used in practice. The former develop lists and the latter develop models. We argue that developing lists of lessons or features can make it hard for readers to comprehend the many different elements and how these integrate. With an underlying model and narrative the interplay between factors is developed and the message is stronger. A notable difference between this thesis and the other studies is the involvement of the client in the system developed in this thesis. This was influenced by the wider perspective taken in this work. Also, the other studies do not use existing literatures as leverage to develop theory: e.g. ‘positive resonance’ has been established as an important concept which underlies the explanation developed in Chapter 11; and the Distributed Cognition literature gave a novel conception of broad computational influences in Chapter 9 of this thesis.

12.4.3.3 Corroborating and shaping usability practice research

As an outcome of the study reported in Chapter 4 a wider base of literature pertinent to usability practice was encountered. This occurred as themes emerging from practitioner interviews, with relation to the performance of methods, integrated with the performance of the HF/usability more generally. Following the development of the functional network we not only gain support from this wider literature, as functional nodes and subsystems relate to its themes, but we can use the functional network to frame this wider literature under. Here, disparate parts of usability practice research can be related together under the more general framework of HF/usability practice performance. Table 12.3 lists references, the area to which these references contribute and their relation to the FRAM network developed in this thesis. We argue that these research topics can be more easily related to each other in Figure 12.2 where their collective significance, and their common research programme to mature usability practice, is more evident.

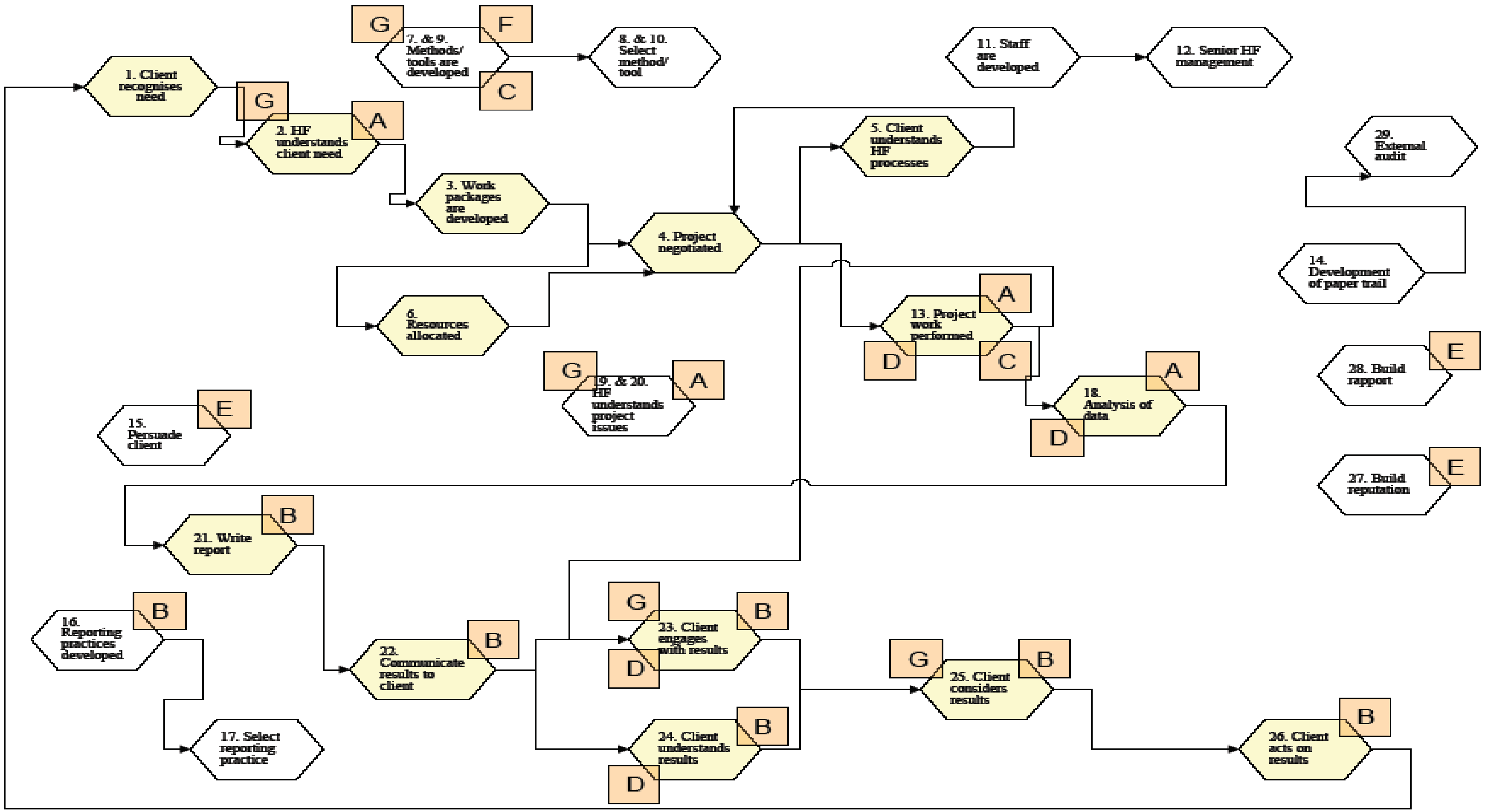
Table 12.3: Relating usability practice research to FRAM network in Figure 12.2

N.B. The codes refer to the location of influence in the FRAM network in Figure 12.2. The superscript numbers refer to the node numbers in Figure 12.2.

Code	Reference and outline	Relation to this thesis
A	Uldall-Espersen (2007). Recognises different types of usability problem.	This work most closely relates to the practitioner's understanding the client's issue[19&20], which has resonance with understanding the client need[2], project work[13] and analysis[18].
B	Hornbæk & Frøkjær (2005). Gives advice on improving the communication of usability recommendations	This relates to those functional nodes toward the end of the project process i.e. from writing the report[21] to the client acting on the results[26]. It also influences the development of reporting practices[16].
C	Nørgaard & Hornbæk (2006). Develops understanding of the use of the think-aloud method in practice.	This is most closely related to performing project work[13]; but this also facilitates reflection and development of methods in practice[7].
D	Molich in Redish et al., (2002). Suggests a method for combining analysis, client observation, and rapid communication of results in usability work.	This work is a good example of using positive resonance in performing project work[13], data anlysis[18], the client engaging[23], understanding[24], and considering the results[25] synergistically.
E	Dumas in Redish et al., (2002). Identifies people relationships as an important factor for usability work.	This strongly relates to how persuasion[15], rapport[28] and reputation[27] are seen to facilitate work.
F	Blandford et al. (2008). Develops a novel method.	Relates specifically to the development of methods[7].
G	Cockton (2008). Suggests a method for engaging with the values that are motivating the client.	Understanding the values that motivate the client has influence on the practitioners understanding of the project[19&20], which has resonance with understanding the project need[2], and getting the client to engage with[23] and consider the results[25].

Figure 12.2: Relating usability practice research to FRAM network

N.B. The letters refer to the codes in Table 12.3. These denote the main areas of influence of different research on usability practice.



12.4.4 An alternative data set: Grounded Theory of CHI workshop

Appendix E details a qualitative analysis performed on 14 papers at a CHI workshop, 2007, on the subject of "Increasing the impact of usability work in software development". It was found that many of the themes from this analysis corroborated results from this thesis. Communication, coordination and the different professionals working in design formed the three main categories of the qualitative study. These categories were composed of many interrelated factors and facets, e.g.: the softer side of culture, value systems, vocabulary, emotions, motivations and politics; and the harder side of resource constraints, goals, procedures, measures, deadlines, methods, skills, and knowledge. It should be noted that these issues can change/fluctuate depending on the specific context, people and project. This qualitative study provides support for the different context dependent factors at work in the performance of usability practice.

12.5 Conclusion

This chapter discusses issues relating to the validation of the thesis. The analysis has been grounded in practitioner interviews; the interpretation of their quotations has been checked with them when used for support in the reporting of the analysis; and the resonance model of HF/usability practice has been checked for its general accuracy (Appendix D). The latter validation stage included internal and external member checking. This has been useful for supporting the distinction between a model and its instantiations, for making explicit the tone of the explanation which some practitioners commented on, and other clarifications to be used as part of future work for modifying the model (Section 12.3). Support for conceiving methods in a system of practice and their non-technical roles has also been gained from its relation to wider literature (Section 12.4.3) and a qualitative study of 14 papers from a CHI workshop on the impact of usability work (Section 12.4.4). An outcome of relating the work of this thesis to wider research on usability practice is the proposal for using its framework to relate disparate areas of research (Figure 12.2). This gives a graphical overview of their complementary nature for improving and maturing applied usability practice.

Part IV

Conclusion

This part concludes the thesis by reflecting on its contributions and suggestions for future work.

Chapter 13: Conclusion of thesis

The core contribution of this thesis has been an argument for appreciating the contextual factors that influence the adoption and adaptation of methods in HF/usability practice. This research has led us to develop new ways of understanding the use of UEMs in a holistic manner. This holistic perspective pushes an agenda for understanding wider aspects of the performance of a system of HF/usability practice; and, importantly, the functional couplings between these aspects. These contingent aspects have been previously alluded to under the practitioner response ‘It depends…’ (referred to in Section 7.4) and academic assertions that decisions will ultimately be made to add value to the design process (referred to in Section 11.4.1).

In terms of method, secondary contributions include a deep reflective account of applying grounded theory, a novel approach to applying Distributed Cognition, a systematic application of Resilience Engineering themes to HF/usability practice and a case study of FRAM which is a new and maturing method.

Another contribution has been our interpretation of the Resilience Engineering literature which is traditionally a risk and safety domain. We reverse the perspective of looking at how things fail or avoid failure to look at performance under constrained resources. This focuses on ‘continuous quality’ rather than ‘rare failures’. The resilience community would maintain that failure is part of the variances and adaptations that naturally occur as part of complex systems and normal work. However, we are not aware of other research that has taken such a sustained focus on ‘positive resonance’ and which looks at how continuous quality can be maximised under constrained resource.

The final contributions include an understanding of inhomogeneous functional dependencies on system performance, and a novel framework for relating disparate parts of the research literature on applied usability practice.

We elaborate on these contributions and their suggested areas of future research below.

13.1 Core contribution: Appreciating contextual factors of methods

The inductive analysis of usability practitioners in the website domain (Chapter 4) concluded that systemic descriptions should be developed to account for the contextual factors that influence methods. Subsequently, three accounts were developed and are described below:

13.1.1 PMO and landscape model

The downstream utility of UEMs accounts for their impact on product development. We extend this stream metaphor to better account for UEM choice and influence in Chapter 6, i.e. the account includes the upstream influence of project planning and a contextual landscape through which the stream flows. As described in Chapter 6, the PMO stream has three stages: project planning (P), method adoption and adaptation (M), and the output of the project (O). There is a downstream influence from P to M, and from M to O.

The landscape also plays a significant and influential role in this model. It is composed of five factors which influence each stage of the stream: technical factors which include the HF/usability issue at hand; social factors which include personal preferences and relationships; structural factors which include the stage and organisation of the project; communication factors which include informal and formal style of reporting; and resources which include times, budgets and capabilities.

This model provides an effective narrative for the consideration of contextual factors in the adoption and adaptation of methods in HF/usability practice. It also provides detail about what we mean by ‘contextual factors’ through five themes.

13.1.2 Distributed Cognition account

Chapter 9 gives a Distributed Cognition account of HF/usability practice and how methods fit within this. This perspective gives leverage through a complex cognitive system view of the context. This uses an information processing metaphor vocabulary to describe systems and considers the wider factors that functionally affect the information flow, e.g. how social structures, use of tools and artefacts, procedures and changes over time influence UEM practice.

From this analysis HF/usability practice is considered as a plug and play technology. This metaphor captures how it adapts its structure, procedures and methods to suit the project and client need. The metaphor is inspired from a computational view of systems as there are many components that work together in the system, of which HF/usability practice is just one. In general, better performance and integration of its components will lead to the better performance of the system.

The complex cognitive system perspective gives structure and leverage to consider how methods are affected by social, information flows, artefacts, evolutionary and physical aspects of the system. The social aspects included power relationships, the information flow included the timing and type of reporting mechanisms, the artefacts included the capability and availability of tools, the evolutionary aspects included the changes of methods and tools over time, and the physical aspects included the closeness of the interaction between the HF/usability practitioner and the client group. This complex cognitive system provides a picture of how methods can be considered a component of a system, and how this component influences and is influenced by the rest of the system.

13.1.3 Resilience Engineering account

HF/usability practice is conceptualised as a system in terms of the Resilience Engineering framework in Chapter 11. This highlights factors influencing the performance of HF/usability practice in a functional manner. From this perspective we can see how internal and external demands, competing goals, and non-linear functional couplings influence method use. The perspective emphasises the variances that happen in normal HF/usability work and how practitioners use their expertise to adapt their methods and actions to fit the context.

HF/usability practice is linked to seven Resilience Engineering themes, including: efficiency-thoroughness trade-offs in terms of the depth of work and research performed; survivability in terms of balancing different goals to make useful and pragmatic contributions to their clients; adaptation in terms of accounting for the normal variances on project work; reflecting in practice to respond to variances; expertise in terms of recognising patterns and knowing what adaptations are suitable; sharp-end / blunt-end distinction to highlight the influence of the client context, practitioner context, and academic context; and tight and loose coupling to capture rigid adherence to deadlines and budgets and the adaptations that are made to method prescriptions.

We relate the development of safety models to introduce why we benefit from a systemic model of HF/usability practice, i.e. to account for non-linear functional couplings. From here we introduce the concept of 'positive resonance' which captures how functions need to integrate well for the benefit of system performance. A FRAM network of HF/usability practice is developed to show how UEMs fit into a system of usability practice. The functional network shows couplings between disparate areas such as method development, communication, client values, staff development, reputation, auditing processes, and resource allocation. We argue that these should be monitored and managed effectively for the resilient performance of the system.

The FRAM network of HF/usability practice defines nodes and relationships between these nodes. These formalised relationships are open to scrutiny and development. There may be arguments for fewer nodes, extra nodes, and even other subsystems which have not been identified in this research context. The advantage of creating such a representation, rather than case studies for example, is that their abstractions across cases can be more easily inspected.

The FRAM network that we offer highlights areas of applied research that impact on HF/usability practice performance. Research and practice can attend to these areas to understand and manage them better. For example, specific focus could be made on the practitioners' skills and their development. Research could look at the skill sets of different HF/usability roles, and practice can monitor these skills in the recruitment of new staff. The broadening of an enterprise's offering may involve employing someone with specialist experience in that area rather than training current staff.

In addition, future research could give more attention to loose coupling so best practice adaptations of methods can be understood and shared. For example, a detailed study of how heuristic evaluation is adopted and adapted in practice could be conducted (much like Nørgaard & Hornbæk's (2006) study on think-aloud testing).

Also, more research effort could go into understanding HF/usability project work from the client's perspective. To this end Klein's (2005) tracer studies might provide a useful model for this investigation. These studies trace the development of a single product, material or project from beginning to end. This form could be used to follow a real HF/usability project from beginning to end noting the development of problems, people's perceptions and interactions along the way. This research may have challenges in gaining such close and sustained interaction with different parties of a business situation but it would be a complement to the current thesis which focuses on the HF/usability practitioner perspective.

13.1.3.1 Relating disparate areas of applied usability research

It is suggested in Section 12.4.3.3 that the FRAM network of HF/usability practice can be used as a framework for understanding research on usability practice. The common objective for research in this area is to improve the performance of usability practice in some way. However, disparate research topics are rarely linked together. A conception of a functional system of usability practice can be used to visualise individual influences on the system and suggest couplings between them. For example, through this framework research on recognising different usability problems (Uldall-Espersen, 2007), communicating usability results (Hornbæk & Frøkjær, 2005), the use of methods in practice (Nørgaard & Hornbæk, 2006), combining analysis, observation, and communication (Molich in Redish et al., 2002), identifying relationships as important (Dumas in Redish et al., 2002), method development (e.g. Blandford et al., 2008), and evaluating what the client really wants (Cockton, 2008) can be more easily related together as the system provides a visual framework for the areas in the system that they impact. These research topics are more cohesive when recognised in this way.

13.2 Secondary contribution: Methodological development and reflection

This section describes secondary contributions of the thesis. These relate to methodological developments and reflections of the theories and methods used.

13.2.1 Grounded theory

The use of grounded theory has become prevalent in HCI research. However, its use remains diverse. We do not perceive this as a problem but it suggests that detailed reflective accounts of its use are needed to understand the nature of these variances, and their effect on results. This thesis covers an extensive account of grounded theory use, covering inductive and deductive modes. The inductive mode included Chapter 4 which presented a grounded theory with extensive quotations and a summary of the analysis under four themes. It also included Chapter 6 which presented different treatments of the qualitative analysis to include summaries of the interviews, an interrelated web of concepts, and the use of a metaphor to provide a narrative for the results. Importantly, the message of the research is not just about being accurate but about having rhetorical power as described by Halverson (2002), so it provides a conceptual structure to map to the real world and so we can communicate it to others.

The deductive mode used Distributed Cognition and resilient engineering conceptual frameworks as leverage for understanding our data. To systematise this process themes were recognised in the respective areas of research (Chapter 8 and 10), and these were related to the data (Chapter 9 and 11). The literature review also provided orientation to the themes and concepts to allow the potential for new insight in the data.

With the diversity of grounded theory use in HCI it seems more important to have detailed case studies and reflections of its use. This thesis is an extensive contribution in this regard.

13.2.2 Distributed Cognition

Our use of Distributed Cognition attempts to combine Marr's three levels of computation, the Resource Model, and DiCoT in a single framework (Chapter 9). In the review of Distributed Cognition literature it was concluded that there is no one right way to apply the theory (Chapter 8). However, there is a need for more structured methods so it is more accessible to researchers and practitioners who wish to apply this perspective. In this respect the attempt to combine different means of applying Distributed Cognition is a novel contribution. This framework could be applied to other contexts to see whether it is a useful and usable way of performing a Distributed Cognition analysis. This is important as Distributed Cognition is acknowledged as having little methodological structure in HCI (Blandford & Furniss, 2005). Distributed Cognition is recognised as a potentially fruitful area for HCI but there needs to be more work with regard to its operationalisation, and this thesis contributes to that area.

13.2.3 Resilience Engineering

Resilience Engineering, as discussed in Chapter 10, is a new paradigm for conceptualising variances and failures in safe systems. There is a small flourishing community following this research agenda but few members focus on the positive side of normal work. This thesis does this and borrows arguments and concepts from the Resilience Engineering literature to do so. We reverse the perspective of looking at how things fail or avoid failure to look at performance under constrained resources. This focuses on 'continuous quality' rather than 'rare failures'. The resilience community would maintain that failure is part of the variances and adaptations that naturally occur as part of complex systems and normal work. However, we are not aware of other research that has taken a sustained focus on 'positive resonance' and which looks at how continuous quality can be maximised under constrained resource.

A critical part of the Resilience Engineering framework is that the source of failure is also the source of success i.e. they are two sides of the same coin. From this perspective the term 'human error' is frowned upon as a gross generalisation. Instead, humans are seen as the source of much resilience because they deal with unexpected variances, stresses and demands that are placed on the system they are involved in. The Resilience Engineering community recognise that failure is part of normal work, because adaptations do not always work and demands can be too much to cope with, but there has been little focused attention on the positive side.

'Positive resonance' has been developed as a concept in this thesis to capture the successful adaptations of a system. This move has been encouraged as we do not focus on the safety of a system, but instead look at how systems survive and compete in a market place, i.e. here resilience is not a question of failure in the safety sense but is a question of offering a competitive solution or service in a dynamic market place. Here, resilient systems mean systems that offer quality against constrained resources.

The documentation of the FRAM analysis is a contribution because it is a new method with few accounts of its use in the public arena. It should be noted that this area is still in a state of flux and the analysis reported in the thesis is our interpretation of the FRAM method. Hollnagel (2008, personal contact) has suggested that there should be better balance between the model which is described in prose and the instantiations which are captured in the FRAM visualisations. We believe that there is more weight given to the prose in the full FRAM analysis (Appendix C) which is not reported in the summary for this thesis (Chapter 11). It should also be noted that the analysis was performed before distinctions between a model and its instantiations were known, which is reflected upon in Section 12.3.1. We have found the visualisations of the FRAM network an important reflective tool for the iterative sense making of the analyst. At this time we believe that the emphasis given to visualisations in the FRAM analysis in this thesis may be a difference in application style. Whilst the method continues to develop and mature it has provided great leverage for this thesis.

13.2.4 Reflection on the relationship between, and the develop of, the PMO, DC and RE accounts

The thesis is presented in a chronological form, and so the PMO, DC and RE accounts successively build on one another. It was hoped during their development that they could be brought together and consolidated at the end but this is not possible. Each model offers something different to the other two, couched in different concepts and often a different level of detail. For example, the PMO model provides a more simplistic account but probably has more rhetorical power (Halverson, 2002) in that a relatively simple message can be mapped to the context and communicated to others through the extension of the downstream metaphor. The other two accounts are couched in the traditions and concepts of their respective theoretical frameworks. The DC account provides more leverage to explore the system from a cognitive perspective through the five models of DiCoT. This integrates the social, information flow, artefacts, physical and evolutionary aspects in a computational way. The RE account looks at the adaptations, variances and functional couplings that were recognised as important in the system. The concepts of these theoretical seem almost incommensurable, and it is expected that joining the two views could prove quite confusing.

In terms of their individual contribution: 1) the PMO model adds rhetorical power by extending the downstream metaphor and recognising five contextual factors that influence the downstream utility of projects (see Table 6.7); 2) the DC account elaborates on the abstract project information flow of the PMO model in Figure 9.3 and recognises different complex computational influences on the system in Figure 9.4; the RE account recognises different details couched in RE themes and the FRAM network elaborates further on the project flow of the DC account. This is where the FRAM network really shows strength for the purposes of our analysis and representation, i.e. it allows one to include functional elements of the system that are distant in time and space from the actual project flow. For example, reputation has a functional influence that is built up through many projects, and method and tool development has a functional influence which may take years of development. This development of the models shows how one is built on the other, and how each offers something different in a different way and so the models do not directly subsume each other. However, if pushed, the FRAM network can be considered the model that supersedes the other two because it is the most developed, and has the semantics to handle the disparate functional resonances that have been recognised as important in our analysis.

From the more developed RE position weaknesses in the other accounts seem to become more apparent. For example, the PMO model is supportive of the more simplistic domino model account although the landscape adds complexity that is not captured by such models. Also, the DC account is much more static and structural and so has a hard time accounting for the system variances, adaptations and disparate functional resonances that the RE account is suited to. A case in point is the plug and play metaphor of the HF/usability component from the DC account and the positive resonances from the RE account. The plug and play metaphor captures how the HF/usability component adapts to fit the client's project and client's context. Here 'fit' suggests an adaptation that remains stable once it has configured itself. Resonances provide more fluidity in the system as functional couplings can reciprocally affect each other, have system feedback and cycles of reinforcement. Plug and play also seems bounded to a project or client whereas resonances allow for functional influences beyond the time and place of single projects and clients, and allows the specification of more functional detail in the FRAM network.

Abstracting across the Distributed Cognition and Resilience Engineering analyses described in this thesis we believe it is important to consider factors that influence the performance of the system that are not limited by a particular perspective. The complex cognitive systems view from Distributed Cognition is 'complex' because it tries to account for diverse factors, and the non-linear functional couplings in the Resilience Engineering view does similar by accounting for effects from a holistic perspective. The former perspective talks about computations, and the latter perspective talks about functional couplings, both of which seek to comment on the performance of the system from systemic perspectives. We have dubbed these sorts of analyses 'inhomogeneous functional analyses' because they involve theoretically different functions (i.e. not homogeneous) that interact and have a functional influence on the performance of the system. Drawing distinction between the two perspectives, Distributed Cognition appears to be more concerned with structures in the environment (e.g. the structure of tools, artefacts and room layouts) rather than Resilience Engineering whose FRAM network for example does not focus on structure but has more emphasis on the variances, demands and adaptations of a system. Abstracting across these inhomogeneous functional analyses in this way could lead to the further development of approaches to holistic system analysis of complex socio-technical systems. We believe more work could be done on documenting case studies of these methods, comparing and developing them, and making them more accessible to other researchers and practitioners. This is an endeavour to have better modelling capability of non-linear features that influence socio-technical system performance.

The DC and RE accounts have been built on the interview data gathered and analysed through the grounded theory process. This has had implications for the development of both accounts. One limitation is that the interview data was collected prior to the use of these frameworks. If we had started the research with these sorts of analysis in mind we might have considered other questions to ask interviewees and other forms of data gathering. For example, it is more typical in DC studies to observe people working in context, with artefacts and other resources. Our interview data has been used to abstract across different patterns of behaviour in practice rather than doing similar through observations. Observations were considered as part of the study, but HF/usability practices did not appear to have a lot of easily observable activity, i.e. there did not appear to be a lot of team work, talking, and the passing of artefacts between people. This does not rule out future studies attempting to do observational work, or more active action research approaches. Indeed, it may even be useful to do specific studies of the artefacts that HF/usability practitioners produce and use like their reports and tools; however, this was not the focus of this study.

The validation efforts of Chapter 12 have largely focused on the FRAM network rather than the DC account. A similar activity was considered for the DC account but pragmatic considerations favoured a focus on FRAM. It was thought unreasonable to ask practitioners devote their time to reviewing both as this requires considerable effort, DC would be hard to translate away from its jargon, and the FRAM network was seen to supersede the DC account. More focussed studies on DC related aspects of HF/usability practice, e.g. a closer focus on artefacts, would complement the work in this thesis.

13.3 Specific implications

We draw out specific implications from this thesis for both research and practice, although this should not detract from the new conceptions of HF/usability practice and the methodological developments and reflections described above. This view shares the same sentiments as Dourish's (2006) comment on how ethnographic work can be done an injustice if it is only valued for its design implications when it offers much more in terms of rich accounts of contexts and behaviours.

13.3.1 Research

This section suggests implications for the research community.

13.3.1.1 Development of new methods

Methods should be developed to exploit functional couplings that maximise the positive resonance between HF/usability practice and project work. For example, methods could be developed to facilitate building rapport with the client, easier documentation, and faster reporting times. Developing methods could also try to avoid heavy notation, expensive specialist tools, which might dampen their uptake and performance. As an example Molich (Redish et al., 2002) briefly introduces the KJ method; this involves developers in usability testing which promotes buy-in and gives them immediately available results. Furthermore, if we took a context that has specific requirements, like the speed of feedback needed in agile software system contexts, we might be able to design methods that positively resonate with that context's requirements, thereby designing methods for specific contexts of use.

13.3.1.2 Reporting of methods

When reporting methods it is recommended that the 'golden path' is supplemented with how the method can be utilised in the realities of practice. This might include pointing out light-weight and intensive versions, different advice to novices and experts, potential pitfalls, how to speed up the process, and synergies with reporting practices and in persuading clients. These ideas could be developed further to see what dimensions should be accounted for in a template for reporting methods, and to test how effective these may be in communicating the potentials of the method. This should help practitioners adopt and adapt methods.

13.3.2 Practice

This section hopes to inspire new focuses and new ways to conceptualise practitioner work to encourage reflections which might lead to the development of practice.

13.3.2.1 Non-linear functional factors of methods

This research has emphasised the non-linear functional factors of methods. This means that attention should be given to the performance of the method within the system of HF/usability practice rather than solely looking at its potential to provide insight into the problem. This may mean using methods that practitioners are well versed in to encourage the effectiveness and efficiency of the work. It may also mean trying to get clients to watch usability testing to encourage buy-in to the issues and to allow more interaction with clients to develop a relationship with them. It may also mean involving specialist tools (e.g. eye-tracking, 3D modelling and simulators) to impress clients and differentiate HF/usability practice offerings. Persuasive evidence in terms of video edits and quotations from actual users, and statistics and graphs will also play their role in influencing decision makers in different contexts. We recommend consideration of non-linear functional effects of methods.

13.3.2.2 A battle for hearts and minds

The wider focus on HF/usability work in this research has highlighted the importance of the relationship and integration with clients. In many of these interactions there is a battle for hearts and minds. By this we mean that clients do not just have to understand the issues (a battle for minds) but also buy-in and appreciate the importance of making changes (a battle for hearts). Along these lines some practitioners would get clients to watch user testing where possible; create ‘pretty reports’; collect evidence for known issues, target recommendations in ways receptive to clients, e.g. tell accountants how much money they can save rather than how it improves usability; and choose clients to whom recommendations might be most significant e.g. tell the customer service manager how to improve the customer experience rather than telling developers the same thing. It is important to consider the battle for hearts and minds to improve the downstream utility of HF/usability work.

13.4 Other further work

Further to the suggested future work highlighted in the sections above, Chapter 7 identified four interesting loose ends which could be developed. The first was the idea that there are different classes of problem that HF/usability practitioners engage e.g. changing colours to business propositions, adjusting seating to organisational change, etc. The second involved ideas like tacit contributions, transitional systems and change agents which see the HF/usability practitioner performing a role which they may not be fully aware of. The third touched on the role of emotion in HF/usability practice work, e.g. managing the emotional journeys of clients, creating ‘pretty’ reports, and ‘opening’ up users to get good quality feedback. The fourth looked at the similarities between community acceptance in HF/usability practice work and academia to maintain standards in complex and uncertain domains. These four areas would benefit from more research attention to lead to the better understanding of HF/usability practice.

13.5 Conclusion

To investigate the opportunities and barriers of methods in HCI practice this thesis has engaged with practitioners’ perspectives. A need for understanding methods in a system of HF/usability practice was recognised. This was developed in inductive and deductive qualitative analyses. We argue that methods should be understood in terms of how they functionally resonate with different parts of the HF/usability system. Here, we move from theories of methods’ capabilities to find problems, and from theories of why methods fail to transfer from academia to industry, to theory of method use within a system of HF/usability performance. Here, critical functional couplings between methods and the context in which they are used should be recognised and exploited to maximise performance.

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Appendices

Appendix A1: Summaries of each interview

This section details a summary of each of the 13 interviews from the safety-critical system development domain described in Chapter 6. These summaries are listed in Table A1.1. Each summary provides the most important points that were covered in each of the interviews. It is perhaps telling of the representation that it is not in an easily digestible form but leaves the reader with a lot of work in terms of bringing the different summaries together to form a general picture or message. However, an advantage of this representation is that it provides insight into each individual interview and allows some engagement with the breadth and differences in the data rather than presenting a more aggregated view.

To further aid engagement with this representation it would be worth looking at the cultural differences between interview 1 and 2, whereby the former is from a design context and the latter from an independent research agency which has interesting implications on their role in design and their communication practices. Also, by way of introduction I have highlighted some themes which can be traced to their respective interviews. The themes listed below, can be found next to corresponding interview summaries in Table A1.1, these indicate where these points of interest are more apparent:

- **Distance**: Different practices can work closely with, or be more independent from, design.
- **Communication**: Communication can happen in different forms, e.g. wordy reports, pictures and meetings. Communication should be the right message, to the right person, in the right way.
- **Capability**: There seems to be a pattern of supply and demand. The former being HF capability, the latter being the client need. From the HF side capability management is very important.
- **Tools**: Tools can play a key role in inhibiting and enhancing capability.
- **Porblem**: There are different types of HF problem, and the detail of each context is very important to consider.
- **People**: People, and the relationships in the practice matter, e.g. personal preference, style, understanding, personalities, reputation and rapport.

- **Audit**: More senior HF practitioners, and HF practitioners from other companies, will check the work of others to make sure it is of an acceptable standard.
- **Client power**: Clients hold the power. Meeting their needs is almost the *raison d'être*.
- **Environment**: Behaviour at a local level can be influenced and shaped by the environment, e.g. ideal solutions are often traded-off to make more streamlined and pragmatic solutions.
- **Methods**: Methods are not used for the sake of it, they are orientated to solve the client's need. Practitioners have a repertoire of methods, which can evolve over time. Proven and well practiced methods are easier to sell, easier to apply and more predictable for the client and practitioner.

Table A1.1: Summary of each interview.

Summary of interview	Bullet code
Respondent S1 Here design solutions were driven through iterations with input from people with knowledge of the products and working practices, rather than the specific identification of safety issues through evaluative methods. Much of the communication is captured in design drawings and so documentation is in pictures and notes rather than wordy reports. Even though they work in-house they still have to sell their ideas and services, and face the same issues of not being involved or being involved too late that out-house people face. The design-solution focus forces them to engage with the real trade-offs. They apply patterns through analogical reasoning to aid the design process, i.e. they are familiar with reoccurring issues which inform designs.	Distance Communication Environment
Respondent S2 This contrasted with solution focussed consultancies in that it was quite formal, independent and research driven. Rather than taking a design orientation the work appeared to be very evaluative, a lot of it taking the form of controlled experiments where safety could be independently evaluated. Reports were written in a similar way to research reports that you might find in academia. Written communication seemed to dominate client contact so an audit trail was maintained and misunderstandings reduced. The rigor of their research and independent status characterise the company's offering. Often they do not know what happens to their results and subsequent designs as they are detached from the process. Expert panels and discussion groups were recognised as useful methods for tapping into domain expertise.	Distance Communication Environment
Respondent S3 This consultancy practice was involved in the evaluation and design of safety systems from a human factors perspective. To maximise performance there was a focus on bidding for work which they could show expertise in, i.e. where they already had experience of the method, project or client. It was apparent that safety behaviour had links with usability behaviour, i.e. people's behaviour at a local level is influenced by a wide array of factors, including the culture they are in, so methods are not solely chosen on their intrinsic characteristics but on extrinsic factors as well. For example, it was thought that some popular methods, like Task Analysis, also functioned as hooks for the client as they would have heard of them and expect them to be used. Redundancy (in practitioner overlap) was also important in evaluations, so one practitioner could cross-reference and error-check their opinions with another.	Audit Environment Methods

Summary of interview	Bullet code
Respondent S4 This interview covered an overview of the design of a major emergency control room. The respondent was an engineer rather than a HF practitioner involved in the design process and the control room's ongoing activity. The design process stretched over a number of years, it involved analysing the old control room, numerous iterations with stakeholder input, and full size cardboard mock-ups with operators testing it through scenarios and giving their feedback. They also contracted an alarms expert from a university in a separate project to help redesign an alarm system. It is of interest to note how individuals or companies can be invited into a project and to see what influence they have in providing expertise, both in the process and the content of the work.	Capability
Respondent S5 There are different levels of problems that people engage with. It should not be assumed that these are part of a design cycle, the client may have a problem that they need help with. Only simple and closed problems err on the side of straightforward method application. More complex problems need real engagement with the problem, the context, the people, and the details. You need to engage with the detail because the devil is in the detail, consequently you need to talk to people that have knowledge of this detail – you need to get 'down in the weeds'. To be a good practitioner you need to be smart, you need to engage with the details, and it must be apparent that you're really interested in helping out. Choosing methods is not really a problem, it is having a sufficient understanding of the problem. Science is at least in part about backing up your claims so you should not over claim and you need to engage with the actual detail of the context to make claims sensibly. Clients are often not interested in the science, they just want the problem to be solved.	Communication Problem People Method
Respondent S6 Project work often involves the coming together of different people with different expertise. HF is perceived as a 'bolt-on'. The respondent has a graphic design background, and progressed into HF through signage projects, building on previous skills and knowledge. The respondent knows when not to design as she appreciates the designer's role, similarly you need to know where other roles stop and start. Project managers should perhaps be educated on the role of HF, so HF is not involved too late. Support from colleagues in discussing ideas and helpful emails are important, this can save time and performs an error checking function. Practical multidisciplinary work experience could be a benefit at university. You can learn the science of methods, but the detail of employing these in practice makes application a challenge. HF practitioners have different styles, favourite methods and domains of expertise. It remains uncertain whether these people shape projects in their way, or whether they gravitate toward those problems that suit them. Iterations and real operator/user input is important – this always has the potential to enlighten intuitions.	People Audit
Respondent S7 Analysis may be restricted by the design stage, i.e. if it is in its early stages feedback may have to be at a high level. Communicating to the client is very important. It is not good practice just to report errors. The respondent will often propose potential redesigns to suggest what is required. Visuals are often a good communication tool as a picture or diagram paints a thousand words and people want to avoid a weighty report. A weighty report will often be desired from an auditing perspective. In some safety projects HF practitioners will check the quality of each other's work between companies in the process. Bureaucracy in this process can be frustrating, particularly when details in the report appear to have been overlooked. Tool support is important to practitioners, e.g. it can greatly influence time in drawing diagrams and videos can be awful to edit – this can impact method choice, communication choice, times and budgets. Clients may have to involve HF in some industries because it is written in their procedures. Good HF practice developed in one industry may be carried over to another by practitioners transferring best practice. It would be good if academia could do more in the way of tool support.	Communication Tools Audit

Summary of interview	Bullet code
Respondent S8 Quality control is important. Repeat business provides a large proportion of work so keeping clients happy is paramount. Big differences between academia and consultancy include speed, commercial pressures, and sociability – this softer side of consultancy is important. There is a clear career progression within the company, with senior members providing support and checking the quality of more junior members. In communicating work one should be aware that different people are interested in different things; for example engineers might be looking for the solution in the project output, whereas other HF practitioners might be checking methods and processes have been executed well. It is important to scope your work and claims, and have a common understanding of the deliverables between the client and service provider. Tools are useful, some are developed in-house. They will use multiple sources to test and validate claims when they can, e.g. use simulator after an expert review, and get client feedback. There are trust issues and the community acceptance of research work like in academia (with more senior members judging the quality of work); you need to have a good reputation as a company and practitioner, and be able to defend that you have robust results through good work and processes.	Communication Tools People Audit
Respondent S9 Practitioners are extremely busy covering a broad range of topics, including engaging with different topics in the same day. He estimated that two or three academic work years equalled one consultancy year in terms of coverage of work topics. Human factors practitioners are like specialised project components that have to recognise, gather, analyse, interpret and then filter the right information in terms of the goals of the project. All methods have pros and cons, and your work is governed by the context. You should do the best reasoning, data processing and evidence gathering that you can in light of this context. You never start off completely new, you can look at old reports, use prior experience, and ask the office. Different people have different ways of thinking, and what seems obvious from a human factors view might not be so obvious to someone else with a different interest and background.	Methods
Respondent S10 The client is at the top of the food chain and so they will choose the work that can and cannot be done. The client is offered work packages to choose from. The respondent was experienced and so work packages for different types of projects sprang to mind easily. Gold standard projects could give the practitioner freedom to do what they wished but these are very rare; these might be motivated by client PR for example. Speaking to the right person in the right way is extremely important to affect work. People will not listen to things they are not interested in. Language also has to be couched in the clients' terms rather than HF jargon. Industries are different in the language they use and the way they work. Tools must be simple, quick and cheap. Tools can reduce analysis time considerably when they work well. Academia could go further in developing tools. Academia produces interesting work, but unless it specifically answers a client problem or need it is hard to see how it might transfer – clients are interested in solving their problems and not in HF interests per se. There could be more dialogue between academia and industry.	Communication Tools Client power Methods
Respondent S11 There is an interplay between the technical side and 'softer side' of usability practice to work successfully, e.g. personal relations and politics. Sometimes clients assess you, for example by checking to see if you know certain people, before they will take you seriously. The reputation of, and trust in, the practitioner is very important and this must be maintained through doing good professional work that is on time. People have different perspectives and these can be employed at opportune times, e.g. getting an expert engineering perspective on a problem can prove enlightening. There may only be a feeling of uneasiness about a potential problem, until it is articulated and becomes obvious. Sometimes independent reports are used for political weight behind otherwise unheard internal voices. Ideas can have inertia because they reach a threshold of	Communication Problem People

Summary of interview	Bullet code
acceptance and then people fail to question them – this can go as far as claiming to use models that do not logically support the results. Academics sometimes stop at publishing work, but could have a role to play in pushing and marketing their ideas if they want them to be more widely accepted. It is believed that the experience of practice orientates a more rule-based and modular organisation of knowledge which is instilled at university, into a more solution driven and strategic organisation of knowledge – so it better adapts to the problems that practitioners commonly face.	
Respondent S12 Human Factors is multi-disciplinary and bridges different areas of expertise, e.g. psychology, physiology, and modelling. Capabilities need to be managed so the business can perform successfully. Recent budgetary pressures have led to a more consultancy based style of working where the delivery to the customer is the focus. This means that the company's offering has to be streamlined and competitive within the market place, which can lead to less freedom in experimenting with methods, practices and research. There is a sense that you should play to your strengths so the company does the sort of work that it knows it can do, and can do well, through experience. Methods are influenced by context-shaping factors like what is technically appropriate, what the practitioner is used to, the amount of time permitted, and access to users. Outcomes have caveats where an ideal research process has been balanced with the realities of the work. Depth exists in individual expertise in methods and domain knowledge, and there is also breadth so support can be given elsewhere. Organisational expertise exists in reports and team work. Staff develop through increasing levels of complexity in their work and increasing responsibility. Personality is important for client facing roles carried out at more senior levels, because it is people that give you work and repeat business. You have to negotiate specific objectives for projects, particularly where the client is unclear what they want; and then give the client guidance in how to exploit the outcomes of the work. The best way to communicate value is to do the work and do it well. Human Factors has challenges in being involved earlier in projects, and in communicating what it does. Perhaps more standardisation in methodologies could help.	Capability Problem People Client power Environment Methods
Respondent S13 This work is more on cognitive performance enhancement than safety per se. The company has made a transition to a consultancy model, so there is less pure research taking place, and work is focused much more on solving client problems. Clients are not interested in the details of HF, they want to understand what's important to them and they want to be able to exploit what they are told so there is a clear transfer of value. Something like 3D modelling can be a good communication tool as it can impress, hold attention and be talked around. Ideal research situations have to be traded off with the realities of consulting constraints. Ideally you would have a team of close working people, covering the relevant areas of expertise needed for the design, regularly talking to each other and sharing their ideas and concerns. It is better to have overlap in projects, where work is discussed, understood and integrated than to send off a report to someone that you might not even meet. The project depends on the people in charge of shaping the project – clients may bolt HF on at the end, or it may be an integral part. Personal relations and valued contributions are important for building work and keeping clients coming back. In projects you start with the issue to be addressed and then employ appropriate data gathering and analysis tools, these parts of the project are carefully costed in. There are hundreds of methods to choose from. You do not use a method for the sake of it, you need streamlined projects that solve the clients issues to win bids. Experience builds templates that signify what is appropriate, what works well, what does not, etc. Good methods and tools are added to the repertoire a practitioner uses. It is important to realise that no two projects are the same because part of the context always differs, so reusing work can detract from the nuances of the situation – there is not such a thing as a 'handle turning project'.	Capability Tools People Environment Methods

Appendix A2: A view of the Code Network: Open and Axial Coding

This is a view of the code network that was developed from the grounded theory of human factors practice in the safety-critical system development domain (summarised in Chapter 6). It first contains a visual representation of the network diagram and then a description of each of the codes. Table A2.1 shows these codes, how grounded they are; how dense they are; the spread of respondents that mentioned this code (there were 13 respondents in total) and the codes that they link to. The codes highlighted in grey were described more fully because they were either highly grounded, dense or subjectively selected to enhance the picture of the code network presented in Chapter 6.

Table A2.1: Table to show individual codes, groundedness, spread, density and code neighbours (their links).

No.	Name	Grounded	Density	Spread	Code neighbours
1	Analysis, research, and experimentation	24	2	10	Systematic, method
2	Assurance	14	6	6	Audit, capability, client need, reputation, stringency, usability vs safety
3	Audit	11	7	6	Report and Documentation, Reputation, Assurance, Quality, Redundancy in people, Regulations and Regulator, Validation
4	Audit trail	12	3	5	Report and Documentation, Similarity with academia, Regulations and Regulator
5	Bidding	11	5	8	Client negotiation, Project design phase, Resource constraint, Selling, Window of opportunity
6	Capability	33	6	12	Motivation, Selling, Assurance, Client need, Practitioner skills, Tool
7	Career development	16	4	7	Practitioner experience, HF to admin, business, management, Process, Support and mentoring
8	Client contacts	4	3	4	Other groups, Perspective and perception, Redundancy in people
9	Client need	54	10	12	Capability, Decision and negotiation, Perspective and perception, Problems: closed, open, simple, complex, Assurance, It depends... , Motivation, Relationship, Validation, Window of opportunity
10	Client negotiation	11	4	5	Bidding, Project design phase, Window of opportunity, Decision and negotiation

No.	Name	Grounded	Density	Spread	Code neighbours
11	Closeness	22	7	9	Method, Rapport, Relationship, UCD iterations, HF organisation, Prejudices, Validation
12	Comments on academia	38	0	8	
13	Communication	36	7	12	Feedforward, HF organisation, Language, Method, Recommendations, Selling, Report and Documentation
14	Company organisation	9	1	6	HF organisation
15	Consultancy vs researchy	7	0	4	
16	DC	29	2	12	External knowledge, Internal knowledge
17	Decision and negotiation	11	7	4	Client negotiation, Client need, Feedforward, Other groups, Priority, Resource constraint, Systematic
18	Def of HF	13	1	6	Language
19	Design evolution	21	2	5	Early, middle, late, all., Process
20	Designy	21	1	7	Usability vs safety
21	Domain experts	24	5	10	In the trenches, Meeting, presentation, discussion, Method - workload, Rapport, Variety
22	Domain Industry	14	1	10	Variety
23	Early, middle, late, all	36	4	12	Method, Project output, Design evolution, Method - scenarios
24	Expertise and background	22	3	7	Perspective and perception, Other groups, Reputation
25	External knowledge	21	8	10	DC, Knowledge sharing, Method, Method - checklists, Method - guidance, Templates, Report and Documentation, Standards
26	Feedforward	58	11	12	Decision and negotiation, Scope claims, Communication, Motivation, Priority, Project output, Quality, Rapport, Recommendations, Report and Documentation, Resource constraint
27	Frustration	4	3	2	Prejudices, Rapport, Motivation
28	HF organisation	43	9	12	Closeness, Company organisation, Communication, Process, Project design phase, Project length, Project roles, Resource constraint, Scope of development
29	HF to admin, business, management	14	3	8	Career development, Practitioner experience, Selling

No.	Name	Grounded	Density	Spread	Code neighbours
30	In the trenches	29	5	10	Domain experts, Internal knowledge, Method, Method - scenarios, Validation
31	Internal knowledge	17	7	9	DC, Knowledge sharing, Practitioner experience, Practitioner skills, Templates, In the trenches, Succession and Repeat business
32	It depends...	49	6	11	Client need, Method, Perspective and perception, Reflective practice, Report and Documentation, Variety
33	Job title	2	0	2	
34	Knowledge sharing	7	2	6	External knowledge, Internal knowledge
35	Lab vs Real world	2	2	2	Method, Validation
36	Language	18	3	9	Def of HF, Perspective and perception, Communication
37	Learning	26	4	10	Process, Reflective practice, Support and mentoring, Templates
38	Literature review	6	3	6	Method, Method - survey, Similarity with academia
39	Meeting, presentation, discussion	26	4	11	Domain experts, Method - workshop, Other groups, Project output
40	Method	0	64	0	Analysis, research, and experimentation, Closeness, Communication, Early, middle, late, all. , External knowledge, In the trenches, It depends..., Lab vs Real world, Literature review, Method - accident data, , Method advice, Practitioner experience, Practitioner skills, Pragmatics, Prejudices, Problems: closed, open, simple, complex, Process, Project design phase, Qualitative and quantitative, Recommendations, Report and Documentation, Reputation, Resource constraint, Risk and Predictability, Selling, Standards, Stringency, Tool, Validation [plus all 'method – X's]
41	Method - accident data	1	1	1	Method
42	Method - checklists	12	2	7	Method, External knowledge
43	Method - contextual inquiry	3	2	3	Method, Method - observation
44	Method - ethnography	2	1	2	Method
45	Method - expert review	4	2	1	Method, Perspective and perception
46	Method - fault tree analysis	2	2	2	Method, Method - talking

No.	Name	Grounded	Density	Spread	Code neighbours
47	Method - feedback	3	1	1	Method
48	Method - field studies	5	1	3	Method
49	Method - focus groups	1	1	1	Method
50	Method - goal structuring notation	3	1	1	Method
51	Method - GOMS	1	1	1	Method
52	Method - guidance	10	2	6	Method, External knowledge
53	Method - hazard analysis	2	1	2	Method
54	Method - HAZOP	1	1	1	Method
55	Method - human error identification	9	2	5	Method, Method - task analysis
56	Method - interviews	11	1	6	Method
57	Method - link analysis	1	1	1	Method
58	Method - modelling	5	1	4	Method
59	Method - observation	6	2	4	Method, Method - contextual inquiry
60	Method - prototype	14	1	6	Method
61	Method - questionnaire	7	1	3	Method
62	Method - risk assessment	3	2	2	Method, Qualitative and quantitative
63	Method - root cause analysis	2	2	2	Method, Method - talking
64	Method - scenarios	2	3	1	Early, middle, late, all. , In the trenches, Method
65	Method - simulator	2	2	1	Method, Method - user testing
66	Method - social network analysis	1	1	1	Method
67	Method - static story boards	1	1	1	Method
68	Method - survey	9	2	4	Literature review, Method
69	Method - talking	8	3	4	Method, Method - fault tree analysis, Method - root cause analysis
70	Method - task analysis	17	2	9	Method, Method - human error identification
71	Method - user testing	13	3	6	Method, Method - simulator, Prejudices
72	Method - video	2	1	2	Method

No.	Name	Grounded	Density	Spread	Code neighbours
73	Method - wireframe	1	1	1	Method
74	Method - workload	10	2	3	Domain experts, Method
75	Method - workplace assessment	1	1	1	Method
76	Method - workshop	6	3	3	Meeting, presentation, discussion, Method, Relationship
77	Method advice	18	2	9	Method, Tool
78	Motivation	35	8	11	Client need, Feedforward, Frustration, Prejudices, Regulations and Regulator, Reputation, Capability, Politics
79	My PhD	14	0	6	
80	Other groups	16	7	9	Decision and negotiation, Expertise and background, Meeting, presentation, discussion, Perspective and perception, Project roles, Client contacts, Politics
81	Perspective and perception	23	8	10	Method - expert review, Client contacts, Client need, Expertise and background, It depends... , Language, Other groups, Problems: closed, open, simple, complex
82	Politics	14	4	8	Motivation, Other groups, Power, Prejudices
83	Power	14	4	7	Window of opportunity, Politics, Rapport, Resource constraint
84	Practitioner experience	14	5	8	Method, Variety, Career development, HF to admin, business, management, Internal knowledge
85	Practitioner skills	21	4	9	Capability, Method, Rapport, Internal knowledge
86	Pragmatics	12	4	7	Method, Priority, Resource constraint, Reflective practice
87	Prejudices	21	8	9	Closeness, Method, Method - user testing, Reputation, Validation, Frustration, Motivation, Politiics
88	Priority	6	6	3	Decision and negotiation, Feedforward, Project output, Recommendations, Pragmatics, Resource constraint
89	Problems: closed, open, simple, complex	30	4	10	Method, Perspective and perception, Project output, Client need
90	Process	19	5	6	Career development, HF organisation, Method, Design evolution, Learning
91	Project design phase	23	5	10	Bidding, HF organisation, Method, Client negotiation, Selling
92	Project length	1	1	1	HF organisation

No.	Name	Grounded	Density	Spread	Code neighbours
93	Project output	29	7	12	Feedforward, Meeting, presentation, discussion, Recommendations, Report and Documentation, Early, middle, late, all. , Priority, Problems: closed, open, simple, complex
94	Project roles	33	3	11	HF organisation, Relationship, Other groups
95	Qualitative	3	1	2	Qualitative and quantitative
96	Qualitative and quantitative	8	3	4	Method, Method – risk assessment, Qualitative
97	Quality	22	4	9	Audit, Feedforward, Stringency, Validation
98	Quantitative use, and validity	11	0	7	
99	Rapport	10	7	6	Domain experts, Feedforward, Power, Selling, Closeness, Frustration, Practitioner skills
100	Recommendations	17	7	8	Feedforward, Method, Scope claims, Validation, Communication, Priority, Project output
101	Redundancy in people	18	4	6	Audit, Client contacts, Support and mentoring, Validation
102	Reflective practice	9	4	5	It depends… , Pragmatics, Learning, Tool
103	Regulations and Regulator	13	6	5	Audit, Audit trail, Risk and Predictability, Safety culture, Motivation, Report and Documentation
104	Relationship	24	6	9	Client need, Method – workshop, Scope of development, Closeness, Project roles, Succession and Repeat business
105	Report and Documentation	37	10	12	Communication, External knowledge, Feedforward, It depends… , Method, Regulations and Regulator, Audit, Audit trail, Project output, Validation
106	Reputation	13	9	7	Expertise and background, Method, Succession and Repeat business, Assurance, Audit, Motivation, Prejudices, Risk and Predictability, Selling
107	Requirements	6	0	5	
108	Resource constraint	64	11	13	Bidding, Decision and negotiation, Feedforward, HF organisation, Method, Power, Priority, Scope of development, Pragmatics, Risk and Predictability, Validation
109	Risk and Predictability	10	7	7	Method, Reputation, Resource constraint, Stringency, Window of opportunity, Regulations and Regulator, Validation
110	Safety culture	8	2	4	Regulations and Regulator, Standards

No.	Name	Grounded	Density	Spread	Code neighbours
111	Scope claims	9	3	6	Feedforward, Recommendations, Validation
112	Scope of development	7	3	5	HF organisation, Relationship, Resource constraint
113	Selling	16	10	9	Bidding, Method, Project design phase, Reputation, Succession and Repeat business, Window of opportunity, Capability, Communication, HF to admin, business, management, Rapport
114	Similarity with academia	13	2	9	Literature review, Audit trail
115	Standards	27	3	11	External knowledge, Method, Safety culture
116	Stringency	31	4	9	Method, Assurance, Quality, Risk and Predictability
117	Succession and Repeat business	16	5	10	Internal knowledge, Relationship, Window of opportunity, Reputation, Selling
118	Support and mentoring	7	3	4	Career development, Redundancy in people, Learning
119	Systematic	1	2	1	Decision and negotiation, Analysis, research, and experimentation
120	Templates	8	3	6	External knowledge, Internal knowledge, Learning
121	Tool	20	4	6	Capability, Method, Method advice, Reflective practice
122	Type of clients	2	0	2	
123	Type of consultancy, service	9	0	6	
124	UCD iterations	9	1	4	Closeness
125	Usability vs safety	5	2	4	Assurance, Designy
126	Validation	16	14	7	Audit, Client need, Closeness, In the trenches, Lab vs Real world, Method, Quality, Redundancy in people, Report and Documentation, Resource constraint, Risk and Predictability, Scope claims, Prejudices, Recommendations
127	Variety	14	4	8	Domain experts, Domain Industry, It depends... , Practitioner experience
128	Window of opportunity	1	7	1	Bidding, Client need, Client negotiation, Power, Risk and Predictability, Selling, Succession and Repeat business

Network diagram

The network diagram in Figure A2.1 shows that the codes are heavily interrelated. The ‘method’ code is a focal point but this is slightly artificial as it links with all the individual method codes that were mentioned in the interviews.

Code descriptions

This section contains a description of the 128 codes that were derived in the grounded analysis. Codes that were either highly grounded (i.e. they had lots of quotations in the data), codes which were dense (i.e. they had lots of links to other codes), and a selection of other codes have been described more fully. The rest, apart from the individual methods which do not add a lot to our overview of HF system, have been given limited attention for the sake of brevity, in which is already a large section. The superscript numbers refer to the number of the codes when placed in alphabetical order e.g. ‘method’ is 40th in the list. This numbering is to aid referencing between different code descriptions, as the codes are explained in the web of codes around them.

1. **Analysis, research, and experimentation**

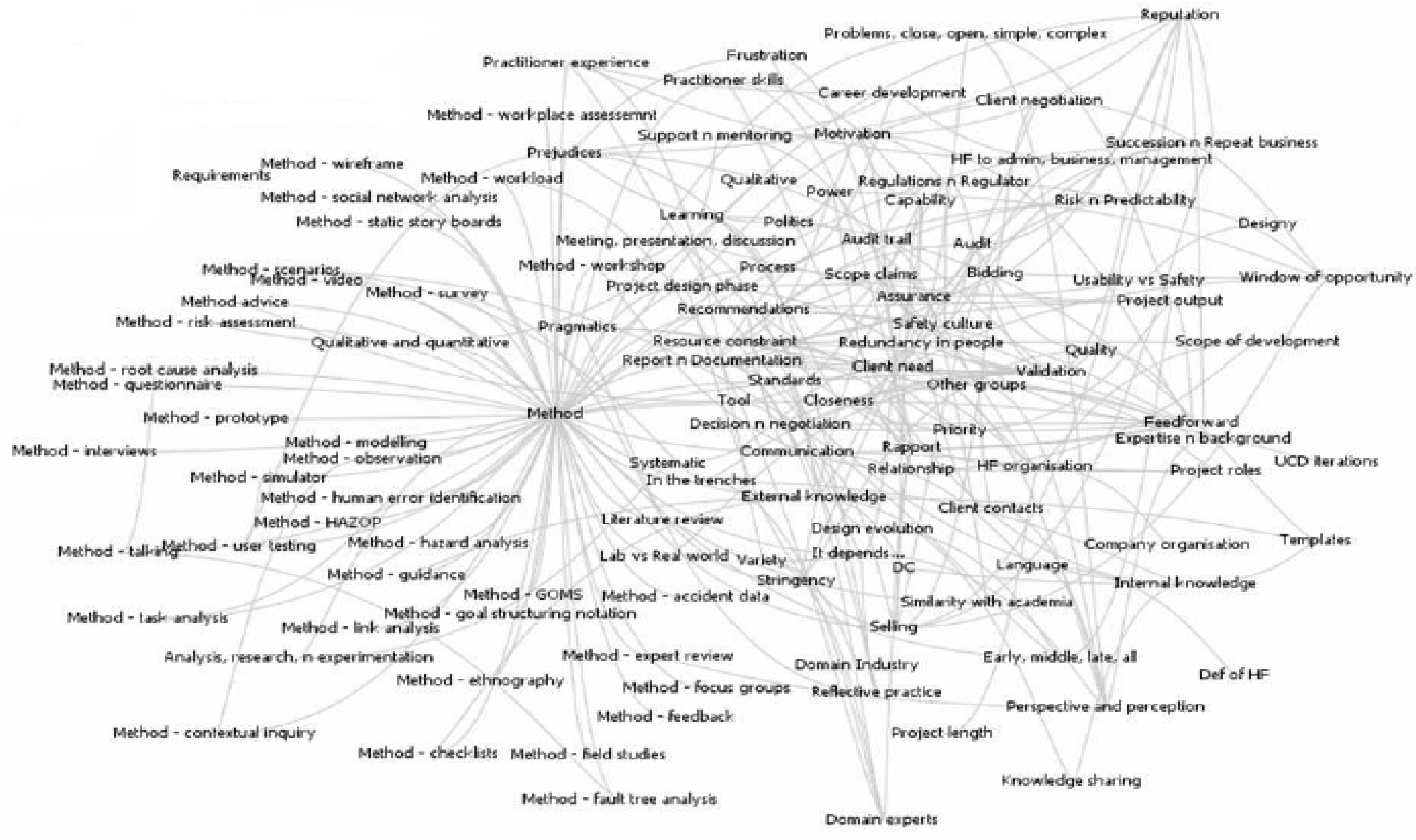
This code was borne out of the fact that some human factors (HF) projects do not involve specific HF methods[40] but can be more generally conceived as analysis, research and experimentation. For example, a client’s need[9] might require a practitioner to come in and view operations on a ship as they may have problems with a new piece of kit, or it might require a practitioner to sort through accident reports to find patterns, or it might entail setting up an experiment to identifying the most suitable product for a task from a selection.

Each method has advantage and disadvantages, and it is up to the practitioner to know which should be chosen and why. The aim should be to get at the right information in the right way.

Depending[32] on the sort of research project that is being carried out it may be more or less systematic[119], the less systematic might entail an exploratory study, adapting to what is found, taking photos, measurements, interviews in a workplace, and creating designs to get feedback from; the more systematic might entail setting an agreed criteria for making a decision and having a formal process to go through to make that decision.

Methods[40] are an important part to analysis but there is a lot of analysis that goes on outside of methods. For example, negotiating what the project should be with the client[10] will entail trying to understand what issue they are dealing with and how to best go about helping them[91]; and a practitioner may think things through and doodle on a pad to help themselves try to understand a situation.

Figure A2.1: Complete code network of 128 codes



2. Assurance

Clients will want[9] assurance that the work has been done competently and that the recommendations and claims can be trusted. This might include auditing[3] the company to check their processes are adequate, and having an audit trail[4] in terms of the methods that were used and how the recommendations were derived.

HF practice should have the capability[6] in terms of expertise and experience[24] to deal with the issues they aim to address. Some assurance will be given by the reputation[106] of the HF practice and practitioners, but work will have to be stringent[116] and of good quality[97] for this reputation to be maintained and improved. This will impact repeat business[117].

Clients may need more assurance in some cases than in others. For example a high safety risk[109] may need more than a low usability issue[125]. Practitioners are wary about properly scoping their claims[111] so a system may only be deemed acceptable as far as the tests have shown e.g. testing the workload of a train driver does not make driving the train safe. Safety claims should be made with caution.

3. Audit

Auditing refers to the checking of the quality[97] of a process[90], performance or work. It is to provide assurance[2] that standards have been met. Auditing the quality[97] of work has potential to impact on a practitioner's or a company's reputation[106].

Internally, staff performance may be monitored which may affect career development[7], etc. Externally, client satisfaction may be monitored; some practices do this explicitly through surveys[68] others are satisfied with implicit monitoring of how projects have gone and whether there is repeat business[117].

In safety cases there will be a redundancy in HF knowledgeable practitioners[101] to check on each others' work: that the right things have been done, that they have been done well, and the right recommendations made. They can check how the project was carried out as they share this knowledge.

Work can also be audited during the project, for example, in methods like HAZOP[54] domain experts[21] will review a task or process and they will raise concerns if they are not satisfied that it is safe. Different domain experts[21] are involved in HAZOPs to check the system from different perspectives[81].

There is a relation to closeness[11] in auditing. If a person lacks a particular knowledge base they will not understand what is going on and cannot judge the quality[97] of it. HF practitioners want the client to understand what they are doing at least to some degree. Even when a client is not interested in HF details, and they just want the problem to be solved, there may be third parties that have an interest in auditing the details of the work e.g. company directors might be told by regulators[103] that they have a HF problem[9], they then utilize HF services to solve the problem but don't care about the details[78], but the regulators[103] may then check the work of the HF practice to make sure the problem has been properly addressed.

Documenting[105] work is important to leave an audit trail[4] for auditing. Sometimes reports serve different purposes for different audiences; taking the example above a client might be motivated[78] by the solution, whereas regulators may be more motivated[78] by the process and methods that derived the solution. Similar to academic work[114] people will judge the validity[126] of the results on the process, methods and arguments that have derived them.

Goal Structuring Notation (GSN)[50] was described as a method that breaks down the argument that HF has adequately covered the different parts of a system and then links up what has actually been done on a project to cover those parts. This makes the argument and evidence more structured, and aids auditing. Not all projects will need this level of detail. Environments and projects which are more designy[20] may be less inclined to keep an audit trail[4] of why design decisions were made.

HF practitioners may develop tools[121], checklists[42] and guidelines[52] so non-HF qualified people can carry out audits of their own in working contexts.

4. Audit trail

This refers to the documentation[105] of the processes[90], decisions[17] and methods[40] that can be audited[3].

5. Bidding

This refers to when HF practices compete for a project. This gives the client options.

6. Capability

This refers to the capabilities of organizations and practitioners. This affects what they have to offer e.g. a company may have the capability to offer 3D modeling of a control room or carry out test in a high fidelity simulator; a practitioner may have certain expertise in carry out different methods[40] or may have knowledge about a particular domain[21].

7. Career development

Practitioners will be mentored and supported[118] in the early stages of their career. They will then move on to more complex tasks, with more responsibility. As they mature they will be involved in project design[91], selling[113], client contact and management.

8. Client contacts

Different projects may mean contact with different people on the client side which might affect communications. For example, HF practitioners on the client side may be more interested in the HF detail of the work, than other professionals.

9. Client need

A client need is often the driver and initiator for the project. Clients will be coming from their own perspective[81] and may be motivated[78] by non-HF issues e.g. to satisfy regulators[103], to increase revenue, to get safety assurance[2], to reduce manning levels. The HF practitioner will need to engage with the client's issue and negotiate[17] a programme of work aimed at addressing it[91]. Sometimes the client might not understand what their HF need is. One practitioner believed that it can be complicated in that you may think you are employed to solve a technical problem, but the actual problem may be something else like organizational change. Like in academic research[114] the real nature of the issue might only reveal itself after the work has begun. What programme of work is decided upon will depend[32] on the type of problem[89], the resources invested in it[108], the risk[109] involved if the problem is not addressed properly, the level of validity required in the solution, and the capabilities[6] of the HF practitioners and practice.

Client needs bear a lot of influence on the methods[40] that are used. One practitioner stated that they would turn to methods they had not tried if a client requested it.

Practitioners' work needs to be paid for and so they are largely restricted to what the client will pay for[108]. The client may be willing to invest more resource into projects where there has been a window of opportunity[128] for HF e.g. when they have a big problem like new navigation systems, or highly publicized train crash; or where they have a good relationship[104] with the HF organization.

The integration of HF differs in different industries[22], some where it is mandatory, like nuclear power; some where it is strongly encouraged, like transport industries; and some where it seems less well established, like hospital design and renewable energies.

10. Client negotiation

HF practitioners will negotiate the shape of the project at the start, and what should be done about the recommendations toward the end.

11. Closeness

Closeness manifests itself in HF organization[28]. For example some projects may entail the HF practitioner as a design friend that is embedded in the design team, working closely giving informal input; other projects may be more distant in providing an independent evaluation of a design.

12. Comments on academia

Comments on academia include understanding the practitioner context better and providing outputs which are more suited to this context:

- there could be more work in developing commercially viable tools, validating tools and methods, and generally bridging the gap between what academia produces and what practice can use. Practitioners can adapt methods so they are more suitable to practice, but perhaps academics should take into account the practitioner context more. Many incremental developments are not significant enough to change practice e.g. a slightly updated attention model will probably not make much difference to practical workload studies and recommendations.
- some academics could do more to market their ideas by doing more studies and more papers.
- academics can focus on ideal method use rather than taking into accounts the pragmatics of the situation e.g. practitioners focus on value and the solution, rather than the method per se. Recommendations have to be grounded by talking to clients

and operators. Claims should be appropriately scoped by the systems and evidence engaged with.

- doing HF work in practice, under commercial constraints, and where recommendations could mean loss of life is very different to academic claims presented in journals and conferences. When your decision could mean loss of life the sort of judgment you make changes.
- there should be a better appreciation of practitioner work including the organizational swirl, attitudes and politics involved; you need to be battered by organizations to appreciate these complexities.

13. Communication
This refers to the communication between different parties.

14. Company organization
This refers to the organization of the company, HF organization will be affected by this.

15. Consultancy vs researchy
This reflects HF practice and projects, where some are more like consulting, advice driven and closer to the design; whereas others are more independent, evaluative and research driven.

16. DC
This refers to Distributed Cognition elements in the data. Reflecting information flows, coordination, information gathering, information processing, and information filtering.

17. Decision and negotiation
This refers to decision and negotiation points in processes.

18. Def of HF
This refers to issues of definitions and conceptualizations of HF.

19. Design evolution
This refers to the evolution of design. Designs rarely start from completely fresh, and there are constant developments at different stages of the design processes.

20. Designy
This refers to a characteristic of practice in that some environments and projects are more designy i.e. they have more iterations, faster and more informal feedback, and less detail in audit trails.

21. Domain experts
This refers to the workers in a domain which have specific knowledge of it, this may be operators on the ground or HF practitioners with extended experience of a domain[22]. It is important to get in the trenches[30] and engage with these people and this knowledge.

22. Domain Industry
This refers to the different industries e.g. nuclear power, navy, train, and aircraft.

23. Early, middle, late, all
This refers to the stage that HF gets involved in a project: it may be early, in the middle, late, or it may be integrated throughout. This will impact on HF organization[28].

24. Expertise and background
This refers to the expertise and background of different people e.g. HF practitioners might have a psychology, graphic design, or ergonomics background and this may influence their motivation[78] and preferences[87] in HF work.

25. External knowledge
This refers to knowledge that is externalized in documents[105] and meetings[39].

26. Feedforward
This is the transfer between components in a system. It is quite structured in that it assumes that there are different parties and processes doing different things[94], that these different parties and processes are coordinated, and there is feedforward between them. This could be the transfer of some value, information, opportunities and technologies from one part of the system to another. In terms of usability practice's integration with design good feedforward would impact on the actual design, poor feedforward what not lead to design impact even if the actual work was good.

Projects are engineered to meet a client's need[9]. The feedforward of this information should be of enough value to the client that they will invest resources[108] to fund the project. There may be some negotiation[10, 17] in what work is carried out and what the HF service will provide. The transfer of value is not only important to design, but for business as well. Good HF work[97] and early HF work[23] may feedforward to further involvement in projects and more contracts[117]. Reputation[106] will feedforward in attracting work between projects.

Feedforward should not just stop at the project output[93] but should consider how well the transfer of recommendations[100] takes place. So this goes beyond what is transferred, for example scoping claims[111] properly, and making sure recommendations are properly couched in the details of the context[30]; to how transfer happens which emphasizes the communication[13] of recommendations[100], which can be prioritized[88], design solutions, in words, pictures, reports[105], meetings[39], etc. Softer factors can also facilitate the transfer of recommendations like the rapport[99] and relationship[104] between the client and practitioner. Feeding forward also has to be timely, for example, in designy contexts[20] over emphasis on recording details, decisions, etc. can hinder the speed of design input; and practices that work at different speeds have to find some suitable way of working effectively.

It is important to consider what information you feedforward, to whom, and how. For example, chief executives might not be interested in the detail and might not have time to read a big report; developers may need detailed information for implementation but not be interested in the HF sides; regulators might be interested to see that appropriate HF methods have been performed; and accountants might be interested in costs and savings. Here, reports[105] may serve multiple functions as different people are motivated[78] by different things.

It may not be in the interests of HF practice to try and feed all recommendations forward. It is wise to manage this process and choose which battles to fight as good report needs to be maintained. Also the client may be working under constrained resources[108], might be contractually restricted on what they can do[112], and might not be able to do everything. This negotiation[17] can involve political[82] elements.

Feedforward is also affected by process[90]. Different information will be gathered, processed and fed forward in different stages of the design process e.g. there may be a literature review[38] of previous work and standards[115] at the very start and there may be tests[71] once a prototype[60] is available. If HF is involved too late in a design cycle[23] then there may be little potential to influence the design. HF might also be organized[28] to prevent feedforward from one department to another, so the departments are not involved in the development, and so they can independently evaluate the design.

The feedforward of knowledge[37] might also be more implicit and diffuse, for example, in educating clients about methods[40] they can offer, and in mentoring[118] more junior members of staff. Indeed, non-HF people may become aware of its philosophy by coming into contact with the work. Away from traditional design cycles one practitioner recognized the importance of the process of doing HF work; where talking to people, having meetings and working through options actually achieves the desired outcome for the client rather than delivering a report with recommendations, which he related to organizational change. Here it appears that you become part of the process of introducing new technology.

There is also the sense of feeding forward from academic research to industry practice[12]. If methods[40] are not sufficiently different and add value to current practice; if they are too costly in terms of time and budget; if they are complicated; and if the topic or approach cannot be sold to clients then the likelihood of transfer will be severely reduced.

A client might be using HF for political[82] means so they can feedforward results in their own organization e.g. their opinion might not be listened to on its own but an independent research report might. A report[105] captures conclusions and is a stable artefact that can be passed to others; correctly produced it has a certain presence and authority that might be missing from verbal communication.

27. Frustration

Frustration may manifest itself in doing work that might not motivate you[78] and in the conditions that you have to work in e.g. resource constraint[108] might limit the work HF actually wants to do. Designers and developers may also be frustrated by negative feedback and so this has to be managed so rapport is maintained[99].

28. HF organization

This code refers to the organization of human factors within a company, between companies, in projects and processes[90]. There are different dependencies[32] that will affect the organization of HF; structure and roles add stability. Here we see that methods[40] are only part of a wider HF offering that should fit with the project and the client.

There can be different HF practices involved in large projects[92] at different stages. These can be organized to do checks on each other's work[101]. Even within a company HF practices might be kept separate[11] so they are in a position to perform an independent evaluation at some stage. HF practices might have to adapt their communications and procedures depending on how the client is organized[14] e.g. clients might have specific preferences and report structures. Clients may want close contact[11] and regular informal feedback, projects may involve integration in to a wider design team, or work may be quite detached, structured and independent – this organization may depend on their role in the project. What is considered early project[23] involvement will also vary between projects as some may have a vague idea of a design, whereas others may have moved to a specification and prototype[60]. Once a HF practice has started on a project they have an internalized understanding of the design, issues and client practices which may make them more efficient to continue working on the project rather than someone starting from fresh.

HF can be brought in at different stages of a design process[23], or even as problems arise outside of design processes. HF want to be brought in early so they have more opportunity to influence the project but this is not always the case. HF involvement is dependent on the available budget[108] and the client's own perspective on HF[78] e.g. pro-HF clients might be more willing for extended involvement of HF services. HF is normally organized around satisfying a client need[9] and specific methods[40] and actions will be agreed at the project design phase[91]. It is here that the HF practitioner will have to negotiate[10] and sell their offering to the client[113], perhaps in competition with other HF offerings.

There are different project roles[94] in projects. It was recognized as good practice to speak to different people with different backgrounds to engage with the details and issues of the stakeholders and users[30]. It was also recognized that different industries[22] have different organization, languages and practices which need to be accounted for to work with them sufficiently. It was recognized as important to deliver the right recommendations in the right way to the right people to improve the feedforward[26] of recommendations. Rapport[99] also needs to be maintained so recommendations are listened to and HF is seen as approachable and useful.

HF practitioners might do other things than technical HF[29]. For example, they may take part in selling HF services, project management, mentoring staff, training, and accounting. In terms of career development practitioners may be involved in more complex, responsible and management roles as they mature. The capabilities[6] of different members of a HF team will have be managed for short term project completion and staff development in the longer term.

HF organization between companies will also be affected by contracts. Contracts will limit the scope of investigation from the HF perspective. Contracts will also affect the feedforward[26] of recommendations that are made outside the scope of development[112] e.g. a software company may be contracted to update a software interface in a train cab and they might have employed HF services to help them, recommendations about the hardware in the train cab discovered in tests will be outside the scope of development of the software company.

29. HF to admin, business, management

This relates to those duties that go beyond the application of HF methods. As people develop in their careers[7] they will have more responsibility and a wider role.

30. In the trenches

This refers to getting down in the trenches, speaking to real users, stakeholders and observing the context so the peculiarities of that context can be considered.

31. Internal knowledge

This refers to that knowledge that people hold in their heads. HF practitioners will have a wealth of information in their head from a project including notes on personalities, preferences and the right people to contact to get certain information within companies. Clients will also have more HF knowledge through having contact with the work[37].

32. It depends...

It depends... relates to the variability in different contexts, and the fact that practitioners and working practices will adapt to suit those contexts. Dependencies will affect the type of work, how it is done, how the results are communicated, and whether they are taken on board. These will include preferences, capabilities, personalities, skills, experiences, time, budget, strategies, project roles, type of problem, the stage of design, relationships and people. There are a lot of project options and a lot of variability[127]. This is negotiated[10] and decided in the project design phase[91] where stability is added into the system, so the client and the practitioner can agree a contract. Below are examples of variances and dependencies in the system of usability practice.

Some projects are open to competition, some aren't; some projects are big and some are small; some are additions to ongoing projects and some are repeat business[117]; some may be new clients and others may have familiar working practices with the company. If there is a bidding process[5] the client will have options to choose from. Some clients might want[9] to go cheap, some might want to be thorough, some may feel more of a fit with a company or a practitioner. Some clients might be HF savvy, some naïve; and some HF friendly, some not.

The methods[40] proposed will be dependent on external factors like the client need[9], the sort of problem faced[89], the resources available[108] for the project like time and money; and internal factors like capabilities[6], skills[85], and experiences[24] of the HF practice.

They will depend on the required level of validity[126] i.e. it might be paramount that everything is absolutely right first time, which will generally be governed by the risk[109] involved in the system. For example, a user test[71] might be short, with a few substitute users on a mock up of the system towards the end of the cycle; compared to repeated user tests, with real users on fully operational simulations of a system in many different scenarios[64]. The stringency of the audit trail[4] will also be influenced by the environment, for example, more designy[20] contexts might not need the detail that safety checks in nuclear power plant input will need.

Project options will be heavily dependent on the sort of issue it is[89] e.g. it might be an attention issue, a workload issue, a physical issue, or a context issue. Even within these the context of the situation has to be taken into account[30]. Unlike engineering issues that have large reliable generalities, like the behaviour of copper and iron; issues in social science will be heavily influenced by the context e.g. the sort of people, training, expertise, the local environment, task design, interface design, displays, audio, protective clothing and interactions between technologies. Here the devil is in the detail[30].

Project options will depend on the stage in the design lifecycle[23], and HF services may be sought outside of design lifecycles for input into particular problems that arise. The project length[92] may also vary from a couple of days to years of work which will affect project involvement. Project roles[94] may vary as HF practitioners may have to act as a design friend or as an auditor in different projects. Sometimes the client is seen regularly, sometimes not; sometimes the practitioner is working in a team, sometimes they work more independently.

Preferences and practices also play a role in project options, practitioners will develop templates[120] of projects and have ideas about what things work well e.g. some might prefer workshops for giving feedback, some might particularly like task analysis, some might like running experiments, some might like tables and others graphs. Some practitioners might be more open to new methods, look at new research developments and look to adapt their practices[102]. Some practitioners like to work analytically, some like to work in a more exploratory manner.

The way recommendations[100] are communicated[13] also has dependencies. Some clients may want a large report, some may want something more concise. A report[105] can also serve multiple functions and have different parts that are relevant to different people e.g. the chief executive, regulators and developers will look for different things. The project roles[94] and relationship[104] may influence whether recommendations[100] are dictated or worked through together with the client.

People make decisions[17] about projects that have different perspectives[81], political motives[82], prejudices[87] and understandings, so these will play a role in determining project choices as well. In sum there are many different dependencies which will affect the design and the outcome of a project. HF practitioners engineer project options for clients. Sense and stability is added in the apparent fluidity of project options by practitioner expertise, preferences, project templates and methods.

33. Job title
This refers to the job title of the practitioner.

34. Knowledge sharing
This refers to the sharing of knowledge. This may be verbally in meetings[39], or written in reports[105]. HF practitioners may 'ask the office' for advice.

35. Lab vs Real world
This refers to controlled studies that are done in a laboratory and studies which are performed in context. Each method has different pros and cons.

36. Language
People in different domains use different terms. It is sometimes important to become familiar with the language of a domain to facilitate communication[13]. Buzz words can encapsulate topics that are of particular interest and attractive at that time.

37. Learning
There is constant learning in the system, which is different for different parties. The biggest lesson may be the solution to the client need[9]. Clients will also learn more about HF as they come in contact with the work. Practitioners will learn about the client's practices and issues. Practitioners will also learn about the application of methods[40] and the administration of HF services[29].

38. Literature review
This reviews current work related to the project.

39. Meeting, presentation, discussion
This refers to face to face communications which may be more suitable for client negotiation[10] and delivering project output[93] and recommendations[100].

40. Method

This code encompasses all the methods mentioned by practitioners. Methods are central to HF practitioners work. They structure the work, provide capabilities[6] that can be sold to clients[113], and they provide convenient packets of work which facilitate communication[13]. Here methods represent externalized HF knowledge[25] and processes. Many methods can be adopted and adapted for projects, and how this happens has many dependencies[32].

Methods are selected to address a client need[9] which will normally be a certain sort of problem[89] e.g. it may be a workload issue, it may be to evaluate an interface, it may be to plan a control room, or it may be to change a task in response to some new technology. There may not be a specific HF method label to put on the work, it may be more inline with general analysis, research and experimentation activity[1]. Depending on the project requirements it is generally recognized as good practice to really engage with the details of the users, tasks, and context of the system under study[30].

Other factors also constrain and influence method selection; not least of all the resources the client is willing to invest[108], which if tight will lead to a compromise and a pragmatic solution[86]. Also, the stage in the design may limit feedback[23] e.g. very early on there might not be a design and so something like a literature review[38] might be appropriate; too late in a design will leave little opportunity to influence the design. Feedback to the client will also be influenced by how close[11] the methods are being carried out e.g. a workshop[76] will involve clients in working through an issue, clients could observe a user test[71] in person or through video, or a more formal independent review may be quite distant with little communication. The process[90] of the method should fit the wider processes it aims to fit in to.

Methods can be qualitative or quantitative[96]. They can be performed in the laboratory or in the actual context[35]. All methods have pros and cons and these should be factored into the design of the project[91] and the scope of the claims[111]. The level of validity[126] needed by the client[9] will also influence what methods are used and how they are integrated. The stringency[116] of the work will in part depend on the level of risk[109] that the client's system is exposed to.

Risk[109] does not just lie in the system being investigated by the HF practitioner. The client is also taking on risk when entering into a contract with a practitioner. Generally it will be less risky to enter a contract with a practitioner that has the adequate skills[85], experience[84], support[118], and tools[121] to apply a particular method successfully. Experience will generally lead practitioners to apply a method faster, more effectively and to a higher standard[115]. Here the practitioner's reputation[106] in applying a particular method and their work in general can help them sell their services[113]. Practitioners and clients will also have preferences and prejudices[87] in methods and ways to approach problems. Practitioners adapt methods to suit the project, the need and the client in reflective practice[102].

Different methods will facilitate different forms of communication[13] e.g. a workshop, observations or meeting[39]; but generally all will lead to a report[105] with conclusions and recommendations[100]. Practitioners advice on what should be sought for in a method used in practice[77] can be found under code 77, method advice.

41. Method - accident data
42. Method - checklists
43. Method - contextual inquiry
44. Method - ethnography
45. Method - expert review
46. Method - fault tree analysis
47. Method - feedback
48. Method - field studies
49. Method - focus groups
50. Method - goal structuring notation
51. Method - GOMS
52. Method - guidance
53. Method - hazard analysis
54. Method - HAZOP
55. Method - human error identification
56. Method - interviews
57. Method - link analysis
58. Method - modelling
59. Method - observation
60. Method - prototype
61. Method - questionnaire
62. Method - risk assessment
63. Method - root cause analysis
64. Method - scenarios
65. Method - simulator
66. Method - social network analysis
67. Method - static story boards
68. Method - survey

69. Method - talking
70. Method - task analysis
71. Method - user testing
72. Method - video
73. Method - wireframe
74. Method - workload
75. Method - workplace assessment
76. Method – workshop

77. Method advice

Practitioners requirements for methods included that they add value; are useful; valid; pertinent to the client's need; easy, cheap and fast to use; easy to understand and understandable to the client to some degree; reliable and predictable; and easy to interpret. In practice trade-offs between these requirements will need to be made, and different trade-offs may be appropriate for different contexts e.g. a well funded project that is safety-critical may have cheapness low in its list of priorities, whereas a small internal project comparing website usability for business opportunities may weight speed and cheapness very highly.

78. Motivation

There are many different motivators or drivers involved HF practice which stem for different people and different contexts.

Clients will have different motivations for seeking HF work. Some may be very pro-HF[87] and look to have a large involvement of HF to improve the quality of their project; some may just want a small contribution; and others may be forced to seek HF advice by regulators[103]. These factors affect HF organization[28]. Within a project clients may be motivated by project that are cheap[108], that are stringent[116], or that are managed by practitioners with a good reputation[106]. The client will have a need[9] and this might not be a HF need directly e.g. they may want to raise revenue, adhered to regulations, improve weapons capability, reduce manpower, or gather evidence to support internal political[82] arguments within a company. When communicating[13] recommendations[100] it is important to give the right message to the right person in the right way to facilitate feedforward[26] from HF work. Recognizing there are different audiences for HF work allows for a report[105] to serve multiple purposes e.g. the chief exec might just want to know the problem has been solved, regulators may want to know about the process and methods followed in the work, and the developers may need to know the technical detail of the implementation.

Practitioners will have different preferences[87] and be motivated by different types of work. Some may be frustrated[27] by working through detailed guidelines, standards and checklist, some may be very analytical and like running experiments, others may be more motivated by interface work rather than physical ergonomics. These motivations might play an influence on the sorts of projects they do and hence the development of expertise[24] in that area. On a wider scale these developments will affect the capability[6] of the HF organization.

It is wise to realize that different people will be coming from their own perspective[81] with different political motivations; and that non-HF people will generally have concerns that HF can help with, but they will not be too interested in HF detail. This knowledge can facilitate communication[13] and feedforward[26].

79. My PhD

This code was added to cover parts of the interviews where I or the interviewees started talking about the aim or progress of my PhD. Interviewees thought my PhD might lead to better two-way communication between industry and practice, and that it might give an overview and a better identity for HF.

I commented that my PhD was about adopting and adapting methods in practice, which has gone beyond technical details like problem identification of methods to organizational and social factors e.g. building rapport, getting client buy-in, and relationships. There is no magic method for safety assurance, instead practitioners build understanding, use common sense, scope their claims and have other HF people check their work. Practitioners choose what information to gather, how to gather it, how to process it, and then how to filter this into the system.

80. Other groups

There are many different groups involved in design work.

81. Perspective and perception

Different groups have different backgrounds, motives[78] and understanding.

82. Politics

Different groups will have their own political motives[78], interests and agendas.

83. Power
There are different sources of power in the system; clients hold contractual power, senior HF practitioners hold hierarchical power; HF practitioners have expertise power; and regulators have legitimized power.

84. Practitioner experience
This refers to practitioner experience.

85. Practitioner skills
This refers to practitioner skills.

86. Pragmatics
This refers to choices that are balanced between what might be ideal and the resources available for the project[108].

87. Prejudices
This refers to the preferences that people hold in HF services, HF practitioners, methods[40], design ideas and recommendations[100]. These should be validated[126] to check that preferences do not impact on the results.

88. Priority
This primarily refers to the prioritization of recommendations[100].

89. Problems: closed, open, simple, complex
There are different sorts of HF problem: from working out the layout of a single desk, to designing a control room, to testing if a drink enhances performance, to improving the safety culture of an organization. These will suit different methods and knowledge bases.

90. Process
There are different processes with some more structured and formal than others. There is a learning process[37], a career development process[7], a bidding process[5], a design process.

91. Project design phase
This is beginning stage where a practitioner will design a project to suit the client's need[9].

92. Project length
This refers to the project length which can vary from days to years.

93. Project output
This should be agreed in the project design phase[91] and can be communicated in reports[105] and meetings[39].

94. Project roles
There are many different roles in design projects.

95. Qualitative
This refers to qualitative research.

96. Qualitative and quantitative
This refers to qualitative and quantitative research.

97. Quality
This refers to the quality of work and recommendations[100]. It can be assessed and audited[3] and impacts on reputation[106].

98. Quantitative use, and its validity
This refers to comments on the validity and scope of quantitative work. It is used and some practitioners are more critical than others about the scope and validity of quantitative analysis.

99. Rapport
The rapport between the practitioner and the client can facilitate selling[113] and listening to recommendations[100].

100. Recommendations
Recommendations are related to the project output[93].

101. Redundancy in people
HF practice in the safety sector can have overlapping HF roles to check on the quality of each others' work.

102. Reflective practice
Practitioners will adapt their practices to the context.

103. Regulations and regulator

Regulations and regulators can oversee practices in different industry. They can force the involvement of HF services when needed.

104. Relationship

The relationship between the client and practitioner can facilitate repeat business[117], selling[113] and listening to recommendations[100]; it is strongly related to rapport[99].

105. Reports and Documentation

This code has much to do with communication[13].

Documentation can capture knowledge externally[25] which can then be distributed. Reports and documentation can hold advice, procedures, regulations[103]; they can request services and initiate action; they might be the basis for agreement and negotiation; and they may provide a record for decisions and actions for auditing.

Design processes before a prototype is made can be a developing set of documents that are integrated, from design idea, to design specification, and all manner of communication in between including user specifications, design requirements, etc. Information gets gathered and distilled at different stages of the design process. So documents can act as vehicles to feedforward[26] information to the next stages of design and decisions, and they also leave an audit trail[4] so the process can be reviewed.

Documentations may be wordy, they may be concise, they may contain pictures, and video[72]. They may be written with different audiences in mind and for different purposes. There are many dependencies[32] which will influence how a document is composed and how it is used to facilitate communication[13].

Different methods[40] may facilitate different forms of communication e.g. a task analysis can be displayed, statistics can be displayed in a graph, and users tests can be observed. Documentation from methods will not just contain the project output[93], but will form an argument for why those conclusions are valid and should describe the scope of the claims, so they can be audited[3] and provide assurance[2].

106. Reputation

There can be the reputation of HF in general, the HF organization, the HF practitioner, methods[40] and ideas; and this can be influential in organizational decisions.

Reputation has to be worked for and quality[97] maintained. The reputation of a practitioner will facilitate selling[113] their services as it will provide the client with some reassurance[2] that the work will be completed to a good standard[115] and their recommendations[100] will be sound. The expertise of the practitioner[24] will be linked to their reputation, and greater experience will reduce the risk[109] of a project failing. New practitioners, new methods and new practices that have a weak track record will make a project less predictable. There will be a motivation[78] and prejudice[87] to select practitioners and methods that they have confidence in.

Practitioners and organizations can be audited[3], by clients and regulators, to check their quality which will influence their reputation. Good work will more likely lead to repeat business[117] and attract more work.

107. Requirements

These relate to the requirements in a project e.g. design requirements and user requirements.

108. Resource constraint

This code refers to the management of resources, for example time and money. People can also be considered resources that have different qualities, such as knowledge, skills, contacts and experience. Indeed, knowledge and skills in a particular domain would qualify that person as a domain expert[21]. In design it is important to get the right project roles[94] working together, as people will have different perspectives[81] and expertise[24] to contribute. Here, resource and capability[6] management overlap; whereby the individual or organisational capability[6] can be considered an asset or resource.

Projects hinge on the client’s need[9] and it is their decision how to best use their funds, they hold the power[83] in terms of investment. It is important to realise that projects aren’t all about money. For example, the availability of funds might be a low consideration in making a nuclear power plant control panel safe to use, or to enhance the weapon system controls of the latest military aircraft. It is more about the transfer of some sort of value for the client[26]. Where funds are tight recommendations and services should be prioritised[88]; for example, safety concerns will outweigh usability concerns[125]. Recommendations from projects may lie outside the scope of development[112] e.g. the development contract may be funded to develop new software and so recommendations to improve the physical controls involved in interacting with the software might be outside the scope of development.

A balance between resources and options may lead to pragmatic[86] rather than ideal solutions. For example there may be different risks[109] involved in projects and there may be different levels of validity[126] about claims; the higher the potential losses the more the client might invest to be sure about the claims.

Resources can be loose (allowing redundancy and flexibility) or they can be tight (putting pressure on the system to be streamlined and efficient). Decisions made about resource allocation will impact on system behaviour, for example the length of the project[92], the methods[40] chosen, which could impact on the stringency[116] of the recommendations[100].

Generally resources will be negotiated[17] and allocated at the project design phase[91], based on the client's need[9]. More flexibility in resources for projects may be allowed where there is a good relationship[104] between the client and service provider; and where there is a window of opportunity[128] e.g. they wish to do a gold standard project for marketing purposes, or a recent rail crash might have heightened concerns for safety.

Resource management is important for a successful business. In Human Factors this will mean streamlining services. For example this will encourage working for the same clients and doing projects in ways which are predictable[109] and are known to be successful; rather than spending time on developing new methods and money purchasing new tools that may prove unsuccessful. The business has to concentrate on what the client will pay for, and will generally have to assure[2] them they have the competence to deliver before the client commits to the contract. Human factors practices operate in a competitive market and so their bids[5] for contracts and projects need to be competitive. They will often engineer a project to satisfy a client's need[9] by employing suitable methods[40] and organising the human factors[28] to 'fit' the client's structure.

109. Risk and Predictability

There are different types and different levels of risk in HF practice.

First there is the risk involved in the system under study; in safety systems this could lead to injury or loss of life, this might also be associated with financial risks and risks to reputations as well e.g. a plane crash may lead to loss of life, reputation and business from customers.

There is also the risks and uncertainties associated with working with others. How can a client trust that the work will be done to an appropriate standard, that the recommendations can be trusted and they will not be let down? Here the client can audit[3] the HF practice, other HF practitioners can be employed to audit the technicalities of the work[101], and a client can gain reassurance from the HF organization's or practitioners reputation[106]. If a client has had a successful experience with a HF practice then there are incentives to sustain the relationship to reduce uncertainties that will entail from an unknown relationship.

The HF practitioner will also want to reduce risk and act in a predictably good way. This will typically mean playing to their strengths, doing what they know works, and what they have done before. Experimenting with new methods[40] raises the levels of risk and costs extra resource[108].

Different risks need to be managed. Where there is a lot of risk in a system, HF practice might recommend a more thorough and stringent project[116] and the client may be willing to invest the extra resource[108] to get the required results. Clients and practitioners can reduce risk by working with people, methods and processes that they know will work rather than introducing unknown elements. This makes the system more predictable.

110. Safety culture

The safety culture of a practice refers to those unwritten rules, assumptions and beliefs that affect people's decisions and actions. Cultural analysis and recommendations for improvement may be the object of HF work, HF work might also be affected by it e.g. a more mature safety culture might be more willing to invest the resource[108] into HF work to make sure systems are safe.

Cultures may also be more designy [20], they may be consulting or researchy [15], they may be focused on pragmatic solutions, they may be focused on thoroughness, they may be formal or informal. There may be a mix of different cultures which will bear influence on the sorts of methods[40], HF organization[28] and communication[13] style of the work.

111. Scope claims

Clients will rarely invest the resources for HF to make all the checks to certify that a system is safe. What work they do will be limited in the focus, the methods used, the context the system was tested in, the sample size, etc. so claims should be adequately scoped.

112. Scope of development

Projects will generally be limited by the resources[108] available for a particular line of development, this might be structured through contractual agreements. Sometimes HF practitioners may make recommendations[100] that fall outside the scope of development e.g. a software company might not be able to make changes to the hardware of a system.

113. Selling

In practice it is common for practitioners to play a role in designing projects[91] and trying to sell work to clients, which is beyond the application of HF methods[29]. The projects will be designed with the client's need[9] in mind, it will include options for methods[40] and capabilities[6], and have associated resource costs[108].

There may be some competition in trying to win projects[5], which will not necessarily go to the cheapest offer. There are issues of stringency[116], validity[126] and quality[97] to consider. Certain practitioners may have a good reputation[106] in a certain domain[22] or method[40]. Practitioners may have a good rapport[99] with the client, or may be building on previous work[117].

Selling is tied into communication[13], in convincing clients that certain methods[40] and work-packages are worthwhile; and in selling recommendations[100].

There may be a window of opportunity[128] that facilitates selling e.g. a client PR motivated project may allow for inflated resources that might otherwise not be available, or a highly publicized accident may allow for more extended HF work.

114. Similarity with academia

Some practitioners made comments on academia which were mainly focused on the differences between the contexts[12], but there are apparent similarities. For example, one practitioner likened her report to clients like an academic paper that had a summary, introduction, methods and conclusions. It was also usually presented to the client in a presentation, where they could ask questions which seemed similar to presenting a report to an academic conference or workshop. This practitioner was in a research culture[15] which valued the stringency and independence of their work.

Academia also involves the application of methods[40] for research and the development of understanding, and the scoping of claims[111] that come from these studies. HF standards in safety are often maintained by other HF practitioners[101] auditing their work[3]. This is similar to academia where work will be refereed by peers. Here valid[126] work has to follow correct processes and methods, but we move from objective standards to standards defined by community acceptance. The quality[97] of research can often not only be judged on the conclusions but the processes that led to them. Like academia the rationale and processes of a study should be documented[105], so there is an audit trail[4] open for assessment.

115. Standards

This code reflects informal and informal standards. The most formal standards are similar to regulations[103] where some agreed quality[97], design or process needs to be met. There are also standards for keeping things consisting and behaving in predictable ways so they can integrate; a trivial example is that UK plugs will be of a standard design to fit UK sockets. The amount of work on standards and the type of standards vary between industries[22]; for example the rail industry was recognized as being very standards driven. Some practitioners get on with standards better than others, with some finding them quite detailed and tedious.

There are also informal standards like following best practice. Work may be audited[3] to check that it is up to standard. Here standards will impact on reputation[106].

Some methods[40] and practices can become standard once a critical mass of people start doing it; it can become expected and the norm. Standards in one industry can cross over to another e.g. best practices in one industry might be brought over by the HF practitioners working in both areas.

116. Stringency

Stringency refers to how strict and in-depth the work is carried out. Sometimes the resources[108] available for a gold standard project are not available and so practical[86] considerations have to be made at the project design phase[91].

117. Succession and Repeat business

Repeat business was cited as a large proportion of HF work. Practitioners therefore are motivated to meet the client's need[9], provide a good service and maintain their relationship[104] with clients. Both parties can benefit from extended relationships as they gain experience of how best to work for each other e.g. the way the company likes reports[105], feedback, who to contact[8], etc.

118. Support and mentoring

Members of staff will need different levels of support and mentoring as they progress through their careers[7].

119. Systematic

This refers to the level of systematization e.g. a project may be quite exploratory and decisions may be made by group consensus; or projects might have formalized stages and processes, and decisions might be determined by set criteria that are determined before the meeting.

120. Templates

This refers to internal[31] and external[25] patterns of knowledge and working that can be reused and adapted. For example, through experience[24] practitioners will build templates of what is an appropriate project design for different contexts, e.g. designing a control room will employ a certain group of methods; also external templates like guidelines and checklists can be used to guide thoughts and actions.

121. Tool

Tool support for methods[40] can greatly facilitate work. They can speed up calculations, encapsulate processes and knowledge, and help create visualtisations for communicating[13]. Tools are directly linked to capability[6]. Where there is good tool support work can be done faster, better and cheaper; where tool support is lacking HF practitioners might find alternative routes to achieve their goal e.g. if video is too hard to edit then capturing and analyzing video footage might be avoided all together.

122. Type of clients

The type of people that HF service can vary from the industry[22] they work in, the culture they are from[110], and the standards they adopt[115] e.g. working with a design company will be different to working for safety; and working for the navy will be different to working for a train company.

123. Type of consultancy, service

HF services also vary on their expertise[24], in the domains they deal with[22], their size, and the sort of culture they support[115] e.g. they might be of the independent research sort, they may be give advice and work closely with designers[15]; and they might be less involved with safety per se and more involved with performance and usability[125].

124. UCD iterations

This code refers to the iterations that are performed in different stages of the design process.

125. Usability vs safety

Some HF work would not claim to be directly involved in safety per se, but instead scope their claims to be more centered around performance evaluation and enhancement.

126. Validation

This code refers to the validity of the conclusions, recommendations and results.

The project is based on the client need[9] and this may have certain validity requirements e.g. a huge risk[109] in safety or large financial loss may mean that the design has to be right first time. This will have to be balance with the resources[108] that the client is willing to invest in the project. The HF practitioner will try to design a project to meet the client's needs. They might employ different methods[40], and combine methods to improve the validity of their results. Each method has pros and cons e.g. controlled studies can be performed in a lab[35], but this might miss important contextual variances in the real world. It was recognized as important to get into the trenches[30] and engage with these contextual details for the recommendations to be valid for that context.

HF can be organized in different ways[28]. The closer[11] that HF is to the design phase the less it is thought to be able to cast an independent critical eye over the design which may be important for a valid evaluation. For example, one practitioner said they had a favorite design[87] in a user test and was disappointed when it was not the users' favourite. Closeness is a double edged sword in terms of validity as it may be important to get close to the design, the stakeholders, and users to make suitable contextualized recommendations[30]. Here we can see that there are different processes in projects, and they should be managed effectively to maximize the quality[97] of the project output[93] under constrained resources[108].

The project output[93] will normally be some form of recommendation[100] and this should have adequate supporting documentation[105] for auditing purposes. The case for auditing[3] may be more important in some contexts than in others. Auditing can take different forms, to audit technical HF practices requires auditors with HF knowledge[101]. In any case, the HF claims and recommendations need to be adequately scoped[111] as the client will rarely invest enough resources for all the HF checks to declare that the system is safe.

127. Variety

This refers to the variety of work, people and contexts that make the dependencies that shape work[32].

128. Window of opportunity

This refers to circumstances where a potential client might be more receptive to HF ideas, and investing more resources[108] into HF e.g. because of a recent highly publicized accident, or to do a gold standard project for PR and marketing purposes.

These moves tend to be politically[82] driven on the part of the client and be linked to maintaining or developing their reputation[106].

Appendix B: DiCoT Principles

This appendix contains principles associated with the five models in DiCoT.

(B1) Information Flow Model

Table B.1 lists some DC principles in relation to this model.

(B2) Physical Model

Table B.2 lists some DC principles in relation to this model.

(B3) Artefact Model

Table B.3 lists some DC principles in relation to this model.

(B4) Evolutionary Model

Table B.4 lists some DC principles in relation to this model.

(B5) Social Model

Table B.5 lists some DC principles in relation to this model.

Table B.1. Principles related to the Information Flow Model.

DC Principle:	Description
Information movement:	Information moves around the system. This can be achieved in a number of different ways which have different functional consequences on information processing. These ways differ in their representation and their physical realisation, for example these differing factors may include: passing physical artefacts; text; graphical representation; verbal; facial expression; telephone; electronic mail; shouting; and alarms. Even inaction might communicate information.
Information transformation:	Information can be represented in different forms; transformations occur when the representation of information changes. This can happen through artefacts and communications between people. For example, a table of numbers could be represented as a chart or graph; and the strength of a person's opinion might be recorded on a numerical scale.
Information hubs:	Information hubs can be considered as a central focus of where different information channels meet and where different information sources are processed together e.g. where decisions are made on various sources of information. Busy information hubs can be accompanied by buffers to control the information to the hub, which can keep it working effectively.
Buffers:	As information propagates around a system there may be times when the arrival of new information may interfere with important ongoing activity creating conflict and increasing the chances of an error occurring by losing or distorting the new information or the message, or making a mistake with the ongoing activity. Buffering allows the new information to be held up until an appropriate time, when it can be introduced. In the case of the ship there is a phone talker on the bridge who can decide when to report information that he receives over the phone; this will depend upon the activity on the bridge and the urgency of the message received (Hutchins, 1995a).
Communication bandwidth:	"Communication between persons who are copresent in a shared physical environment differs in many ways from communication across a restricted bandwidth" (Hutchins, 1995a, pp 232) e.g. computer mediated communication, radio and telephone will not share the same richness as face-to-face communication.
Informal and formal communication:	Informal and formal communications play important functional roles in the system. This can include the propagation of important information about the state of the system, and the transference of knowledge through stories, which can have important consequences for learning how the system behaves.
Behavioural trigger factors:	It is possible for a group of individuals to operate without an overall plan as each member only needs to know what to do in response to certain local factors. These can be dubbed 'trigger factors' because of their property to trigger behaviour.

Table B.2. Principles related to the Physical Model.

DC Principle:	Description
Situation Awareness:	One of the key things in shared tasks is to keep people informed of what is going on, what has happened and what is planned. This can be influenced by how accessible the work of the team is. For example, in large control rooms the fact that an operator is in one area may lad to the correct inference of what they are doing, as that area pertains so certain activities.
Space & Cognition:	This relates to use space in ways that support cognition e.g. this might include having meaningful piles of paper on your desk, and leaving an umbrella by the door so it is remembered when leaving.
Perceptual Principle:	"Perceptual and spatial representations are more natural and therefore to be preferred over non-perceptual, non-spatial representations, but only if the mapping between the representation and what it stands for is natural – analogous to the real perceptual and spatial environment" (Norman, 1993, pp 72).
Naturalness Principle:	Cognition in relation to a representation is aided when the form of the representation matches the properties of what it represents; in these cases what is experienced is closer to the actual thing, so the necessary mental transformations to make use of the representation are reduced.
Subtle bodily supports:	In interacting with the environment we may use our body to support our cognitive processes e.g. pointing at a place in a book we are reading whilst responding to an interruption is part of the retrieval mechanism of remembering where we are.
Horizon of observation:	The horizon of observation is what can be seen or heard by a person. This will differ for each person in an environment depending on their physical location, the activities they are close to, what they can see, and the manner in which activities take place. The horizon of observation of a person will play a large role in influencing their situation awareness.
Arrangement of equipment:	In the DC approach the physical layout of equipment is not just an issue for physical ergonomists. The physical layout affects access to information and hence the possibilities for computation. As well as physical representations and artefacts this would also hold for the different levels of access to people, their conversations and their work.

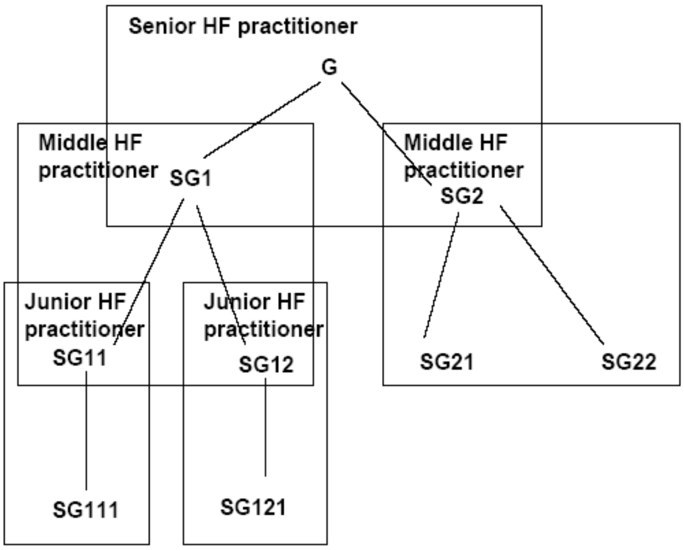
Table B.3. Principles related to the Artefact Model.

DC Principle:	Description
Mediating artefacts:	Mediating artefacts include any artefacts that are brought into coordination in the completion of the task. The full range of mediating structures cannot be listed because they are too numerous but examples include: language, writing, counting, maps, signposts, computer programs, mental models and diaries.
Creating scaffolding:	"The environment is one's partner or cognitive ally in the struggle to control activity. Although most of us are unaware of it, we constantly create external scaffolding to simplify our cognitive tasks" (Hollan et al., 2000, p. 192).
Representation-goal parity:	In Hutchin's (1995b) example of cockpit speeds it is necessary to notice when the declining speed reaches the target speed, at which point the flap setting for the plane should be increased. "One of the coordination processes that is carried out is therefore to make a comparison between a target or goal state (the target speed) and the current state (i.e. the current speed). In order to do this, the goal and current state resources must be brought into co-ordination, and precisely how this happens is highly dependent on the way the resources are represented" (Wright et al., 2000). The closer the representation can be to the cognitive need or goal of the user the more powerful that representation will be (it will be more efficient in addressing the need).
Coordination of resources:	Resources are described as abstract information structures that can be internally and externally coordinated to aid action and cognition by Wright et al. (2000). The six resources that they describe in their Resource Model are: plans, goals, affordance, history, action-effect, and current state. A good example of the coordination of resources is a shopping list which contains a list of goals; if the products are in the order they will be picked up the list will constitute a plan; and if the items on the list are crossed off then the list will show the current state. Without this external coordination of resources the individual will have to internally coordinate the activity, which will become more demanding with the increasing complexity of the activity.

Table 4. Principles related to the Evolutionary Model.

DC Principle:	Description
Cultural heritage:	Hutchins extends Simon's (1981) parable of an ant's movements scouring a beach. In this we are asked to envisage a whole history of ants searching for food. After a time the seemingly random behaviour becomes more focused and directed as the later ants can go straight to the food source. In refraining from attributing a greater intelligence to the later ants the changes that we have actually been observing to influence behaviour has been the changing landscape as chemical trails have been left on the beach. In the same way as ants we haven't changed but have been left with an enriched landscape to support our behaviour. In the case of ship navigation the team has adopted maps, tools, strategies and lessons all developed and laid down by previous generations. This forms part of our cultural heritage.
Expert coupling:	The more interaction and experience a user has with a system the better they perform in it as they become tightly coupled with the environment. Here the processing loops in the functional cognitive system become tight, fast and spontaneous.

Table B.5. Principles related to the Social Model.

DC Principle:	Description
Social structure and goal structure:	The social structure can be superimposed with a goal structure such that a subordinate can only stop when their superior determines that their goals have been met. In this manner the goals filter down through a hierarchy with overlapping responsibility. This creates robustness in the system through group monitoring and job sharing, if necessary, to get the work done. It also means that the system can work through individuals whose main concerns are their local goals. Figure 43: Goal Hierarchy and Distribution of Responsibility (adapted from Hutchins (1995a, pp 203)  Figure 1 shows a goal structure represented by goals and sub-goals (e.g. G, SG1, SG12) and the area of responsibility of agents (e.g. A1, A2, A3). In this representation the agent A1 has overall responsibility of the goal but does not explicitly share the sub-goals performed by A4 and A5. In these cases each agent is aware of their local responsibilities and goals, it is the social structure and the overlap in responsibility that maintains the goal hierarchy. Intermediary agents (in this case A2 and A3) provide the link between the accomplishment of sub-goals (performed by subordinates) to contribute to the overall goal (responsibility of superiors).
Socially distributed properties of cognition:	"The performance of cognitive tasks that exceed individual abilities is always shaped by a social organisation of distributed cognition. Doing without a social organisation of distributed cognition is not an option. The social organisation that is actually used may be appropriate to the task or not. It may produce desirable properties or pathologies. It may be well defined and stable, or may change moment by moment; but there will be one wherever cognitive labour is distributed, and whatever one there is will play a role in determining the cognitive properties of the system that performs the task" (Hutchins, 1995a, pp 262). Two ways that social distribution can be organised to produce some cognitive effect include: 1) lots of overlap and the sharing of responsibilities for error checking, and 2) separating communication channels to make sure that decisions are robust in checking that multiple independent sources agree.

Appendix C1: Introduction to the FRAM Analysis of HF/usability Practice Steps 1 and 2

Appendices C1 and C2 document the four steps of the FRAM analysis of HF/usability practice. This analysis works toward building up a system description which can be interrogated to identify characteristics which affect the functional performance of the HF/usability system. The steps are explained as the analysis progresses. Appendix C1 covers steps 1 and 2 of the analysis, and Appendix C2 covers steps 3 and 4 of the analysis.

Readers are referred to Chapter 11, Section 10.5.3.1, for an introduction to FRAM (Functional Resonance Accident Model).

FRAM Step 1: Identify essential system functions

This step was focused on identifying the main goals and functions of the system. This step identified 29 different functions in the system of HF/usability work. These functional nodes are listed in Table C1.1.

Each functional node was elaborated according to their system function characteristics. Primarily this meant their main input and output. However, it also looked at whether there were preconditions for that function, the time needed, the required resources and what controls were in place. This stage also identified whether the function was focused on human (M), technology (T), and organisational (O) factors.

All these details are contained within the template in parts A and B of Figure C1.1. For example the number and title of the functional node comprise part A in Figure C1.1. The six connectors detailing input, output, precondition, time, resources and controls; and the MTO focus comprise part B in Figure C1.1.

FRAM Step 2: Determine the potential for variability

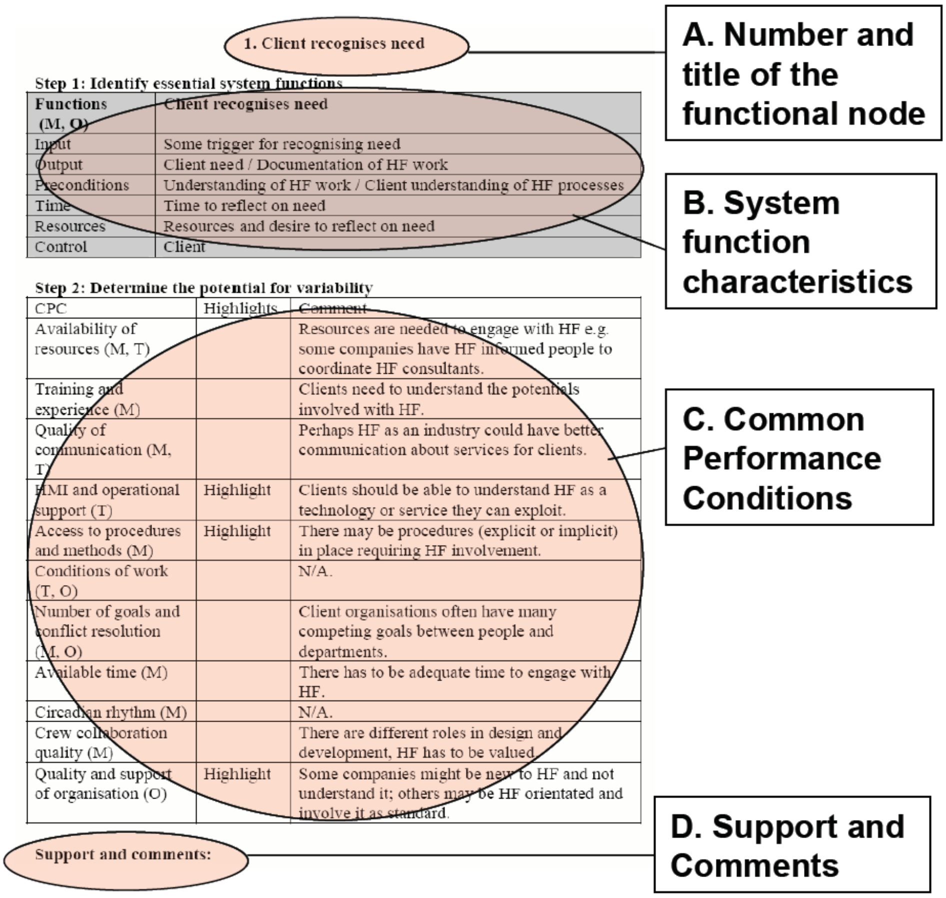
This step used the checklist proposed in Hollnagel (2004, p. 191) for identifying the context dependent common performance conditions (CPC) of the function. Instead of grading the variability of each condition the important conditions are highlighted as the analyst chose not to go to this level of granularity (represented in part C of the template in Figure C1.1).

Steps 1 and 2 are further elaborated on by support and comments which appear in part D of the template in Figure C1.1. The goals and functions developed in this section are integrated as nodes in the FRAM network in Step 3, which provides a graphical representation of their relationship.

Table C1.1 Different functional nodes of HF/usability work.

Functional Node Number	Functional Node Title
1	Client recognises need
2	HF understands client need
3	Work packages are developed
4	Project negotiated
5	Client understands HF processes
6	Resources allocated
7	Methods are developed
8	Select method
9	Tools are developed
10	Select tool
11	Staff are developed
12	Senior HF management
13	Project work performed
14	Development of paper trail
15	Persuade client
16	Reporting practices developed
17	Select reporting practice
18	Analysis of data
19	HF understands project issues
20	HF understands domain
21	Write report
22	Communicate to client
23	Client engages with results
24	Client understands results
25	Client considers results
26	Client acts on results
27	Build reputation
28	Build rapport
29	External audit

Figure C1.1: Sections of the template used for Steps 1 and 2 of the FRAM analysis



1. Client recognises need

Step 1: Identify essential system functions

Functions (M, O)	**Client recognises need**
Input	Some trigger for recognising need
Output	Client need / Documentation of HF work
Preconditions	Understanding of HF work / Client understanding of HF processes
Time	Time to reflect on need
Resources	Resources and desire to reflect on need
Control	Client

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Resources are needed to engage with HF e.g. some companies have HF informed people to coordinate HF consultants.
Training and experience (M)		Clients need to understand the potentials involved with HF.
Quality of communication (M, T)		Perhaps HF as an industry could have better communication about services for clients.
HMI and operational support (T)	Highlight	Clients should be able to understand HF as a technology or service they can exploit.
Access to procedures and methods (M)	Highlight	There may be procedures (explicit or implicit) in place requiring HF involvement.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)		Client organisations often have many competing goals between people and departments.
Available time (M)		There has to be adequate time to engage with HF.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		There are different roles in design and development, HF has to be valued.
Quality and support of organisation (O)	Highlight	Some companies might be new to HF and not understand it; others may be HF orientated and involve it as standard.

Support and comments:

1. Client recognises need

Step 1: Identify essential system functions

Functions (M, O)	Client recognises need
Input	Some trigger for recognising need
Output	Client need / Documentation of HF work
Preconditions	Understanding of HF work / Client understanding of HF processes
Time	Time to reflect on need
Resources	Resources and desire to reflect on need
Control	Client

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Resources are needed to engage with HF e.g. some companies have HF informed people to coordinate HF consultants.
Training and experience (M)		Clients need to understand the potentials involved with HF.
Quality of communication (M, T)		HF as an industry has varied communication about services for clients. Different clients find HF need in different ways.
HMI and operational support (T)	Highlight	Clients should be able to understand HF as a technology or service they can exploit.
Access to procedures and methods (M)	Highlight	There may be procedures (explicit or implicit) in place requiring HF involvement.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)		Client organisations often have many competing goals between people and departments.
Available time (M)		There has to be adequate time to engage with HF.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		There are different roles in design and development, HF has to be valued.
Quality and support of organisation (O)	Highlight	Some companies might be new to HF and not understand it; others may be HF orientated and involve it as standard.

Support and comments:

There are different reasons why clients use usability services. The quotation below shows that most are financially driven, some are driven by legislation and others adopted as a matter of course:

> "R: Probably some in the US are legislation driven. I'm trying to think of specific examples. Most of them are financially driven. Most of them believe that usability is going to do something in terms of returning on their investment. But some don't articulate it that way. I'm thinking of one client in particular that just knows it's the right way to do it and doesn't question it." W9

Practitioners referred to a range of reasons to do with why clients sought usability services. Most identified this with some underlying motivation toward revenue generation. However, some specified examples that were not about money, e.g. to comply with legislation, to conform to their own internal procedures, to fulfil contractual obligations, as part of a media showcase, to improve safety and performance, to do the same as competitors, because it is fashionable to do so, and for political reasons like gathering independent evidence to support an argument.

The respondent below compares the maturity of how clients differ in their acceptance of HF/usability services to the maturity of safety cultures, where level five is very mature and accepting and level one is safety naïve:

> "R: The motivators tend to be that someone is pushing them to sort themselves out at the beginning... I think actually the safety culture is actually good way of describing it because you have different stages of safety culture. If a company is at the fifth stage which is like the top stage, then they will want to improve continuously, they're really high up, they have got very good safety but they can see that they can drive it further and further; and they would come and approach us on their own as part of some kind of programme because they're thinking let's try and do more in human factors. But if you've got someone who is at number one then, who is right at the other stage who doesn't even know that they've got a problem, just get on with it, do the job day to day, get things done, but don't really think about how they can change or improve, they're not going to come and try and find human factors help, but they are the type of company that's then going to have some accident and then the [regulator] is going to come along [reprimand them]." S3

Companies will also carry out prospective work to try and generate business i.e. they will try to encourage the client to recognise a need and acquire their services:

> "R: Erm yes... done heuristics […] it's more set criteria and that was more for driving sales opportunities I guess in terms of things like who's got poor accessibility, who's got poor usability, because if you can go to someone and say, we've evaluated a load of websites and yours frankly isn't as good as your competitors we can help you to improve this and improve that, again that can be quite a powerful means for getting your foot in the door. I did that for a number of sites, UK financial sites […]" W4

This commentary shows that different clients will recognise need for usability in different ways depending on their own maturity of acceptance toward HF/usability services, whether they can recognise a specific need themselves, or whether they are encouraged by others. These different needs will have to be understood and catered for by HF/usability practitioners.

2. HF understands client need

Step 1: Identify essential system functions

Functions (M)	HF understands client need
Input	Client need
Output	Understanding of client need
Preconditions	Client approaches HF
Time	Time to reflect on need
Resources	Competent staff
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)	Highlight	Need time and expertise to understand clients' issues, even when they might not understand the real issues themselves.
Training and experience (M)		Experience is needed to understand and translate into HF issues.
Quality of communication (M, T)		Important so both parties understand each other.
HMI and operational support (T)		N/A.
Access to procedures and methods (M)		Implicit in the experience of HF practitioner, also maybe company standard practices.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)		It is important to understand the conflicting goals of the client, so they can be resolved and the true goals focused on.
Available time (M)		Need time to understand clients issues.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		Need time with, and access to, key stakeholders.
Quality and support of organisation (O)		If culture of the company values HF then they will be given more time and attention.

Support and comments:

The straightforward case is that a client has recognised a need that is clearly translated into HF/usability terms and so the project can be planned. However, there are more complicated scenarios. For example, where the client doesn't know their need:

> "R: Yeah, it would range... well the unspoken assumption behind that question is that all the clients know why they have come to us, and they don't, sometimes the biggest portion of our job is to work with them to figure that out." W8

There is also the scenario that the ‘client’ has internal inconsistencies as in this case where part of the client company was satisfied and another part saw problems with the recommendations:

> “actually and I have had one project recently where there was a team and I only had contact with the middle management team for a while, and they loved the work, the absolutely loved the work, presented it back and they were ecstatic, then they arranged for me to meet the director who was going to make the final decision and he hated it, hated the whole lot, he just said it doesn't meet our business objectives at all and I think he might have had a point. Because the remit I was given was come up with the best user experience proposition and nothing else, if I had been thinking about the business proposition in that project then I might have taken more his point of view.” W5

Then there is the scenario where even highly experienced practitioners do not have a clear grasp of what the project is about before the research i.e. so the client’s real need unveils itself in the process of project work or becomes clear only after the work has been complete:

> “as I say it was the navigation system, the main problem was presented was that people didn’t understand the numbers, so it became a problem of understanding statistics, and the way that that was displayed was seen as the issue, because the displays were very poor in those days, but it ended up much more to do with organisational change, people being comfortable that computers were there at all.” S5

This commentary shows that there are different scenarios concerning the HF/usability practitioner’s understanding of the client need. There is the straightforward case where both parties understand the need, the case where the client needs help to understand their need, the case where part of the client organisation has a different understanding to another part, and the case where the real need remains concealed before the research has started.

3. Work packages are developed

Step 1: Identify essential system functions

Functions (M)	Work packages are developed
Input	Understanding of client need / Some method / Some tool / Some reporting practice
Output	Potential work packages
Preconditions	Client is interested in HF potential
Time	Time to develop work packages
Resources	Methods / Tools / Competent staff
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Resources are needed for the process of planning, and for the proposed events.
Training and experience (M)	Highlight	Expertise so tools and methods are adopted and adapted correctly.
Quality of communication (M, T)		Work packages need to be communicated so client understands choices and consequences of decisions.
HMI and operational support (T)		N/A
Access to procedures and methods (M)	Highlight	Access to procedures, tools and methods for work package development. Implicit access via experience and expertise seems most efficient, rather than referring to unknown procedures.
Conditions of work (T, O)		N/A
Number of goals and conflict resolution (M, O)		Need to balance between doing current work and securing new contracts. Also balance between ideal research package and pragmatics of the situation.
Available time (M)		Adequate time needed to think about and write the proposal.
Circadian rhythm (M)		N/A
Crew collaboration quality (M)		HF management should oversee work package development, and client should provide information so project can be tailored for them.
Quality and support of organisation (O)		N/A

Support and comments:

From understanding the client need the practitioner can start to develop a proposed plan of work to meet that need. Very experienced practitioners have various project options accessible to them to suit the situation. This quotation shows some of a respondent’s thought processes when designing work packages:

> "From the scope of work I typically read it and quite often identify what is the problem because a client might not know what their problem is, and from the wording from the client you can quite quickly pick up on, yeah, they've got a human error problem […] So first of all, you would be breaking down the work packages, so typically the first work package would be 'kick off meeting', […], so identify the key parts in the project, then within the control room design I would typically probably have maybe a work package for task analysis,[…] I would also typically develop an equipment list so from that task analysis […] from that I may identify which equipment relates to which task and then you are maybe getting into the stage of possibly doing a link analysis, […] then I would have to start performing some sort of work load study, in which case I'll flesh out a work package where I'll be speaking to operators[…], it all starts coming together then, because you say 'right well my work load analysis is telling me that I've got three or four people and I've got this much equipment, I've got this much space to work with', you can kind of, fit it all together." S10

The quotation below reminds us that designing research must also take the pragmatics of the situation into account:

> "There's not only ideal research conditions there's realities for times, budget …, and sometimes those things play off against themselves and when you design a research project you've got to think of the options, if we do this that lowers the cost, the effect might be a certain lack of robustness in this particular area …, or if you're having trouble getting users of this variety we could use this parallel group of users and change the methodology in such and such a way." W8

This commentary demonstrates that practitioners develop project plans according to the issues that they have to overcome to meet the client need whilst conforming to the pragmatics of the situation. The proposed work will shape the work carried out in the project.

4. Project negotiated

Step 1: Identify essential system functions

Functions (M, O)	Project negotiated
Input	Potential work packages / Persuaded client
Output	Agreed project / Rapport / Documentation of HF work
Preconditions	Resource available
Time	Time to reflect on project
Resources	Competent staff
Control	Client understanding of HF processes / HF management /

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Appropriate resources have to be committed for the project to work.
Training and experience (M)	Highlight	Experience for negotiating, selling, correct work package planning, and client need understanding.
Quality of communication (M, T)		Required so HF and client understand each other adequately.
HMI and operational support (T)		N/A
Access to procedures and methods (M)		Required so correct work packages are developed.
Conditions of work (T, O)		N/A
Number of goals and conflict resolution (M, O)	Highlight	Negotiation between ideal HF project work and the realities and constraints of the context e.g. time, budget, preferences and access to users.
Available time (M)		Adequate time to negotiate.
Circadian rhythm (M)		N/A
Crew collaboration quality (M)		Rapport can build trust between parties allowing more freedom.
Quality and support of organisation (O)		If organisations have worked together before they will be in a better position to support each other.

Support and comments:

The project is negotiated so the HF/usability practitioner and the client agree on what the goals of the project are and what work will be done to meet those goals. This quotation highlights how the agreed contract already gives shape to the work and the recommendations of the project work:

> "you also have a really good idea of the changes that they want to make because you have the signed contract in front of you, so you know what kind of changes they're after, so they want to make it easier to find X and Y on their website or they want to make it simpler for users and limit the click path the users have to take." W2

Again we are reminded at the project negotiation stage that the client is controlling the resources and so they have an overbearing influence on what work packages should be funded under the advice of the HF practitioners. Here a respondent says that they tried to push for more methodology but that it wasn't feasible for the client's time scales:

> "Yeah the biggest thing really is that was kind of the areas that we could sell in, […] it was kind of difficult to do some ethnographic research or anything like that, which would be great, and we did try and push a couple of times, [it] not feasible for our clients and the time scales were quite often […] you needed something like yesterday. It meant that we were limited in the methodologies that we were going to use. We just had to focus on two or three key points of the project that we could actually get involved in actually making a difference." W6

The project is negotiated to meet the client's need under constrained resources.

5. Client understands HF processes

Step 1: Identify essential system functions

Functions (M)	Client understands HF processes
Input	Potential work packages / Agreed project / Understanding of HF work
Output	Client understanding of HF processes
Preconditions	Client interacts with HF
Time	Time to reflect on HF
Resources	N/A
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)	Highlight	Client should have sufficient resources to understand HF processes e.g. some companies have HF informed people.
Training and experience (M)		Clients should understand HF processes more and more through interaction with it.
Quality of communication (M, T)		To help the client understand.
HMI and operational support (T)		N/A
Access to procedures and methods (M)		Access to these is good for client learning.
Conditions of work (T, O)		N/A
Number of goals and conflict resolution (M, O)		Often HF isn't part of a clients normal work so they have other goals and drives which motivate them.
Available time (M)		Time given to HF.
Circadian rhythm (M)		N/A
Crew collaboration quality (M)		Client should collaborate with HF to understand potentials and procedures.
Quality and support of organisation (O)		A client can have a more or less friendly HF culture.

Support and comments:

As was explained in the '1. Client recognises their need' section above, there are different sorts of clients: from those that incorporate HF/usability services as a matter of course and those that are very naïve as to what they can offer as this quotation illustrates:

> "So we're doing a lot of work at the moment in [industry] and the people that we are working with have human factors problems and they know they have human factors problems because they have been told to sort themselves out basically, but they don't know anything about human factors at all.
>
> I: Who's told them that?

R: The [regulator]." S3

It has also been observed that clients learn more and more about HF/usability services as they have more interaction with them.

> "There's an education process definitely, I think about 4 or 5 years ago that definitely being the case, I remember […] trying to explain just the very basics, why you should do usability testing at all during the process never mind the different techniques or anything, […]it's a lot better, it got to a point […] where clients were actually coming in and saying we want testing at this point, this point, this point" W6

There are different sorts of clients which will affect the relationship and pattern of the negotiation. At one end clients will know very little about HF/usability processes and at the other end clients will actually employ their own HF/usability informed people that can liaise with consultants on their level of expertise in their terms. It has also been observed that over time clients will learn more about HF processes through repeated contact, and so move from a naïve position to informed.

6. Resources allocated

Step 1: Identify essential system functions

Functions (M, O)	Resources allocated
Input	Potential work packages
Output	Agreed project
Preconditions	Client understanding of HF processes
Time	Time to reflect on project
Resources	Adequate resources for project
Control	HF management

Step 2: Determine the potential for variability

CPC	Value	Comment
Availability of resources (M, T)	Highlight	Resources obviously must be available for the agreed project plan.
Training and experience (M)	Highlight	Experience of running projects must lead to more accurate predictions and costs of the project plan.
Quality of communication (M, T)		Communication is essential so both sides understand each other.
HMI and operational support (T)		N/A
Access to procedures and methods (M)		There may be standard projects and costs to base estimates on.
Conditions of work (T, O)		The way the project is planned will affect working conditions in the project, for example the company might get practitioners to do overtime to get more work at a lower cost.
Number of goals and conflict resolution (M, O)		Goals in terms of an ideal research situation and pragmatics of the research have to be resolved.
Available time (M)		Adequate time has to be allocated for this process.
Circadian rhythm (M)		N/A
Crew collaboration quality (M)		More freedom might be given to companies that have a good relationship.
Quality and support of organisation (O)		More freedom might be given to companies that have a good relationship.

Support and comments:

The allocation of resources plays a large role in project negotiation, as the client will often want a competitive offering and value for their money. When considering what methods to use for a project the constraints and pragmatics of the situation are of constant concern in practice:

> “there would be several steps […] to go through before it was even considered to be used, we might think, ‘oh that’s brilliant, lets use it, we’ve got plenty of time, plenty of money, great, but that doesn’t happen very often, and we will kind of be assessing it, is this going

> to add value and is this going to cost the company too much money from what we are going to gain from using it?" S10

Sometimes resources are not constrained:

> "We have a client now who is just throwing stuff at us and it's hard for us to keep up with it. And money is not a big issue" W9

However, when they are constrained they have to be managed, and depending on the values of the company and the style of work the pressure on resources might be focused on different parts of the system:

> "the consulting firm, that I worked for so many years ago constantly under sold projects, I never ever worked less than sixty hour weeks there, it was constant push push push […] it was all about getting the most money for the shortest amount of time, we were all on salary so it didn't matter whether we were working 40 hours or 80 hours it's still salary […]. It was really unfortunate it was one of the many reasons I chose to leave because it was just a ridiculous culture, a ridiculous way of thinking." W2

The allocation of resources plays a large role in project work; it will affect what methods are performed and how they are performed. Sometimes resources are not a problem, but it is more often the case that a client will want a competitive proposal for their investment. The balance between cost and quality will be offered by HF practice and evaluated and chosen by the clients.

7. Methods are developed

Step 1: Identify essential system functions

Functions (M, T, O)	Methods are developed
Input	Methods are developed in industry and academia
Output	Many methods
Preconditions	N/A
Time	Adequate time to research and develop
Resources	Funding for research and development
Control	HF management / Academia / Funding bodies

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)	Highlight	The funding that is available affects the research breadth and depth in this area.
Training and experience (M)		Experienced people can build on previous research and move it forward in interesting ways.
Quality of communication (M, T)		Good communication has to be maintained between different groups so research is useful, usable and used.
HMI and operational support (T)		Methods should be useful, usable and used.
Access to procedures and methods (M)		Access to previous research is required so researchers can develop new areas.
Conditions of work (T, O)		If there is too much pressure to do project work in consulting then method development may be neglected in practice.
Number of goals and conflict resolution (M, O)		There has to be a balance in practice in practitioners doing their paid consultancy work, and developing methods.
Available time (M)		Adequate time has to be given to research.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		People may be encouraged and supported to develop methods in practice.
Quality and support of organisation (O)	Highlight	There may be more or less of a climate for research into method development, and making sure this is useful, usable and used rather than just published.

Support and comments:

Methods are developed in academia and in industry, with developments in one sparking developments in another. However, there is not always the opportunity to utilise research in a practical context if the need is not there:

> "It was a piece of work on situation awareness amongst teams, its very early stages […] it was really interesting approach to trying to find out where errors can occur in a group environment not just within an individual environment. But getting a client to agree to that kind of study, unless there has been a significant accident that they believe is

contrived from group error, it would never happen, so that piece of research, as fascinating as it is, I don't know how it's going to go from being research to being applied in the real world." S10

Another practitioner observes that the marketing of ideas, even in academia, plays a role in their proliferation:

"If I don't agree with an approach then intellectually I like to show why it's wrong, and write a paper about it. But it requires considerable stamina to go beyond that, […] to write paper after paper saying why this is a different approach.

I: Almost like marketing, really cement it down and push on at it.

R: Yes. I'm sure some people love to take their ideas as far as they can, but I lose interest. Once I've done it to my satisfaction, and said what I wanted to say then I feel that should be good enough." S11

Methods are communicated from research to practice and if practitioners can find some value in different approaches then they will adopt and use them. This quotation shows how ideas might be proliferated from a talk at a conference, through different practitioners trying the new approach and those practitioners moving to new companies spreading the practice:

"I mean I was CHI last year and my boss was with me we saw this one really cool information given by an [X] guy about trying to standardize usability measures, and they had this really interesting idea and then she went back and she tries it, now if she tries it and it works well then she'll tell her colleagues and they'll tell their colleagues, and it percolates up that way very often, but she was not the only professional sitting their, and that guy working at [X] now may not be working at [X] tomorrow." W2

Like tools and reporting practices, methods are developed in academia and industry. Sometimes they are more successful at affecting practice than other times and such things as the need for that method or the way ideas proliferate will affect this.

8. Select method

Step 1: Identify essential system functions

Functions (M, T, O)	Select method
Input	Many methods
Output	Some method
Preconditions	Experience: Awareness of methods and their applicability
Time	Time to search methods and consider applicability
Resources	Competent staff
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)	Highlight	Past projects of the practitioner and company will inform what will work well in the future.
Training and experience (M)		Practitioner's expertise will guide their options and choice.
Quality of communication (M, T)		Communication between practitioners can help when getting advice.
HMI and operational support (T)		Archiving systems may help in finding previous similar projects to current ones.
Access to procedures and methods (M)		The practitioner should have easy access to past projects and sources of methods.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)		Practitioners need to balance ideal research circumstances with the pragmatics of the situation.
Available time (M)		Adequate time is needed for method selection, although experienced people often do this quickly once the client need is understood.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		HF practitioners working in groups can get advice from others.
Quality and support of organisation (O)		Companies may be more or less supportive in allowing for the search and selection of new practices.

Support and comments:

Methods are selected based on the project need and with consideration to the constraints of the situation. Selection also involves what the practitioner is used to:

> "I: if you are approaching a new problem how do you negotiate that selection and what you are actually going to do?
>
> R: I would imagine, and this isn't my area, I would imagine that you would just use the one that is most appropriate and the one that you are used to. […] It's always focus on the problem, and illustrate to the customer that you have solved this type of problem before, you can solve this problem, and then worry about what tools you use based on [what is needed], and practical concerns come into it." S12

This selection process can become a bit of a non-issue for experienced practitioners as this quotation demonstrates:

> "there has got to be a belief that there is a problem there and what method you select is probably, I can't imagine how it's a choice! If it's training it's one set of things, if it's manpower its another set of things, I mean, there may be some slight variation of what people try to do, but in broad terms, I've never seen it as an issue, the issue normally is, do we have any idea of what the problem is" S5

The above quote shows that the HF/usability issue shapes the selection. It also gives support to the observation that experienced practitioners have problem categories and methods to tackle these problems which are readily accessible to them. This ease of accessibility is supported by habituation and this can be demonstrated at an organisational as well as an individual level. The quotation below shows that the organisation has developed ways over working:

> "We work in a particular way. Over the past 25 years, (this company has been going for a long time) we have (refined a set of methodologies with in a process) used methodologies that are very standard to us […]. Although... our methodologies are standardised, our deliverables are standardised, you still need to be able to manipulate those for the purpose of each project or client. If something's different, if you don't have that depth of knowledge you can't be flexible with your methods or process, it's not really turning the handle. Does that make sense?" W9

Method selection obviously affects the way the project is performed and its outcome. They are selected on their suitability for addressing the HF/usability problem, the constraints of the context, and their familiarity with the HF practitioner and organisation. Organisations develop ways of working which they can tweak and adapt for the context of different projects. W9 stresses that those with a clear understanding of the domain can more easily and reliably manipulate the process and/or methodologies to cater for the requirements of each project. You cannot expect every client or project to fit into the mould.

9. Tools are developed

Step 1: Identify essential system functions

Functions (M, T, O)	9. Tools are developed
Input	Tools are developed in industry and academia
Output	Many tools
Preconditions	N/A
Time	Adequate time to research and develop
Resources	Funding for research and development
Control	HF management / Academia / Funding bodies

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)	Highlight	The funding that is available affects the research breadth and depth in this area.
Training and experience (M)		Experienced people can build on previous research and move it forward in interesting ways.
Quality of communication (M, T)		Good communication has to be maintained between different groups so research is useful, usable and used.
HMI and operational support (T)		Tools should be useful, usable and used.
Access to procedures and methods (M)		Access to previous research is required so researchers can develop new areas.
Conditions of work (T, O)		If there is too much pressure to do project work in consulting then tool development may be neglected in practice.
Number of goals and conflict resolution (M, O)		There has to be a balance in practice in practitioners doing their paid consultancy work, and developing tools.
Available time (M)		Adequate time has to be given to research.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		People may be encouraged and supported to develop tools in practice.
Quality and support of organisation (O)	Highlight	There may be more or less of a climate for research into tool development, and making sure this is useful, usable and used rather than just published.

Support and comments:

Like methods, tools are developed in academia and in industry. Sometimes they will develop in both and enhance each others work as this quotation illustrates:

> “R: Part of it did, it used a tool called [tool Y] and that came from […] University, I’ve forgotten who developed that, […]. And then the other side of [tool] is my tool [x], two of them have been put together and they support one thing, it works quite well, in 2003 I was doing a work load assessment on the project I’ve been doing, now I’ve assessed fifteen [designs] and it took me less time than it took me to do the original one for [tool x], because it has been developed into software and a tool, and it’s easy to use.” S10

However, tool development isn't always as successful as one practitioner comments that academics do not have the interest in making their tools commercially useable as it isn't their primary motivation:

> "Well over the last fifteen years I've done surveys, and I mean serious surveys probably about half a dozen and the single biggest thing with most alleged tools is actually they have never been developed to a state that it is useful[…]. I don't think the academics ever had any interest in developing to a point where they could be understood, because that isn't how academics get ahead, move up the chain." S5

This practitioner describes tool development in academia as the next step on from developing theories and models:

> "like academia may produce some theories and models, but then it's up to the consultants to take that into a tool, but if the academics could take that one step further maybe, the progress and development of tools would be faster, because we wouldn't have to ask a client, occasionally a client pays us money […] it's up to the client to give you the budget to spend the time developing that kind of software tool." S10

Practitioners who have the skills, time and money can try to develop their own tools because they are reluctant to spend large amounts of money on tools they are not confident in and which they might not use again:

> "Anything that involves us having to spend a lot of money, we're quite reluctant as we don't know whether we are going to use it on other projects and we don't know whether if it is going to be any good anyway, even if there is a trial it's only once you've used it for a whole project that you realize... so often we have to build our own sort of tools, using Access or some other sort of thing. Not everyone knows how to programme visual basic or knows about these type of things, so it depends on the person, whether they do that or just end up doing it by hand." S7

Tools are developed in academia and in industry, sometimes with more success than others. It seems that commercially viable tools are not a common output of academic work. Where commercially viable tools are available they can involve a high investment cost and practitioners might not be confident in the benefits of using them.

10. Select tool

Step 1: Identify essential system functions

Functions (M, T, O)	Select tool
Input	Many tools
Output	Some tool
Preconditions	Experience: Awareness of tools and their applicability
Time	Time to search tools and consider applicability
Resources	Competent staff
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)	Highlight	Past projects of the practitioner and company will inform what will work well in the future. Lack of tool support may put off certain practices, and good tool support may attract to other practices.
Training and experience (M)		Practitioner's expertise will guide their options and choice.
Quality of communication (M, T)		Communication between practitioners can help when getting advice.
HMI and operational support (T)		HMI will affect the tools' usability, usefulness and whether it is used.
Access to procedures and methods (M)		Presupposes that a selection of tools and their applicability is available to practitioners.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)		Adequate time is needed for tool selection, although experienced people often do this quickly once the client need is understood.
Available time (M)		Adequate time for selecting tool.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		HF practitioners working in groups can get advice from others.
Quality and support of organisation (O)		Companies may be more or less supportive in allowing for the search and selection of new practices.

Support and comments:

Tools can save a lot of work when they are implemented in a useful way as this quotation demonstrates:

> "an excellent example of that which I've used recently is the [x] tool, […], it's been integrated with other tools and there is now an Access database that basically runs all the calculations and the maths in the background, so now where before, it took me several weeks to develop the tool to apply it, literally, but now I can do one of these work load assessments in a couple of hours because all I'm doing is inputting raw data and the computer does the rest." S10

Tools which are useful like this are added to the practitioner's repertoire of things that they can call upon to help perform their work:

> "Once you've used it once, it's there and you can use it on other projects. It tends to be more a requirement of a particular project where you use it, and tools that you find are really useful end up going into the repertoire of the tools you've already got." S13

However, when tools are not implemented in a useful or usable way, and so the cost of using them is high, then practitioners will adapt their practices and work around the problem:

> "Yes but not always in terms of things like highlight videos and stuff like that... I was surprised that all the testing that I have been involved in although it is all being recorded none of it is actually taken to use as highlight video and I think the reason for that is that it is a time consuming process, and unless there's a very good reason that... again something like that is good in terms of buy in and getting people aware of the problem, but if they're already aware of it or there's not the budget to spend two or three days doing it then it doesn't really get done so" W4

When useful and usable tools can be selected and become part of a practitioner's repertoire of tools which help them perform their work. When there are activities that involve cumbersome manipulations, like the video editing example above, then practitioners are likely to find an alternative route. So, tools can inhibit or enhance particular practices.

11. Staff are developed

Step 1: Identify essential system functions

Functions (M, T, O)	Staff are developed
Input	HF experience / Increased reputation / Increased rapport
Output	Competent staff
Preconditions	N/A
Time	Time to develop staff e.g. training, mentoring, supervision
Resources	Staff
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Senior staff should have the resources and time to support and train junior members.
Training and experience (M)		Senior staff should have experience to support and train junior members.
Quality of communication (M, T)		More frequent and better communication with junior members will lead to more implicit learning.
HMI and operational support (T)		Tools and methods that are easier to learn will require less start up cost.
Access to procedures and methods (M)		Junior members could have access to previous work as an example.
Conditions of work (T, O)		Some companies might be more willing to take on junior members and develop them.
Number of goals and conflict resolution (M, O)		Training and supporting staff conflicts with having staff that can get on and do the job already.
Available time (M)		Adequate time is needed for mentoring on the job, and training outside of the job.
Circadian rhythm (M)		N/A
Crew collaboration quality (M)	Highlight	Better collaboration between experienced and junior staff can lead to implicit learning.
Quality and support of organisation (O)		Some companies might be more willing to take on junior members and develop them.

Support and comments:

HF/usability staff do many different parts of the entire cycle of project work and so they are a critical resource for the performance of the system. The more developed they are they the more responsibility they will be given and the more they can be left to function autonomously. However, we should not depersonalise them as a ‘resource,’ they are individuals and should be treated as such:

> “You certainly wouldn't send someone in their first day to do that, they wouldn't have the tools and experience, we try and, people evolve at their own rates, not every project is so complex that it requires somebody with a [depth] of experience to sort it out, and so as

> opportunities come up that are where people are at they get to sort of dive in, people also have different comfort zones, I can think of consultants that for years weren't comfortable with the business side of things and other people who were ready for that maybe within the [first month in the role] so it has to do with comfort level and desire but not job title." W8

HF/practitioners are not passive entities to be developed but want the opportunity to learn more and progress:

> "Saying that, most of the projects that I work on now are team projects where there is either two or three of us working together. So once you get people involved in those you can learn from each other, which I prefer because there are some guys that have 25 years experience and I want to know what they know [laughs] I don't want to keep doing what I think is the right thing if they... if I can learn more." S3

Another example, is a practitioner who believes experience at a dedicated usability consultancy would have given her more and better opportunity to learn:

> "I like the company, but I think I would have learnt faster at a consultancy, I would have done more testing, better examples, better mentoring, and this bank of knowledge like shared slides..." W3

Staff are a critical resource that carry out HF/usability work and their development needs to be managed as it will affect the performance of the system. They are individuals with different skills, needs and goals. They can recognise and promote their own development opportunities.

12. Senior HF management

Step 1: Identify essential system functions

Functions (M, T, O)	Senior HF management
Input	Competent staff
Output	HF management
Preconditions	HF experience
Time	Adequate time for staff to develop and mature
Resources	N/A
Control	N/A

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Management should have adequate staff and resources to configure for project work.
Training and experience (M)	Highlight	Senior staff should be sufficiently experienced for management.
Quality of communication (M, T)		Senior staff should facilitate good communication in management.
HMI and operational support (T)		Management should facilitate operational support.
Access to procedures and methods (M)		Senior staff should be aware of procedures and methods.
Conditions of work (T, O)		Management influence the conditions of work.
Number of goals and conflict resolution (M, O)		Senior staff should have adequate judgements to resolve conflicts
Available time (M)		Senior staff should have adequate time to manage properly.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		Management should have a good rapport with staff to facilitate management.
Quality and support of organisation (O)		Management to support and facilitate a suitable company culture.

Support and comments:

As HF/usability staff develop they become more competent, gain more responsibility and move in to more managerial and mentoring positions. This movement is illustrated by one practitioner who outlines their company structure:

> "[Tier A] is students, [Tier B] is admin staff and so on, [Tier C] is graduate, [Tier D] is graduate with experience or possibly MSc […]. The sort of job description for a [Tier C] would be: do what you're told and do good work, the job description for a [Tier D] would be do what you are told, produce good work, write the odd bit, make the odd customer contact, make a presentation, bring something back from the customer and work with the team to develop it, that sort of thing. My job role would probably be described as all of

> the above plus actively pursues contact with customers and go out and solve their problems for them […]. As you get to [Tier F] and [G] you tend to take on much more team leadership generally rather than just on a project by project basis.
>
> I: More strategic?
>
> R: Yeah and being involved in the strategy development, absolutely." (Respondent S12)

Senior members of staff are likely to be in positions where they manage projects, manage other staff, and ensure that correct practices and quality is maintained throughout the project work as this quotation demonstrates:

> "Well basically I do some sales work, and prepare lots of proposal from the technical side, and do pre-sales and marketing. I also do more people management as well. I'm also responsible for the quality of all our deliverables, including project plans and what solutions we propose for our clients and how we respond to RFPs So requests for information or requests for services so that's all my responsibility." W9

Senior HF/usability practitioners have much expertise and experience, hence they are put in positions where they face the client, negotiate and make sure that the project runs smoothly. They will mentor and help other staff to improve the performance of the system in general.

13. Project work performed

Step 1: Identify essential system functions

Functions (M, T, O)	Project work performed
Input	Agreed project
Output	Data for analysis / HF experience / Communication with client / Documentation of HF work
Preconditions	Project has been agreed and resourced
Time	Adequate time for project
Resources	Competent staff / Resources for project e.g. tools, methods, software, access to users, equipment.
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Adequate staff and resources should be available for the project e.g. access to users, eye tracking software, prototype.
Training and experience (M)	Highlight	HF practitioners should be competent at the project work they are performing.
Quality of communication (M, T)		Depending on the method practitioners may be alone or may communicate with client e.g. work shop, observing user tests.
HMI and operational support (T)		HF practitioners should have access to appropriate support and equipment to do their work.
Access to procedures and methods (M)		HF practitioners should have access to methods, procedures, past reports and colleagues for help.
Conditions of work (T, O)		Conditions should be suitable for work e.g. user laboratory, in the field.
Number of goals and conflict resolution (M, O)		Goal conflicts should have been resolved in plan but some may come up as research is never certain e.g. users may be hard to obtain so changes in method may ensue.
Available time (M)		Adequate time should be allowed for project work.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		HF practitioners may ask other HF practitioners for advice, or collaborate with client personnel.
Quality and support of organisation (O)		Roles should be respected and appropriate support given to project work.

Support and comments:

The stage of actually doing the project work is a key point. It brings together what has been planned and negotiated, staff as resource, senior staff as management, learning about the situation under study, giving staff experience of the domain and methods, and allows the opportunity for client learning if that is incorporated.

The project work phase is focused on meeting the client need and this is kept in mind during the project where possible, so the work moves in the right direction:

> "R: You spend a lot of time acclimatizing yourself to the information you need to play with and whatever those things are that exist already, in the way that they represent information already, you also have a really good idea of the changes that they want to make because you have the signed contract in front of you, so you know what kind of changes they're after, so they want to make it easier to find X and Y on their website or they want to make it simpler for users and limit the click path for users have to take." W2

As project after project is performed practitioners recognise common problems and solutions:

> "R: Once you've been a consultant for two years you may have worked on three or four retail sites, three or four services sites, and if you keep on websites you will encounter the same problems, like what does the contact page look like, so you are repeating applying the same knowledge to a version of the same sort of thing, I mean websites aren't that different..." W3

This development of expertise provides increased efficiency for the practitioners working on projects as they can exploit the best practice they are developing:

> "You look at what other people do and you say yeah it works! So things like putting the numbers at the top of a page as you go through a sequence for registration so you know you are in step 3 and it has 5 steps, and you can go back and fourth through that, I have no idea who did that first but hey it works!" W9

Practitioners are not the only people that can learn directly from project work as one shows that they will take advantage of the opportunity for clients to directly observe user testing should the method allow:

> "If a methodology allows it we always encourage [clients] to come and watch, we think that they can learn much more from actually seeing users use a product than they can from actually reading a report." W8

The phase of project work is the middle of the project where agreed plans are performed and progress is made in meeting the clients need. It requires competent staff, understanding, and good foresight in planning for it to be effective. Practitioners will use their experience in making the most of insights and recommendations throughout the project work. It is also observed that some will involve clients at this stage if they can discern some tangible benefit from doing so e.g. getting added buy-in and persuasion from the client.

14. Development of paper trail

Step 1: Identify essential system functions

Functions (M, T, O)	Development of paper trail
Input	Documentation from HF work
Output	Store of documentation
Preconditions	HF work is done
Time	Adequate time for filing and storage
Resources	Resources for storage
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Adequate technology and capacity has to be available for archiving if necessary.
Training and experience (M)		There should be appropriate training on archiving if necessary.
Quality of communication (M, T)		Informal communication can often help in learning how to use systems and finding suitable files.
HMI and operational support (T)		If archiving or filing systems are used these should be usable, useful and used.
Access to procedures and methods (M)		If archiving is practiced then procedures should be wide spread.
Conditions of work (T, O)		If necessary working conditions should allow time for archiving.
Number of goals and conflict resolution (M, O)		The cost of filing effectively has to be resolved with getting on and doing more work.
Available time (M)		There should be appropriate time to archive if necessary.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		All crew should partake in archiving if necessary and help the process.
Quality and support of organisation (O)	Highlight	Companies may have more or less of a culture of archiving and auditing.

Support and comments:

The documentation of processes, decisions, communications and methodologies are more valued and important in some contexts than in others. This documentation and record of actions can act as a resource for project work as similar projects and problems can be referred to, to inform and provide support for current issues:

> "Well they have... when they present to the client they have a standard presentation that they give, like so they reuse, so they'll basically have a folder somewhere that'll say useful slides and there'll be one called communicating info scent and... and when you're putting a presentation together for a client you'll put those slides in, and what else is there I'll put those slides in... so you're building this research that you [reuse for clients]." W3

This organisational knowledge that is stored in reports, presentations and other forms of documentation is treated as a valuable knowledge store by some organisations. This quotation shows a company that has thought it worth investing in technology to make the storing and sharing of information easier:

> "we've just finished a huge repository project where we have our own personal knowledge management system that we have redesigned and implemented, so I personally have access to all the company information but I also have access to every project that we've ever done. So I can have a look at what we've done for a client here that we have dealt with in another country. I can see what's been done, and I can see some other project we did where we have evaluated household appliances, we're also doing work on a [medical] machine which is an international project" W9

Organisations and practices who are in an auditing culture and expect to be audited will take this into account even when it might not be of direct interest to their client:

> "I think what we're going to try and do is bear in mind is that the [regulator] will be reading it, so they need to see the methods we used, and they need to know what we've been looking at. But the end of it will be the recommendations and that's the only bit that the […] company will care about, they don't care how many interviews we did, who we spoke to or what we asked. They just want to know how it is going to be resolved, how much it is going to cost them and that sort of thing. So it depends who is going to be seeing it. So I'm not sure... I think it is important to write everything down because if anyone comes back to you and asks you a question then it's there." S3

Other organisations might have less of a need for formal documentation of decisions and processes. This quotation shows that more formal documentation is employed when the detail is required for others to build the system, but actually a more detailed and formal documentation of decisions would be in conflict with the 'ebb and flow' of their design environment:

> "The history of the project was going to be in successive iterations of drawings, that point of view. There is a slightly more formal history in terms of the specification documentation, because the ultimate output of what I have to do is to produce a specification document that someone can build to. So because this was going to be built by subcontractors it makes it all the more important that the specification document is complete and explains everything […] What will then be documented is that we have decided that we are going to do this, not that we considered all these other possibilities and the reasons that we abandoned them, that would be very heavy and very bureaucratic to do that. It 's on the minute, on design decisions, the ebb and flow of... well I know that we told you to put this button in last time and it's just going to confuse the operator, we'll let the system deal with that, and it's those sorts of decisions." S1

The development of paper trails can be more or less valued by organisations in different contexts. It appears useful as a resource to refer to past work to support and inform current work, and it is required for auditing purposes in some contexts. In auditing contexts practitioners will adopt practices so that auditors will be satisfied that an adequate record can be inspected. Some contexts do not identify with this need and a more detailed and formal documenting procedures could actually hinder their current practices.

15. Persuade client

Step 1: Identify essential system functions

Functions (M, O)	Persuade client
Input	Communication with client
Output	Persuaded client
Preconditions	Practitioner has ability and expertise to be persuasive
Time	N/A
Resources	Competent staff
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		N/A.
Training and experience (M)		Practitioner needs sufficient skill and experience for successful negotiation.
Quality of communication (M, T)		Communication is obviously important for listening, understanding and responding.
HMI and operational support (T)		N/A.
Access to procedures and methods (M)		A practitioner needs sufficient access to different knowledge bases so they can call on them as partial solutions e.g. citing cases which have worked before.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)	Highlight	Sufficient experience and skill is required for the practitioner to have the ability to recognise what the client needs and tailor a solution to it.
Available time (M)		N/A.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		If there is a good rapport and relationship between the parties negotiation will be easier.
Quality and support of organisation (O)		A good reputation can instil confidence and aid negotiation.

Support and comments:

Persuading and negotiating is a key skill in consultancy work because work has to be won, collaborations need to be successful, and advice should be persuasive.

In support of this, this practitioner explicitly recognises negotiation as a key skill, and goes on to explain how this should be helpful and in a non-aggressive manner:

> "Right, again it's that sort of negotiation skill right. It helps to negotiate your ideas if you know why the previous ideas are already in place, I really believe that one of the most important skills in HCI is the sort of negotiating between other people and between what's

> there and what needs to be there and trying to build that pathway in a way that's, it doesn't have to be aggressive or mean to people you just have to explain like look I know that this kind a worked for you guys before but maybe we should try this out let’s put it in front of users, let’s see if they like it. I think that this helps clients a lot because they've actually hired you to try and help, but not tell them that they're all wrong all of the time - which I really believe is not the right approach.” W2

Similarly, this practitioner emphasises an engagement with ‘human beings’ and so normal emotional reactions and respectfulness should be taken into account when giving advice on systems:

> “Well we would never report just problems anyway, the short answer to your question is we would consider that bad practice. But we also include positive findings from our study, there are a couple of reasons for that, just as we try and treat our consultants like human beings we try and treat our clients like human beings as well, [some] people often work months or years on a product and how dispiriting it is to have someone to come along and evaluate it and only point out the parts that aren't working well.” W8

W8 stresses that this doesn’t mean they make up or exaggerate the positives just to spare people’s feelings but to acknowledge where there is legitimate success. Persuading clients relates to the rapport between people, the reputations of the people, understanding the issues being discussed, and evidence supporting people’s views. As a skill it involves negotiation, which generally involves getting along with people and treating them with respect.

16. Reporting practices developed

Step 1: Identify essential system functions

Functions (M, T, O)	Reporting practices developed
Input	Reporting practices are developed in industry and academia
Output	Many reporting practices
Preconditions	N/A
Time	Adequate time to research and develop
Resources	Funding for research and development
Control	HF management / Academia / Funding bodies

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)	Highlight	The funding that is available affects the research breadth and depth in this area.
Training and experience (M)		Experienced people can build on previous research and move it forward in interesting ways.
Quality of communication (M, T)		Good communication has to be maintained between different groups so research is useful, usable and used.
HMI and operational support (T)		Research should be useful, usable and used.
Access to procedures and methods (M)		Access to previous research is required so researchers can develop new areas.
Conditions of work (T, O)		If there is too much pressure to do project work in consulting then the development of reporting practices.
Number of goals and conflict resolution (M, O)		There has to be a balance in practice in practitioners doing their more routine paid consultancy work, and developing novel reporting practices.
Available time (M)		Adequate time has to be given to research.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		People may be encouraged and supported to develop novel reporting practices e.g. tables, recommendations, DVD.
Quality and support of organisation (O)	Highlight	There may be more or less of a climate for research into reporting practices, and making sure this is useful, usable and used rather than just published.

Support and comments:

Reporting practices are developed in practice. They have also found at least some attention from the academic community with research in areas such as ‘downstream utility’ (for example a workshop on this issue was held in Toulose, France, in November 2007). Here the subject of intellectual investigation is on how to improve the communication of usability recommendations and results so they have an effective impact on the design process.

Different reporting practices are adopted in industry depending on the circumstances of the project and the preferences and practices of those involved. For example, one practitioner reports the use of quotations in reports which they thought worked well:

> "I had a look at their report and instead of using highlights it was all quotes and picked out the really salient quotations and used those to add impact and I think that worked really well, because it's a lot easier than [messing] around with videos and putting it all together, it can be a real pain […]" W4

Another practitioner observes tension in what the client wants: as they want a short report, but they will also often want a large report so they have all the details for auditing purposes. The practitioner also recognises the need for the report as something tangible so the client can show it as a piece of research to their colleagues. This same practitioner moves on to describe their experiment with DVD presentations:

> "It depends, some clients are happy to get reports which are much more concise. I had a few where we did DVDs where we filmed ourselves doing certain things with the thing that we were testing, and just put highlights on the DVD and put a little report with that. Then they can watch the DVD and have chapters testing this aspect of it, so that was quite good but takes time.
>
> I: How did that go down?
>
> R: It went down well. But then you have issues of editing video, more than what you could believe, so it's almost as bad as writing a report [laughs]. The software can be slow […]." S7

Both practitioners above complain about the issues of editing videos, which bears an influence how they might choose to present their results and recommendations. For example, if it takes too long then they would choose an alterative method. The quotation below shows a practitioner who has been very reflective about developing his reporting style, encouraged by the added working demands placed upon him when a colleague left. They think about the different audiences' needs, his pressures in producing the work, and the effectiveness of the delivery:

> "R: I've done a lot of work on the way we report, and I've come up with a report structure that meets the needs of the different audiences for that report whilst making us money, and I actually developed that report in a UCD way of produce a first version of that report and go back to all the different user groups. If you think of any report there are several different groups that have needs for that report; one is the client team, that's directly the client team they want to know did you do this research right and what are the main findings, they also want you to do an engaging presentation which generally means PowerPoint and pretty, but they also want to look good themselves in their own organisation so they want a report that looks good that they can takeaway and that they can use as a presentation themselves within their own organisation. But you've also got the designers and technical people that have to go through and implement this, and then we've got us that need to get this report banged out really quickly at high quality, so the way in which we develop a report is the first section, it's all done in PowerPoint and all goes through our design team so it looks as pretty as possible. The first bit that I deal with is the bit at the end of the report which is an appendix and that is essentially a table. The

> first column of the table is what's the usability problem at a detailed level, then a severity rating, whether it's a heuristic review or a usability test I give it a severity rating from 1-5, 1 being cosmetic, through to 5 catastrophic; and then a recommendation, and that comes in a table and every time I've done a user test or an expert review I go through that, stepping through the site to fill in those pages, that's really quick to do takes a couple of hours to get it all done. That builds the rest of the report, so that's the appendix. So then you do the central part of the report which is annotated screen shots indicating key issues, but not too many, maybe one or two per page, at a high level, and again because I'm saying that's a high level that very often is marketing proposition rather than detailed usability, but flagging up the odd usability point. And following that we do a bunch of recommendations that are broken down into the key aspects of the site. All that is what we actually write, the start of the report includes details about our methodology, aims and objectives; and that's basically a template, it doesn't really vary on a standard usability report from project to project - and that's how I can write reports so quickly but can achieve a high quality of results because as much of it as possible is standardized process of writing it is as fast as possible but also it meets the needs of those different user groups as well, and it goes down very well." W5

The above examples show how there are different practices of reporting in industry, and that practitioners experiment and develop working styles. There are different pressures and demands placed upon reporting styles. For example, there are different users of reports that might require high level messages or the detailed information for implementation; there will be technical aspects of the report but also softer aspects such as a tangible report for the client to possess and something 'pretty' so they are drawn to it. There is also the effectiveness of the message which might be enhanced by severity ratings, and direct evidence like quotations and video. There is also the pressure for producing reports quickly which can be enhanced by having standardised templates and sections, or helped or hindered by the use of tools e.g. some practitioners find editing video a chore.

17. Select reporting practice

Step 1: Identify essential system functions

Functions (M, T, O)	Select reporting practice
Input	Many reporting practices
Output	Some reporting practice
Preconditions	Experience: Awareness of reporting practices and their applicability
Time	Time to search reporting practices and consider applicability
Resources	Competent staff
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Past projects of the practitioner and company will inform what will work well in the future.
Training and experience (M)	Highlight	Practitioner’s expertise will guide their options and choice.
Quality of communication (M, T)		Communication between practitioners can help when getting advice.
HMI and operational support (T)		Archiving systems may help in finding previous similar projects to current ones.
Access to procedures and methods (M)		The practitioner should have easy access to past projects.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)		Practitioners need to balance ideal research circumstances with the pragmatics of the situation.
Available time (M)		Adequate time is needed for selection, although experienced people often do this quickly once the client circumstance is understood.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		HF practitioners working in groups can get advice from others.
Quality and support of organisation (O)		Companies may be more or less supportive in allowing for the search and selection of new practices.

Support and comments:

Reporting practices are developed, repeated, and become standardised within someone’s work. However, they might change to suit the changing circumstances of clients and projects. The quotation below demonstrates how one practitioner has adapted their behaviour to suit a particular client, they also explain how they have developed their reporting practices after a process of streamlining the reporting procedure:

> “I have one client, particularly the person that I deal with is [very fussy about the details of things], and he always wants changes to reports and report structures which is a pain because you can spend a day just moving pages around and changing them to his format,

I've learnt what his format is nowadays and just do that automatically. But err generally... partly we've got the format right now and so the clients like it, and the first time they will see the report generally, sometimes we will send it over to them directly, but generally the first time is I'll do the presentation part of the report and then I'll explain the structure of the report in the process of giving that presentation and then hand them full colour bound up copies, copies on CD and video outtakes - and they love that because they've got something to walk away with that looks pretty. So actually I think generally I think we've got that format about right now.

I: That's good and that develops over an iteration evolving process

R: Yeah, I mean way back in [month X] there were two of us in our team, one senior to me and the senior person disappeared, and I was left holding the baby with an amazing work load. Basically I went right let's see how much work I can take off my back by standardising as much as possible, and making it as efficient as possible, so it was a needs must situation really but it pays off" W5

The process of development of reporting practices signifies a change, but it is common for practitioners to have reporting procedures that work well for them. This makes their work more standardised and helps their speed as they do not have to reinvent the wheel each time but can rely upon their evolving practices. The quotation below is an example of using a pre-existing structure to help produce work:

"We have template documents which are used and we just alter them for each case, so you start with a standard template and then you alter it for what you need, so the speed of what we do is very quick as well." W9

Practitioners will be reflective about their use of different reporting practices. They will have templates which will provide some pre-existing structure they can work from and adapt this to the context. This allows them to work in a more standardised way and faster.

18. Analysis of data

Step 1: Identify essential system functions

Functions (M, T)	Analysis of data
Input	Data for analysis
Output	Results / HF experience / Documentation of HF work
Preconditions	Data is gathered
Time	Adequate time to analyse data
Resources	Resources for analysis e.g. tools, methods, software.
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Adequate resources have to be available for analysis e.g. statistical packages, video editing, diagramming tools.
Training and experience (M)	Highlight	Staff should be competent at analysing the data they need to.
Quality of communication (M, T)		Analysis should be able to be explained to others.
HMI and operational support (T)		Analysis support should be easy to use.
Access to procedures and methods (M)		Analysis methods and procedures should be easy to access.
Conditions of work (T, O)		Sufficient conditions should be allowed for appropriate analysis to be performed.
Number of goals and conflict resolution (M, O)		Analysis should not ignore the goals of the client.
Available time (M)		Sufficient time should be available for analysis.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		More senior staff can help mentor and support more junior staff.
Quality and support of organisation (O)		N/A.

Support and comments:

The analysis of data will vary depending on the method used and what data has been gathered. This contributes greatly to the practitioners understanding of the project issues but it is important to realise that understanding of the project issues would have also occurred long before e.g. in speaking to the client and designing work packages and in the actual gathering of the data itself. Analysis can take different forms, and will rely predominately on the competence of the people doing the analysis. This quotation shows that project work is a process that has to be managed and where newer members are involved they need to be appropriately supported:

> "You kind of manage resources as you can, there is a lot, fourteen task analyses, so essentially you might give the smaller ones to newer members of staff, […], so they will be doing some of the task analysis, but give them the easier ones. I will be doing some of the more difficult ones, and gradually as they get up to speed, they can perhaps progress and do some of the more difficult task analysis as well, depending on how fast they learn and how quickly they get up to speed with it." S8

The analysis can be quite complex and involve a mixture of qualitative and quantitative techniques. It is about drawing information together and processing this to inform the project issues. The practitioner also has to be mindful of validity issues so their recommendations are not misleading as this quotation demonstrates with emphasis on statistical methods:

> "It's all pulling things together, you need to process it, taking peoples' opinions and process it, but most importantly, to use the technical analysis, the stats to analyse the trend, make sure if anything happens it is statistically significant and not by chance, so you need a testing method for the data. If you just use the graph only, it may show a trend, but this can just be by chance, and it can be misleading." S9

Analysing data is a major part of the technical side of project work. It will depend on the circumstances of the project, and the competence and skills of the staff. However, in terms of a process for understanding project issues it does not work in a detached and isolated manner. Understanding project issues develops before and after the analysis of data.

19. HF understands project issues

Step 1: Identify essential system functions

Functions (M)	HF understands project issues
Input	Data for analysis / Understanding of client need
Output	Understanding of project issues
Preconditions	HF interaction with project
Time	Adequate time for understanding
Resources	Competent staff
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Competent staff.
Training and experience (M)	Highlight	HF practitioner skills and experience will inhibit and enhance their insight.
Quality of communication (M, T)		Communication with stakeholders will allow opportunity to learn more about project issues.
HMI and operational support (T)		N/A.
Access to procedures and methods (M)		There may be specific exploratory procedures and methods to enhance insight here e.g. interviews, contextual inquiry.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)		N/A.
Available time (M)		Time needed to think project issues.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		The access and support they get from colleagues and clients will affect insight.
Quality and support of organisation (O)		N/A.

Support and comments:

The practitioner’s understanding of the project issues will happen throughout the project. From trying to understand the client need, to negotiating priorities of the project, to doing the project work and then communicating it.

This practitioner stresses the importance of knowing the details of the context of the project you are working in, and the importance of speaking to people that actually do the job because they know the day-to-day details and the potential consequences of changes:

> "you've got to work out the details, you've got to sit with the leading people and the cabin boy, everyone else and say, tell me about what you do! And if you aren't prepared to sit there, I'm very happy talking to [company], and I think they know, I was on [vehicle] last year and was sitting with the captain and laughing, and then you go down and talk to everyone else, and they all know I want to be there, and you've got to have that, and you are interested, if you don't care about that detail, you shouldn't be there. So there's a twin thing, you've got to have that academic ability, but if you haven't got the sympathy of the poor soul of the person with the problem, then you shouldn't be there."
> S5

Sometimes understanding project issues can be complicated as a set of prescribed methods might not address the clients need. Respondent S11 was brought in by a client because they were dissatisfied with another company's work. However, on reviewing the previous work S11 thought they had done an 'excellent job' and it certainly wasn't obvious how to improve the work. An engineering colleague gave a different perspective, and a new angle on the problem. Once the project had started S11 observed a member of staff just switching alarms off and not acting on them. The client knew that something was wrong but was uncertain what was happening. The work of the first company was of great quality but hadn't addressed their need. S11 admits that the reason it was uncovered the second time around was affected by the fact that they could now see how the staff were interacting with these systems, rather than dealing with system plans and prototypes.

The understanding of project issues happens throughout the course of the project and is heavily reliant on the expertise, motivation and insights of the practitioner. Sometimes project work is not just a case of selecting the right battery of methods and processing them. Sometimes it is more critical to prepare well, engage with the details and people that actually work at different levels in the context, and be observant as to what the issues might be.

20. HF understands domain

Step 1: Identify essential system functions

Functions (M, T, O.)	HF understands domain
Input	Data for analysis / Understanding of client need
Output	Understanding of domain
Preconditions	HF interaction with domain
Time	Adequate time for understanding
Resources	Competent staff
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Competent staff.
Training and experience (M)	Highlight	HF practitioner skills and experience will inhibit and enhance their insight.
Quality of communication (M, T)		Communication with stakeholders will allow opportunity to learn more about the domain.
HMI and operational support (T)		N/A.
Access to procedures and methods (M)		There may be specific exploratory procedures and methods to enhance insight here e.g. expert panel.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)		N/A.
Available time (M)		Time needed to think project issues.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		The access and support they get from colleagues and clients will affect insight.
Quality and support of organisation (O)		N/A.

Support and comments:

Understanding the issues of the domain is important to get to grips with the details of the project. With this in mind this practitioner will pick members of her team for projects in which they have expertise:

> "R: Yeah, we have a guy in the states that is very very good with financial clients, so either selling investment instruments or banks, you know he is just very knowledgeable about that industry, so he has come over and led some projects for us, which is good. I have a previous background in Biology so I feel very comfortable in the Pharmaceutical area. So it depends on where you've come from or how many projects that you've worked on, you know if somebody asked me to do something with speech and language I would feel quite comfortable with that because I have done it before. Yeah, so it just depends, it

> depends on what the project is. But we definitely try to fill a project with the most appropriate people." W9

If people work on projects and in domains in which they have prior experience and expertise then they will have an advantage over those people that are new to the area. They are more likely to know specialised terms of the domain, concepts, best practice and reoccurring issues.

Of course, understanding the domain will also occur through project work. This can happen in the applications of a method, through talking to people in the context, or just being observant as this quotation demonstrates:

> "everything was happening, […], and it became obvious then that this chap was just turning off these alarms. I thought he was acknowledging them, and then acting on them. But it became apparent that he was just turning them off. He appeared to be giving the right response, but in fact he wasn't. It may seem an obvious thing to notice, but if there is a huge amount going on, you could miss it." S11

Understanding the domain issues of the project relies on people's expertise and experience, on carrying out methods, talking to people and being observant. These factors can be critical in securing a project and engaging with it successfully. Respondent S5 was very conscious of the importance of understanding the domain and the project's context in detail otherwise serious interactions and consequences could be overlooked.

21. Write report

Step 1: Identify essential system functions

Functions (M)	Write report
Input	Results / Understanding of project issues / Understanding of domain
Output	Summary of work / HF experience / Documentation of HF work
Preconditions	HF work has been completed
Time	Adequate time to write report
Resources	Competent staff / Some reporting practice
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Appropriate staff and technologies should be available to produce the report.
Training and experience (M)	Highlight	Well practiced practitioners are likely to find it easier to write reports.
Quality of communication (M, T)	Highlight	The report will need to reflect an adequate format and style for the client, and its message must be timely and clear.
HMI and operational support (T)		N/A.
Access to procedures and methods (M)		Past reports could allow example of what to do.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)		The report should not ignore the goals of the client.
Available time (M)		Adequate time should be allowed for writing the report.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		Some reports may be reviewed or written by multiple authors.
Quality and support of organisation (O)		N/A.

Support and comments:

The report seems also a standard part of HF/usability delivery but in some contexts the main contribution or indirect contribution can fall outside of this traditional scope. For example, practitioners encouraging clients to watch user tests gives feedback before the report and in a manner which is seen as qualitatively different and someway more persuasive than the written word. Also, more design focused services might work with the team and on design iterations rather than working toward a report detailing results and recommendations from an evaluation.

Producing a report will be affected by those issues discussed in ‘16. Reporting practices developed’ and ’17. Select reporting practices’ sections above.

22. Communicate results to client

Step 1: Identify essential system functions

Functions (M, T, O)	Communicate results to client
Input	Summary of work
Output	Communication of results / Experience / Communication with client / Documentation of HF work
Preconditions	Reporting practices
Time	Time to communicate with client
Resources	Competent staff / Some reporting practice
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		There should be competent staff and technologies available.
Training and experience (M)		Well practiced and skilled practitioners are liable to be better at communicating results.
Quality of communication (M, T)	Highlight	This is important for the client to understand and engage with the results and recommendations.
HMI and operational support (T)		There should be appropriate technology to support the communication of results e.g. PowerPoint, video clips, models.
Access to procedures and methods (M)		Previous presentations and can be used as examples or templates.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)		The client's needs and goals should be kept in mind when communicating results.
Available time (M)		There should be adequate time for the presentation of results.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		The quality of collaboration with the client and their staff will affect how they engage with the material.
Quality and support of organisation (O)		How amenable and supportive the client is of HF will affect how they engage with the material.

Support and comments:

Like other practices in HF/usability work there are different practices for different practitioners, companies and contexts. For example, this practitioner who is involved in producing designs for clients prides themselves on the level of communication that they have with the client to make sure that the client is happy with the direction they are going:

> "You meet with them at least once a week, […] at least an hour and a half whether its face to face with a client or via a conference call because very often their in some other

corner of the world, you will meet with the client, present what you've done and get feedback on it. I tell you ideal.... no one else has this as far as I know... it's an ideal world.

I: It does seem good you have negotiation and communication core

R: Constantly

I: .... which reduces unexpected events and conflicts?

R: Well and if you've done a week's worth of work and the client is really unhappy with it, which has happened, like no this is not the direction that we want to go in, no you're doing the exact wrong thing, then you've only wasted a week as opposed to a month down the road and giving them something that they totally didn't want." W2

In contrast this practitioner who works in an environment of independent evaluation rather than design can go through a project from start to finish without informal contact with the client, which they prefer for the reasons stated:

"I: I'm kind of picking up on it because from the web design work that I've done, everything kind of suggests that consultancy practice, which might not be what you're doing or it might be different in the safety industry, but close communication is always good in building rapport with a client and to communicate issues, like those little things that might not come across in a report if you're talking to them.

R: I think a lot of documents go back and forth because you need to get an audit trail of what you've said to people, so increasingly more and more, so if you do phone someone or talk to them in a meeting you still have to write it up, so perhaps people think it is easier to write it up in the first place.

I: Just cut out the middle bit.

R: Yeah, and then there's no risk of miscommunication, well there is still a risk of miscommunication but there's less of saying the wrong thing or implying something that isn't true.

I: And why might these be issues?

R: I s'pose because people are going to make big decisions based on what you tell them. They are paying you, for your expert advice, and research findings and so on, and if they are going to make a big decision like redesign something, or implement something or tell it to a minister which is one of the things that we often have then you want to make sure that you have told them the right thing. […] I think that's the one reason why documents are so important." S2

Regardless of the style of reporting to the client, it is a critical point of interaction with the client, and so inexperienced people will either be protected from or supported in the process:

"I think that, yeah, because the people that we place in front of a client, whether they're from the US, the UK, France, India, wherever... they're very knowledgeable and they can all stand on their own two feet, […] we don't put someone who is inexperienced in front of a client that is paying us [a lot of money] to do a project." W9

Communicating the results to the client can happen in different ways, including a traditional report, observing user tests, or regular meetings about project work. Interactions with clients are always critical as this will directly impact on the perception of the practitioner and the consultancy; hence experienced people normally engage with the responsibilities, uncertainties and questions in client interactions.

23. Client engages with results

Step 1: Identify essential system functions

Functions (M, O)	Client engages with results
Input	Communication of results / Summary of work
Output	Engagement with HF issues
Preconditions	Client motivation to connect with HF
Time	Time to reflect on results
Resources	N/A
Control	Client / Persuaded client

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Competent staff.
Training and experience (M)		Well practiced and skilled practitioners are liable to be better at communicating results on the HF side. HF familiar clients are liable to understand them more on the client side.
Quality of communication (M, T)	Highlight	Message needs to be clear and persuasive so it is understood.
HMI and operational support (T)		N/A.
Access to procedures and methods (M)		N/A.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)	Highlight	Different audiences are interested in different messages, so there is a need to direct message to the right audience and tailor it for engagement.
Available time (M)		N/A.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		The better rapport between HF and client the more receptive they will be to results.
Quality and support of organisation (O)		HF friendly cultures will be more receptive to results.

Support and comments:

Engaging with the project and the results includes considering those things of interest to different parties. For example, this practitioner explains how they are still learning that when they have a recommendation it is important to recognise 'who' the right person is that they should report that to, so they engage with the issue and do something about it:

> "So when you are in an engineering team, like mechanical engineers and chemical engineers, I learnt it very fast and am learning still, peoples' intentions are good, but its knowing which people to talk to, because I could sit and talk to a mechanical engineer

> and I could say, what about this, it's a real risk if this person makes this mistake, a mechanical engineer; it's not his job, he doesn't care." S10

Similarly, this practitioner uses the term 'care' to talk about the different values, interests and motivations people have. Here the practitioner is explaining that they include a full method section in the report for auditing purposes even though the clients won't read it:

> "But yeah, there's different groups of people, the regulators, the top safety people they do care about the methods that we use, but [some] companies […] don't. They are not so worried about it. It doesn't mean anything to them, they don't want to learn about it, they want the problem to go away and they want to get on with their day job basically." S3

This practitioner identifies the importance of the return of investment in project work because it is a central part of the job for people that manage contracts:

> "… at the end of the day it's a financial transaction. By targeting the stakeholders and having an executive champion, undoubtedly those people will be thinking about return on investment because that's their job." W9

Engaging with clients is very much about engaging with their values. This is different from understanding, which is more of a cognitive task. For example, a person might completely understand what is being said but they might not care about it. It seems that practitioners do well to recognise their audience to tailor the message, or recognise which audience their message would be most suitable for.

24. Client understands results

Step 1: Identify essential system functions

Functions (M, O)	Client understands results
Input	Communication of results / Summary of work
Output	Understanding of HF work
Preconditions	Client motivation to connect with HF
Time	Time to reflect on results
Resources	N/A
Control	Client / Persuaded client

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Competent staff.
Training and experience (M)		Well practiced and skilled practitioners are liable to be better at communicating results on the HF side. HF familiar clients are liable to understand them more on the client side.
Quality of communication (M, T)	Highlight	Message needs to be clear and persuasive so it is understood.
HMI and operational support (T)		N/A.
Access to procedures and methods (M)		N/A.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)	Highlight	Different audiences are interested in different messages, so there is a need to direct message to the right audience and tailor it for engagement.
Available time (M)		N/A.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		The better rapport between HF and client the more receptive they will be to results.
Quality and support of organisation (O)		HF friendly cultures will be more receptive to results.

Support and comments:

Understanding the project results seems like an important part in the project process, but this is not always necessary. As this quotation shows some clients, or at least some personnel within the client organisation are not interested in understanding the results, instead they just want a solution:

> "And I was, it's a sign of growing old, but about a year ago, I was doing a presentation, and I said, here's my report, report is about yay thick, and this was quite a senior group of people down at [place], and they said, what's your conclusion? I said, you know, the

> conclusion came out in about two sentences, and they said, alright, next item on the agenda, thank you very much. And now thirty years ago that would have really upset me but the point was they are happy, so thank you very much, bye, and the problem has gone away.
>
> I: So does anyone read the report?
>
> R: No because most of it's science, and makes no difference to them, all they want to know is that the problem has gone away." S5

The important point here is the relationship that the HF/usability practitioner has with the client. If they are coming in as an expert to provide a recommendation for a particular issue then the client might be just happy taking the recommendations at face value. If the practitioner is working alongside the client's team and needs to persuade them to go for one option over another then this will probably include trying to make them understand why. Similarly, if practitioners are questioned on their work they will need to explain what they have done and why. So, the level of understanding that a client needs will depend who the client is within their organisation, their role, and the project context.

The level of rapport and reputation might also influence how critical a client is with recommendations; for example someone who gets on with the client, has had a proven reliable relationship with the client, and has a good reputation in the field will be much more likely to have their results accepted on trust then someone who is unknown.

25. Client considers results

Step 1: Identify essential system functions

Functions (M, O)	Client considers results
Input	Communication of results / Summary of work
Output	Potential actions from results
Preconditions	Understanding of HF work / Engagement with HF issues
Time	Time to reflect on results
Resources	N/A
Control	Client / Persuaded client

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Adequate resources are needed to act on results, e.g. some recommendations might be outside client's scope and budget.
Training and experience (M)	Highlight	Client experience of HF will help in considering actions, e.g. some companies have their own HF informed people.
Quality of communication (M, T)		Clients need to have understood the results to make decisions about next steps appropriately.
HMI and operational support (T)		N/A.
Access to procedures and methods (M)		N/A.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)		Some recommendations may not be resolvable, some may be outside their power to act, or they might not have the budget to support such changes.
Available time (M)		Adequate time is needed to consider the results.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		Consideration of the results may involve different people on the client side and HF.
Quality and support of organisation (O)		HF friendly cultures will be more receptive to results.

Support and comments:

The client considering the results is also a process with variances. One important aspect is to recognise that the client is sometimes not a single entity but might represent a complex organisation with their own political struggles, which need to be considered as a HF/usability consultant as this quotation demonstrates:

> "I: So in terms of getting clients to listen to you its very much convincing those people that have the power to make the decisions?
>
> R: You've got to get key players, you've got to have good political sense, […]. Occasionally you come into situations where there are quite powerful people, […] there is

> a lot of politics going on, and that's where experience comes in and you sort of have to stand back from the situation and say right I have to keep my mouth shut here, or I have to listen to this guy that is talking rubbish or very diplomatically introduce an alternative point of view that doesn't politically challenge his view of the world." W5

Interestingly, HF/usability services can be explicitly used for political means. This quotation demonstrates that the client wanted an external independent report which would be his communication channel to top management, it was explained that this carried more weight than an internal opinion:

> "what he really wanted was somebody independent from [company A] to come out, do a report which would go straight to top management and then they would do something about it, because it was independent.
>
> I: So it was political?
>
> R: It was political, and I believe we found exactly what he wanted us to find." S11

The above quotation therefore links to the client recognising a need; the need being an independent report for political means within their own organisation.

The client considering the results also begs the question as to what level of consideration, and we have already seen in '24. Client understands results' that there are different levels of understanding for the client. The most advanced level of consideration in terms of technically considering the results in a HF/usability way has to involve people who are HF/usability informed. This practitioner describes the two extremes by first referring to an organisation that employs HF informed people to oversee HF work, and then to another client who knows nothing about HF:

> "they employ human factors experts to manage the research projects that are being done so that there is somebody there who is the client who knows and can question why I'm using that method and those sorts of things, so that's how they would know […] the people that we are working with have human factors problems and they know they have human factors problems because they have been told to sort themselves out basically, but they don't know anything about human factors at all." S3

The client's consideration of results will vary depending on their level of HF/usability expertise, their motivation to understand and engage with the project's issues, and the ramifications of the project.

26. Client acts on results

Step 1: Identify essential system functions

Functions (M, O)	Client acts on results
Input	Potential actions from results
Output	Actions from results
Preconditions	Power to act on the results
Time	Time to reflect on results
Resources	Resources to act on the results
Control	Client / Persuaded client

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Adequate resources are needed to act on results, e.g. some recommendations might be outside client's scope and budget.
Training and experience (M)	Highlight	Client experience of HF will help in considering actions, e.g. some companies have their own HF informed people.
Quality of communication (M, T)		Clients need to have understood the results to make decisions about next steps appropriately.
HMI and operational support (T)		N/A.
Access to procedures and methods (M)		N/A.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)		Some recommendations may not be resolvable, some may be outside their power to act, or they might not have the budget to support such changes.
Available time (M)		Adequate time is needed to consider the results.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		Consideration of the results may involve different people on the client side and HF.
Quality and support of organisation (O)		HF friendly cultures will be more receptive to results.

Support and comments:

The standard successful story of a HF/usability project would be that the client accepts the recommendations, acts on these, and the recommendations deliver the predicted results. A project of this nature with dramatic results is described by one practitioner:

> "we did their [support] website, which was very disparate, sort of applications and all sorts of things, very inconsistent, so […] we designed the website. When we started they were getting 300 calls a day to the help desk about information […], and the criteria was to reduce that, and on the first day of launch they had no calls, they had no questions anymore. That's one of our best case studies." W9

However, sometimes clients might accept the results but other things prevent them from acting. For example, practitioners sited contracts restricting the scope of development, so recommendations about accessing a room could not be changed if the development only concerned the room layout itself. Where these barriers to action occur it is the client who makes the decision and the practitioner who is in an advisory role:

> "Well, obviously we have to take some responsibility. At the end of the day they could ignore us... as long as you have a good audit trail and they have been told about this, [...] there's not much more you can do. [...]." S7

In some situations, which occur in the safety domain and the website domain, practitioners are not aware how the client acts on or ignores their recommendations as this practitioner states:

> "Yeah, recently we did a study about [transport] that [Organisation C] wanted to implement and the results showed very strongly that there was a flaw in the design that they had, and we fed that back to them obviously and we said when you implement this you can't have that, that's going to be really bad. But you never really get to find out whether they have taken it on board." S2

The success story of a client accepting HF/usability results and acting them is a standard story but there are variations. Practitioners reported clients needing priorities, so they could decide which ones need most urgent attention and where clients were unable to act on all the results. For example, the client may be persuaded by the recommendations but might have other forces which prevent them from acting. Practitioners have an ethical duty to report results that reflect the true situation even when clients might not want to hear it, this is even more so when safety is concerned. Clients choose how they act upon recommendations and HF/usability practitioners normally only have an advisory role.

27. Build reputation

Step 1: Identify essential system functions

Functions (M, O)	27. Build reputation
Input	HF experience / Results of the audit of HF work
Output	Increased reputation
Preconditions	Opportunity to develop reputation
Time	Time to develop reputation
Resources	Competent staff
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		N/A.
Training and experience (M)	Highlight	Increased experience should influence a practitioner's reputation.
Quality of communication (M, T)		N/A.
HMI and operational support (T)		Expertise in particular tools should influence a practitioner's reputation.
Access to procedures and methods (M)		Expertise in particular methods, procedures and domains should influence a practitioner's reputation.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)		Staff should have adequate development opportunities but client work may be prioritised.
Available time (M)		Time should be available to be invested in staff development.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		Mentoring and supervision will help more junior staff develop.
Quality and support of organisation (O)		Organisations may be more or less interested in their staff development.

Support and comments:

Reputation can be a property of the organisation or the client, and is generally developed through experience. It is believed that past performance will be an indicator of future performance, so a practitioner's and company's reputation will be used to impress clients. This case study is used in presentations to prospective clients:

> "we did their [support] website, which was very disparate, sort of applications and all sorts of things, very inconsistent, so […] we designed the website. When we started they were getting 300 calls a day to the help desk about information […], and the criteria was to reduce that, and on the first day of launch they had no calls, they had no questions

> anymore. That's one of our best case studies, but we have things like that that show..." W9

This practitioner makes an explicit distinction between technical expertise and the softer side of professional practice like their reputation in facilitating their work. The practitioner explained how the group that she was advising only really accepted her when they knew that she was connected to the right people and had a reputation that warranted their respect:

> “so I have found that reputation, friendships, doing good work, not letting people down, and being professional are an important part of your job. It’s not just the technical expertise. Although your technical expertise and experience are also important. Plus of course all the resources you build up, which make you more efficient. It’s a combination of those things.” S11

Reputation is an important element in winning work and inspiring trust in advice and recommendations. It is a valuable commodity, which practitioners and organisations will want to enhance and protect.

28. Build rapport

Step 1: Identify essential system functions

Functions (M, O)	Build rapport
Input	Communication with client / Persuaded client
Output	Increased rapport
Preconditions	Opportunity to develop rapport
Time	Time to develop rapport
Resources	Competent staff
Control	HF management

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		N/A.
Training and experience (M)		Experience and skill in handling clients should make it easier to build rapport.
Quality of communication (M, T)		The clarity of communication, learning client terms, should help in communicating and building rapport.
HMI and operational support (T)		N/A.
Access to procedures and methods (M)		N/A.
Conditions of work (T, O)		N/A.
Number of goals and conflict resolution (M, O)		Need to recognise client goals so HF can address their need in their terms.
Available time (M)		N/A.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)	Highlight	Better collaborations will be related to the rapport between people.
Quality and support of organisation (O)		N/A.

Support and comments:

Rapport is something that falls outside of the technical aspects of HF/usability work but is important for facilitating working relationships between people. This can affect what work is won and whether recommendations are listened to. This practitioner describes the advantages of working with the same client repeatedly, which is reinforced because of the rapport between them:

> “I: Do you work with the same companies over and over again?
>
> R: Yeah, quite often, yeah, you get quite a rapport with them, and then there's the odd, you know, one person that comes for one job or whatever.

> I: Is it easier working with those people that you know, or not really or...
>
> R: Administratively yeah, because you know their processes, you know just the simple things, like how often they are going to want to have meetings, they have standard templates of their progress reports and things like that, and just having a bit more of a rapport with them helps." S2

Rapport can take a long time to develop and can help facilitate relationships within and between organisations:

> "You need to have very good personal relations with other departments/organisations which takes a long time to build up." S11

This quotation demonstrates that the working relationship between a particular practitioner and client is enough for the company to fly them from the United States to England to take part in the work:

> "So we're talking about bringing someone over from the US for a project because they have a particularly good relationship with the US side of the client. So we will bring them over." W9

As well as consciously utilising relationships by getting the right people on the project, individuals will deliberately behave in ways to build rapport to facilitate their working relationship:

> "I try to present myself as polite and humorous, that is deliberate, building a rapport, I'm sympathetic so I listen to people a lot, tell a few standard funny stories about myself, always be courteous, and that goes down well, I know that will work generally speaking, I can be reasonably sure by the end of the meeting I will have everybody laughing" S5

Building rapport facilitates working relationships. This can be deliberately managed either in the way people behave toward each other, or in getting the right people together. Rapport can facilitate work within or between organisations. It is not a formal or technical side of working, but it has a strong potential to affect work.

29. External audit

Step 1: Identify essential system functions

Functions (M, T, O)	External audit
Input	Desire to audit HF work
Output	Results of the audit of HF work
Preconditions	Store of documentation
Time	Adequate time to audit
Resources	Resources to audit and access to material
Control	Client / Other HF management / Regulators

Step 2: Determine the potential for variability

CPC	Highlights	Comment
Availability of resources (M, T)		Adequate staff and technology should be available to help with the auditing process.
Training and experience (M)		Auditors will need appropriate HF knowledge to assess the quality of this work e.g. some companies have their own in-house informed HF people.
Quality of communication (M, T)	Highlight	Work, methods and procedures should be easy to access and assess.
HMI and operational support (T)		There may be support needed in auditing the archiving system.
Access to procedures and methods (M)		Adequate access to the methods and procedures needs to be maintained.
Conditions of work (T, O)		Auditors may be concerned about the professionalism of the working environment.
Number of goals and conflict resolution (M, O)		Auditors need to assess that quality has been maintained despite of competing goals in efficiency and thoroughness.
Available time (M)		Adequate time to audit.
Circadian rhythm (M)		N/A.
Crew collaboration quality (M)		The auditors can be seen as collaborating with the people being audited, and their openness and competence will affect trust.
Quality and support of organisation (O)		Some organisations might value and respect auditing procedures more than others.

Support and comments:

Auditing is generally a process of checking and assessing the quality work, methods and procedures. As discussed in ‘14. Developing a paper trail’ this can be more important in some contexts than in others.

The people who audit work might not necessarily be the clients of the work. In this quotation a practitioner explains how the clients do not care for the HF details but the regulators do:

> "But yeah, there's different groups of people, the regulators, the top safety people they do care about the methods that we use, but [some] companies […] don't. They are not so worried about it. It doesn't mean anything to them, they don't want to learn about it, they want the problem to go away and they want to get on with their day job basically." S3

Again, this quotation from an in-house usability practitioner shows that the auditors are not the company that own the work, but an independent body that assesses the work:

> "Oh.... what happens is we get our site audited by RNIB, they fail us and say you have to fix this, this and this, we try and fix this and this, we get the site audited again, they fail us again and say this and this, and the site is changing so much in-between this six months that every time we test there is new code and new stuff, and we think we might pass but it's a bit of a nightmare trying to pass." W3

This quotation shows that there is an expectation to be audited which might be a requirement of some clients, in terms ensuring that the HF organisation have appropriate quality management procedures in place:

> "It makes you do a good job really, it's the pressure of that, so otherwise, quite often we get audited as well so some of the clients will come down and want to see how we do things and particularly in terms of communications, how we record with people, how we make sure no data is lost, how we manage our data, so they'll come down and do an external audit and that's generally notified, we get warnings and stuff like that, or it might be part of the project that we might have to submit to that.
>
> I: And that's just to, what was the purpose of that?
>
> R: Say for example we do some work for [client A] and part of working for them was the fact that all the quality control of how we do things can be proven, we can tick certain quality management boxes that they have, so they'll come down and audit us, all the files for the project and all the communications that we've had and how we can make decisions and things like that, so they will come down and do an audit, they might be here for half a day and say yeah that's fine or you could do that better." S8

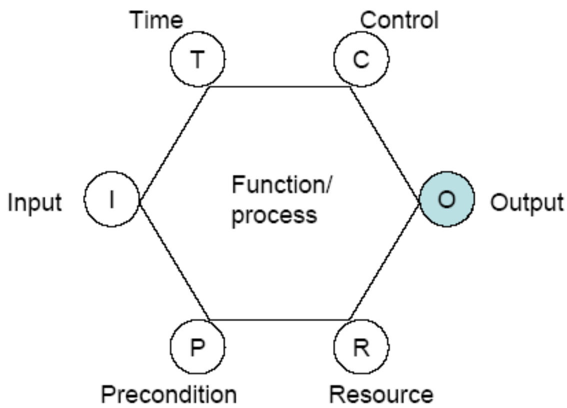
Auditing can be more or less important in different contexts. In some cases clients might require quality management procedures are in place so they are getting a certain standard of work. In other cases the client might be disinterested in the details of how the work is carried out and might just want a solution. Auditing is more common where a minimum standard of quality has to be met e.g. where safety or criteria for meeting accessibility standards are involved.

Appendix C2: Introduction to the FRAM Analysis of HF/usability Practice Steps 3 and 4

FRAM Step 3: *Define functional resonance*

This step looked at the expected and unexpected dependencies among the 29 functional nodes. This was achieved by building up a FRAM network, which displays the nodes and links between them. The nodes represented in the FRAM network are hexagonal in shape and represent the input, output, preconditions, time, resources and control referred to in part B of the template in Figure C1.1. The layout of these functional characteristics is displayed below in Figure C2.1. Many of the node's main links are via there input and output, although there are some links to controls, preconditions and resources.

Figure C2.1. The hexagonal function representation (reproduced from Hollnagel, 2004, p. 126).



How to read the representations (Figure C2.2 to C2.8)

This stage of the analysis describes seven interdependent representations to explain the main functional dependencies in the FRAM network (from Figure C2.2 to C2.8). These nodes use lines to show functional couplings between them. However, presenting one diagram would be too confusing because of the quantity of overlapping lines. To cope with this issue each diagram represents some of the functional couplings. These couplings are coded by letter and number so in the absence of the actual lines connecting them their relationship is still maintained. Descriptions of these codes and couplings are listed in Table C2.1.

The descriptions and representations give part of the picture which is captured by the single FRAM network representation at the end (Figure C2.8). It is recommended that the representations are read in order to support the sense making process. When referring to Figure C2.8 at the end of this process, the codes in that figure can be used to locate which description and representation corresponds to that function. So, the reader can flick back and be reminded of what is going on. For example, when looking at C2.8 the reader may refer to C2.5 for more detail about the relationship between G1 and G2.

The numbers and titles of the 29 functional nodes refer to the number and titles of the functions identified in Step 1 and 2 in Appendix C1. It is recommended that the reader cross-reference when they want evidence, comment and more detail on particular nodes.

Table C2.1. Coding scheme and description of the functional couplings.

Coupling	Description	Figure
A1-A2	The HF/usability practitioner gains a better understanding of the project issues.	C2.3
B1-B2	A better understanding of the project issues informs further functions.	C2.3
C1-C2	The client is further persuaded through knowledge, understanding, reputation and rapport.	C2.4
D1-D2	Persuading the client impacts on the work performed and communicating the results.	C2.4
E1-E2	Rapport is developed through client contact.	C2.4
F1-F2	Reputation is developed through evaluation of HF/usability work and results.	C2.4
G1-G2	Performing HF/usability project functions leads to the development of HF/usability staff.	C2.5
H1-H2	HF/usability staff are a resource for HF/usability project functions.	C2.5
J1-J2	Senior HF/usability manage and control HF/usability project functions.	C2.5
K1-K2	Reporting and communicating results leads to development of practice.	C2.6
L1-L2	Reporting practices are selected.	C2.6
M1-M2	Project work leads to the development of methods and tools for practice.	C2.6
N1-N2	Selections of methods, tools and reporting practices feed into the development of work packages at the start of the project.	C2.6
P1-P2	Documents are produced at different stages of the project which lead to the development of a paper trail.	C2.7

Description of the Project Process (Figure C2.2)

Figure C2.2 shows the central project process. The central process roughly includes: the client recognises a need, HF understand this need, work packages are developed to satisfy this need, a project is negotiated, work is performed, data is analysed, a report is written, results are communicated to the client, they consider the results and how to act on them. This flow is represented in a ‘Z’ shape so the input and output flow from left to right can be maintained, and the process is able to fit on to one page. The ability to fit the process on to a single page is an important requirement as some of the other nodes relate to more than one stage in the process. It also provides the reader with a single graphical representation for the system description.

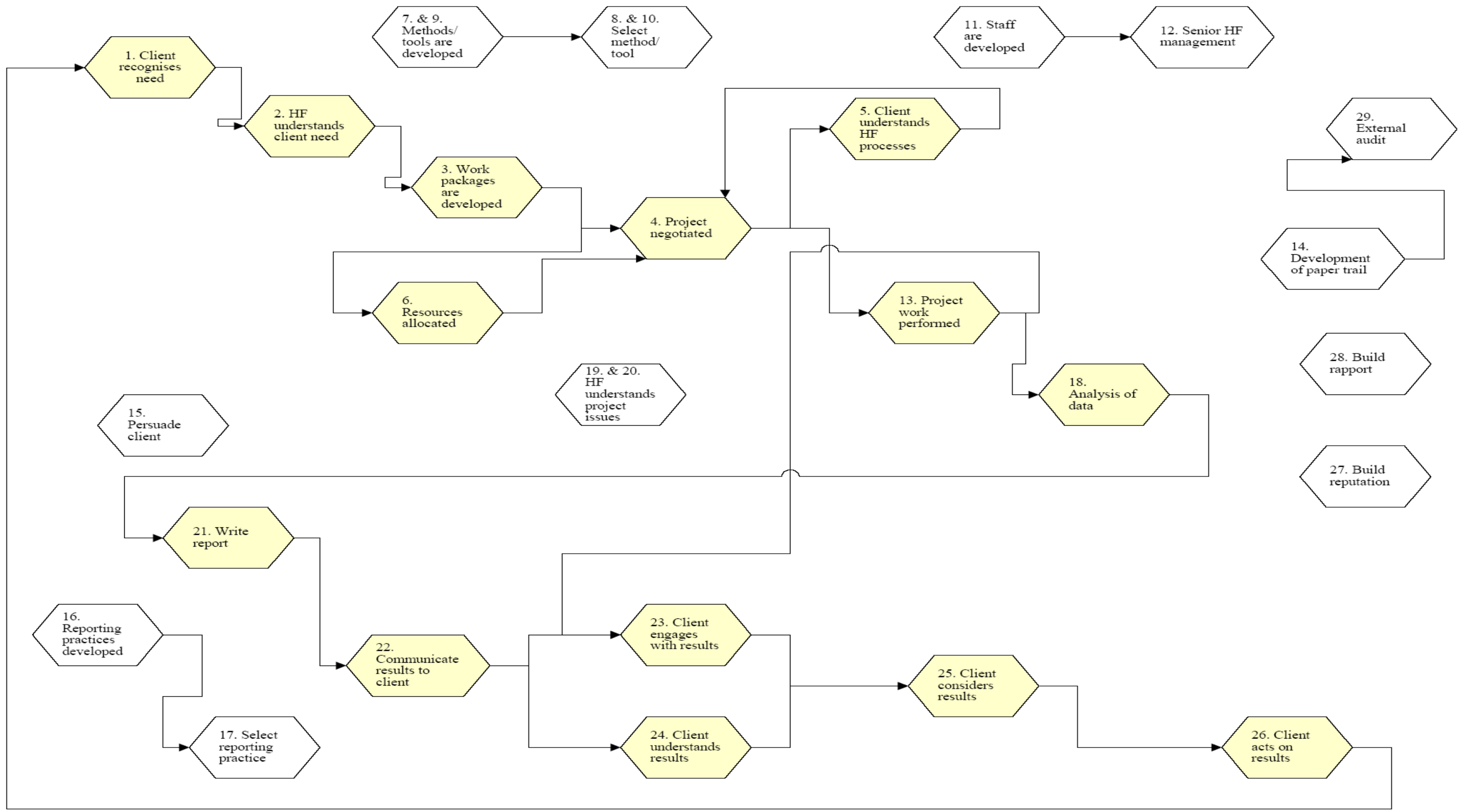
Those deviances from this flow include the processes surrounding function 4 to do with project negotiation; the fact that function 13 goes to function 23 and 24; and that there is a distinction between the parallel components of function 23 and 24; which are explained below.

The negotiation of the project work requires that the client understands, at least to some degree, what they are agreeing to. In the negotiation process the client will understand more about their options and so develop their understanding, this is why function 4 feeds into function 5. The clients understanding will then act as a control in the negotiation, this is why function 5 feeds back into the top of function 4. Important for both parties in the negotiation is that some set of resources will have been allocated to allow the potential for negotiation, this is why function 6 is a precondition for 4. From the HF/usability perspective this will be staff, time and equipment to do the work (which will be shaped by function 3); from the client side this is likely to be time and budget to pay for the work.

Function 13 feeds into 23 and 24 because some practitioners would encourage clients to observe user testing, or get them to speak to users, or watch an expert panel so they receive direct communication which is outside of the data analysis and project reporting process.

There is a distinction between function 23 and 24: 23 is to do with the client caring about and engaging with the issue, whereas 24 is more about the cognitive task of actually understanding what is said e.g. people might fully understand but not care about what is communicated and vice versa.

Figure C2.2: The Project Process [No codes as this is the central process]



HF understanding (Figure C2.3) [This includes codes A & B]

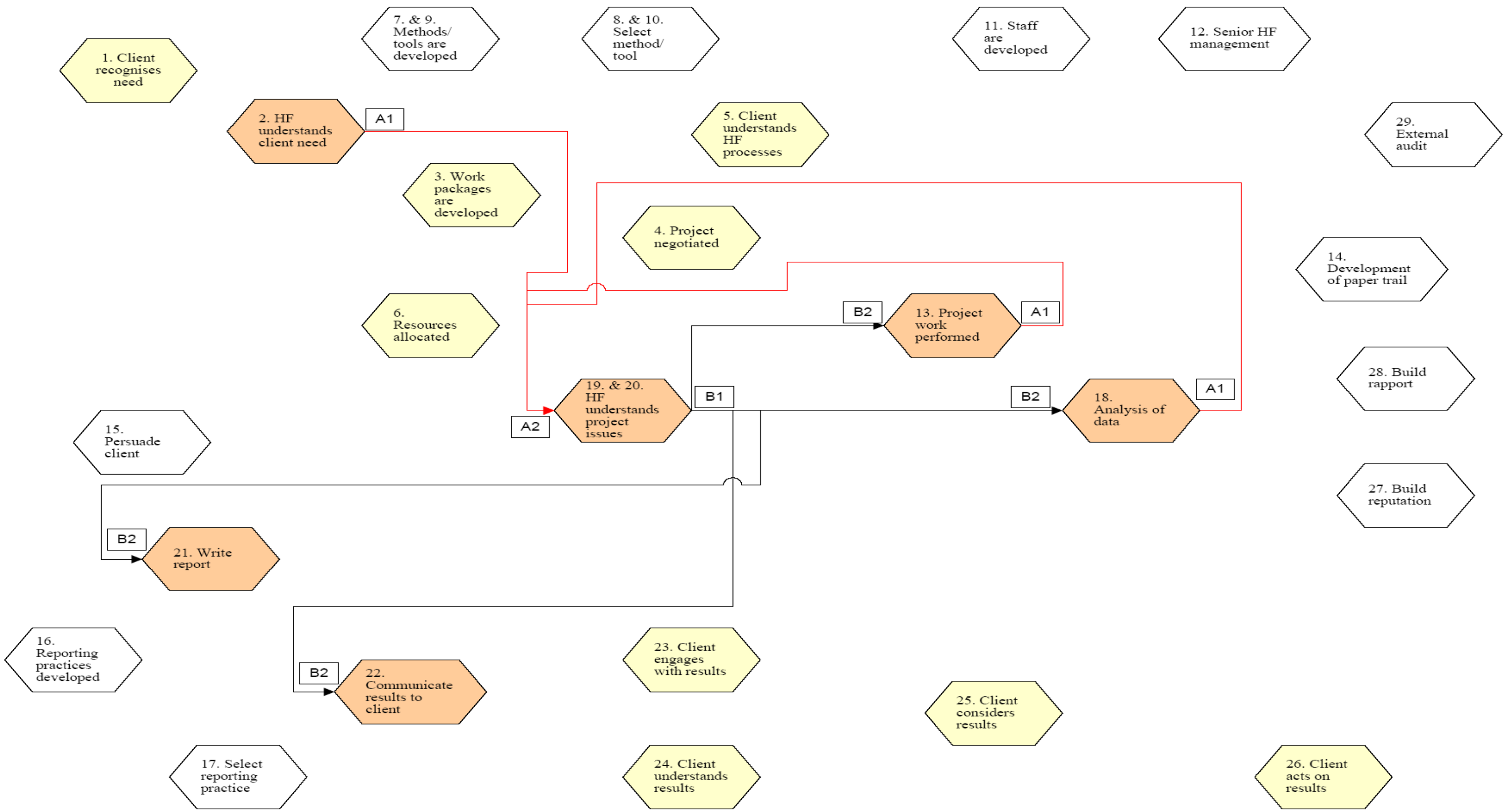
Figure C2.3 highlights functional couplings that are most closely associated with the HF/usability practitioner's understanding of the project and domain issues. Here 19 and 20 have been collapsed as they had the same inputs and outputs in the FRAM network. They are distinguished in Steps 1 and 2 because although they are interdependent understanding the project issues can be different from understanding the domain and context. For example, one practitioner (S5) was very specific about the importance of the context being engaged with, as a focus on project issues alone may lead to recommendations that do not work or are dangerous in the domain and context.

The network represents three main processes that feed into the HF/usability practitioner's understanding of the project and domain issues: 2, 13 and 18. These are: understanding the client need, performing project work and doing the data analysis respectively. Importantly, understanding the project and domain issues does not start with analysing the data, in 18, but in performing the method and understanding the client need which happens before the work is planned. As Figure C2.5 shows HF/usability practitioner experience also plays an important role in understanding which is a resource and control for 19 and 20.

The main output for HF/usability practitioner understanding the project and domain issues can be seen as two streams. The first is a feed into 13 and 18 creating a loop of analysis, understanding and then reanalysis. The second is an output more directed at the client in 21 and 22, which are writing the report and communicating to the client respectively.

HF/usability practitioner's understanding of project and domain issues is a central function which relates to different parts of the central project process. The main functional couplings which have been identified in Figure C2.3 are input from 2, a feedback loop with 13 and 18, and output to 21 and 22. We could say that there should be a feedback loops with 2, 21 and 22; and this suggestion would be perfectly reasonable and in line with the data. However, the representation and analysis are performed with pragmatics in mind. We also wish to give special emphasis to 13 and 18 as feedback loops as these are where analysis is a focus. It is true that there will be some output to 2, and input from 21 and 22, but these are not in the same order of magnitude as the feedback cycles of 13 and 18. As we shall see in Figure C2.5, the fact that the HF practitioner is a critical resource for these tasks means that they will constantly be using and developing their understanding when performing them.

Figure C2.3: Functional couplings of HF understanding [Includes codes A & B]



Persuasion, Rapport and Reputation (Figure C2.4) [This includes codes C, D, E, & F]

Figure C2.4 highlights the functional couplings to do with 15, 28 and 27; which are persuasion, rapport and reputation respectively.

The main outputs associated with the goal of persuading the client are 4, 13, and 22; these are project negotiation, project work and the communication of results to the client. These three nodes are situations where the HF/usability practitioner is likely to have contact with the client and is able to persuade them in agreeing to a project, in observing HF/usability work directly, or accepting the results of HF/usability work.

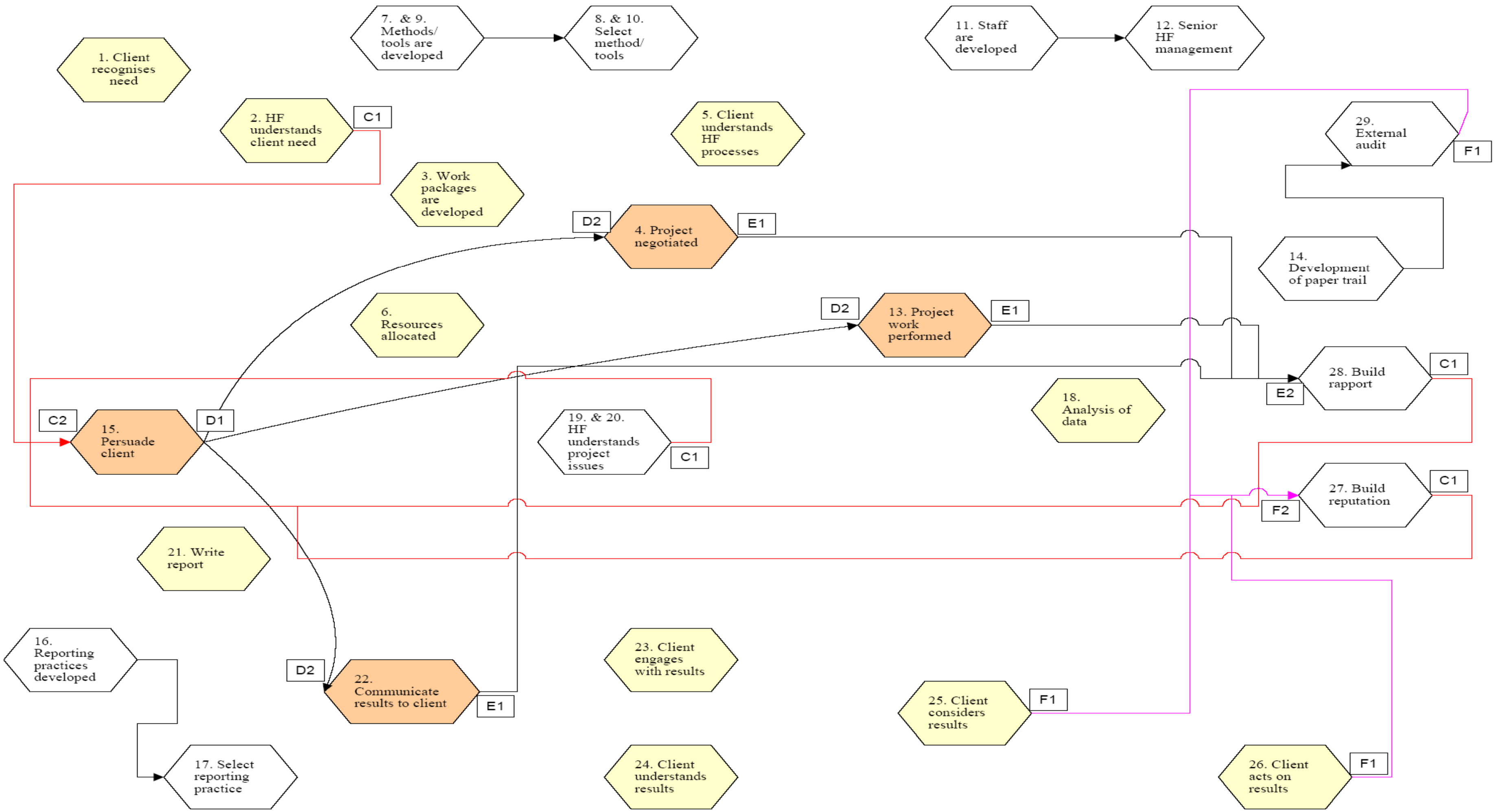
Persuading has five functional inputs which affect it: 2, 19 and 20 which are focused on the HF/usability practitioner's understanding of the client need, project issues and the domain; and 27 and 28 that relate to the softer issues of rapport and reputation which nevertheless play a role in persuading.

The rapport between the HF/usability practitioner and the client has opportunity to develop in points of contact in the project: these are 4, 13 and 22 which are project negotiation, project work and the communication of results to the client respectively. More widely these three contact points make a feedback loop with persuasion and building rapport.

The reputation of the practitioner also affects persuading the client but is qualitatively different for rapport. Whereas the rapport between people is about the relationship between them, reputation is a measure of past success. The main contributors to reputation are 25, 26 and 29 which all relate to the later stages of the process i.e. the consideration of the results, consideration of whether to act on them and external auditing. These three functions reflect on the success and impact of the project. Over a period of time there will be a pattern of results which will make up the practitioner's reputation.

This representation shows functional couplings of persuasion, rapport and reputation with specific parts of the project process and wider system of HF/usability practice. These factors can be considered soft, compared to more technical functions of the system, but they nevertheless play an important functional role. The network not only shows how they influence the system, but also what they are influenced by.

Figure C2.4: Functional couplings of Persuasion, Rapport and Reputation [Includes codes C, D, E, & F]



Description of the functional couplings of Staff as a resource and Senior HF management (Figure C2.5) [This includes codes G, H, & J]

Figure C2.5 highlights the important role of the HF practitioner and the experience, expertise and skills they bring to tasks.

There are many different parts of the FRAM network which are performed by the HF/usability practitioner i.e. 2, 3, 8, 10, 13, 14, 15, 17, 18, 19, 20, 21, 22, 27 and 28. This provides experience for the HF/usability practitioner and so contributes to their development, which is represented as the arrows going into 11 i.e. coded as G2.

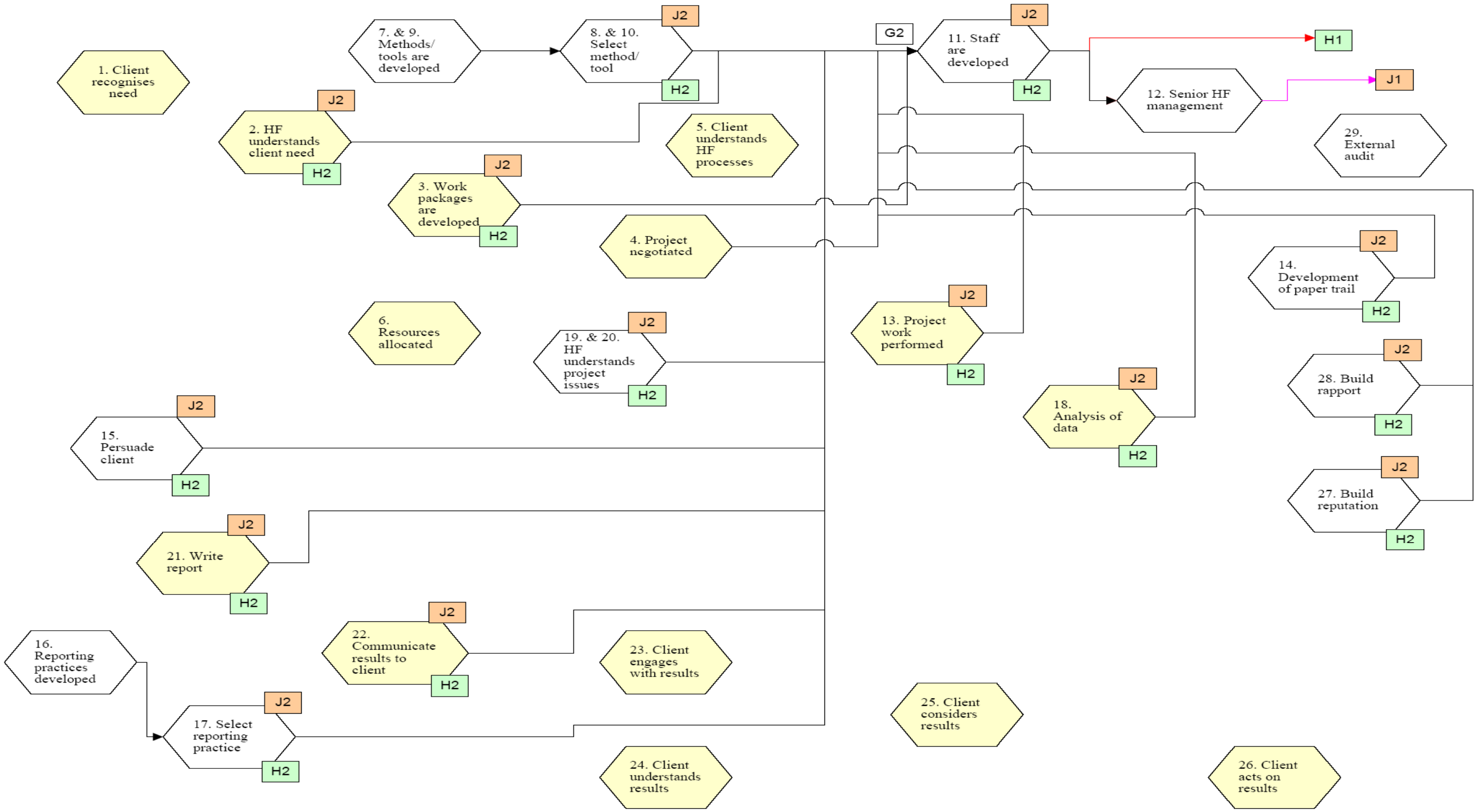
There are two outputs of staff development in 11: the first is represented as code H1 which represents HF/usability staff as a resource for doing work; the second flows into senior HF management through to code J1, which is senior staff as control. In the presentation H1 goes to H2, and J1 goes to J2 (this coding scheme is used to save arrows and make the representation clearer).

H2 shows that HF/usability staff are a critical resource for many of the tasks performed in the system. As they perform the tasks their experience, expertise and skill will play a large role in their performance. J2 represents HF/usability practitioners at a more senior level. These senior members of staff are presented as a control for the tasks that the HF/usability practitioners perform. So, the HF/usability practitioner performs many of the tasks in the system, who is monitored and supervised by senior HF/usability practitioners.

There is a cycle between doing, developing and supervising that reinforces practice, which leads to inertia in trying new tools, methods and procedures but stabilises the system. For example, junior members will typically be given limited rein and be told what to do and how to do it. This prescription will be based on the proven experience of the HF supervising staff. As the junior member develops they will become more accustomed to working in the prescribed manner, and be given more responsibility. As they gain seniority they will have learnt the techniques and standards of the supervising staff and be in a position to advise more junior members on what to do. This leads to a system which is stable as one generation passes their practice on to another. The cycle of supervision, doing and developing which reinforces practice can either be seen as a system characteristic that creates inertia to new tools, methods and practices; or as a stabilising feature that provides resistance against risk and promotes the proliferation of proven practice.

There are HF/usability staff input into other practices, e.g. developing tools and methods, but these have been deemphasised as other parties also play a role in these. Again the choice of what to represent has pragmatic concerns which includes the emphasis of different components.

Figure C2.5: Functional couplings of Staff as a resource and Senior HF management [Includes codes G, H, & J]



Description of the functional couplings of Tools / Methods / Report Development (Figure C2.6) [This includes codes K, L, M & N]

Figure C2.6 the functional influences that are related to the development and selection of tools, methods and reporting practices.

The development of work packages in 3 is a central node in the selection of tools, methods and reporting practices. It is here that an experienced practitioner will devise components for a project to help satisfy the client's need. The proposed work packages will feed down into what project work is performed and the subsequent analysis of the data.

The selection of new tools and methods, and adaptations made to tools and methods in the project work or data analysis stages of the project can lead to the development of tools and methods in practice (Identified by the M code, from 13 and 18 to 7 and 9).

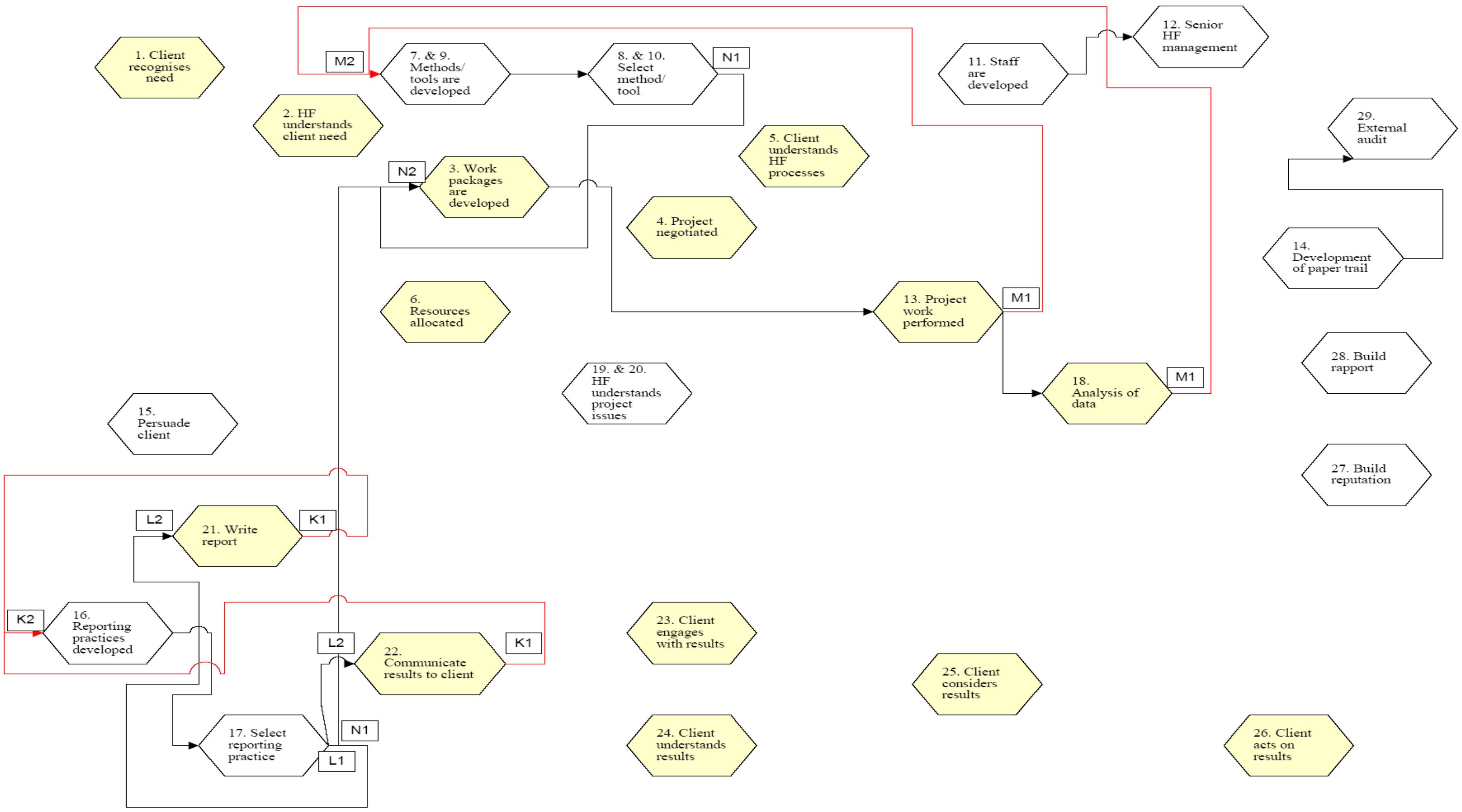
The selection of the reporting practice will influence 21 and 22, which are how the report is written and how the results are communicated to the client. Similar to tools and methods, new reporting practices can be experimented with and adaptations made to current practices which lead to the development of new reporting practices in practice.

External arrows are not included in the FRAM representation, but there is involvement from academia in the development of tools, methods and reporting practices. Indeed, for example, previous research has pointed to the fact that there is a lot of activity in the development of methods in 7, but not many are selected for use in 8 (O'Neill, 1998).

Focusing more on the selection of tools, methods and reporting practices we refer back to the description of Figure 6 which described the reinforcement of current practice: i.e. staff perform a practice, becoming more experienced at that practice, they then recommend it which then reinforces that practice for other staff. Here senior staff play a role in shaping and advising how practice should be done, whilst themselves being a product of years of supervision and practice. Staff will do what they are confident in, what they can predict and what they can do faster and better. This means doing the things they are used to, and not new things that they are not used to.

However, practitioners have been shown to be resourceful and reflective in developing their own tools, methods and practices to suit different demands in different contexts (see 7, 9 and 16 in Step 1 & 2 above). So, there is not stagnation in the face of useful development opportunities, but rather a steadiness which improves predictability, efficiency and effectiveness.

Figure C2.6: Functional couplings of Tools / Methods / Report Development [Includes codes K, L, M & N]



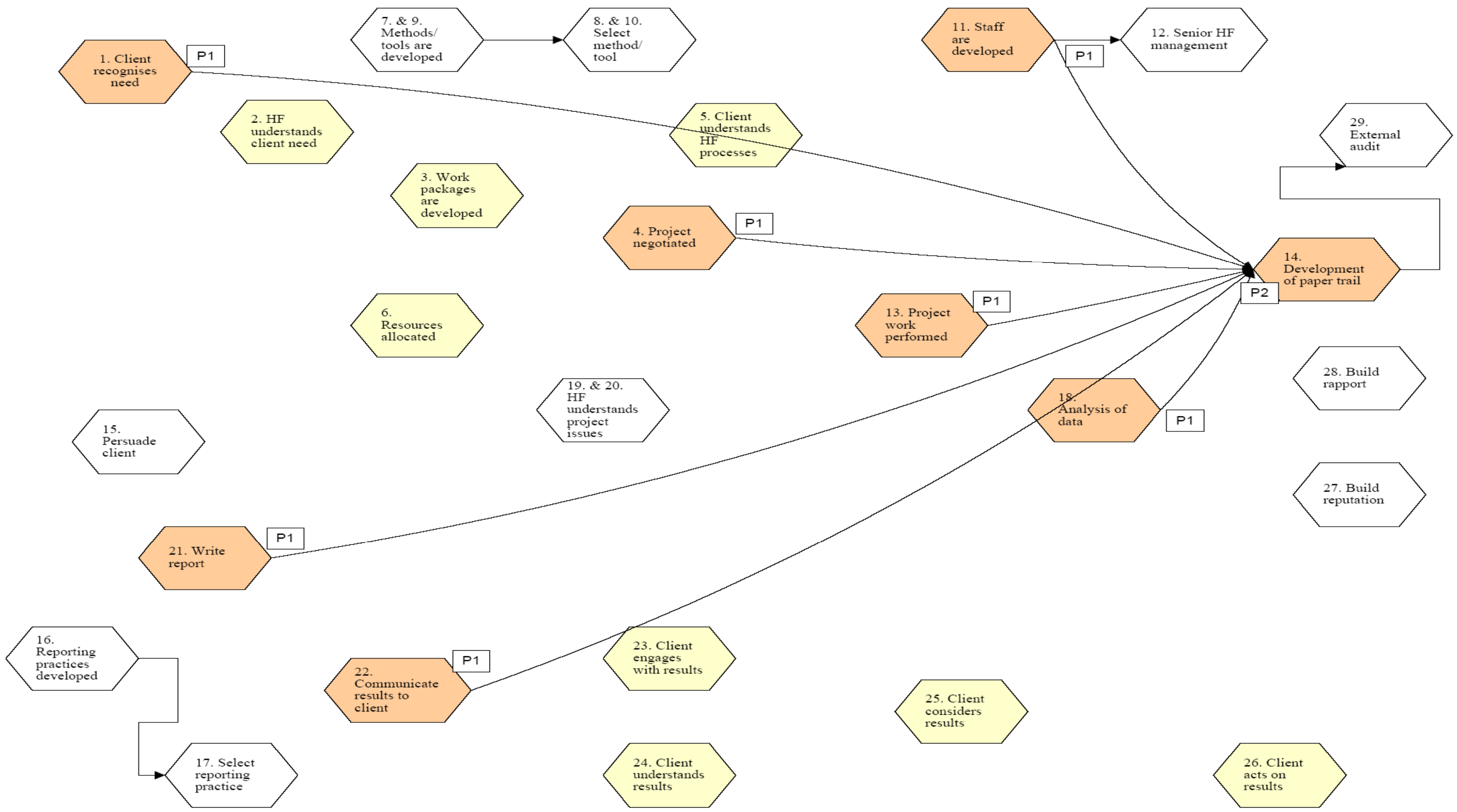
Description of the functional couplings of Paper trail and Auditing (Figure C2.7) [This includes code P]

Figure C2.7 identifies those key places where a paper trail is developed, which is a precondition for external auditing.

From the HF/usability point of view there appear to be six places in the central project process that produce paper work which can be archived for auditing purposes. In 1 the client recognising a need can be a document proposing the client need which invites bidders, sometimes called a request for service. In 4 a contract is normally agreed between the two parties. In 13 some material is normally produced in sketches, documents, videos, and transcripts. In 18 the analysis of the data is normally tractable. In 21 and 22 the report and communication to the client can be archived. In 11 staff may have updated CVs and records of their training. All of these points provide opportunity for archiving documentation and auditing.

As discussed in 13, in steps 1 & 2 above, not all contexts will value the auditing process and some may even find the administration involved in keeping such records a hindrance. However, some contexts and clients necessitate the ability to audit and have quality controls which are inspectable. So, depending on the circumstances of the project there may be more or less need for these functions to produce a paper trail.

Figure C2.7: Functional couplings of Paper trail and Auditing [Includes code P]



Description of the Combined FRAM network (Figure C2.8) [This includes all codes: from A to P]

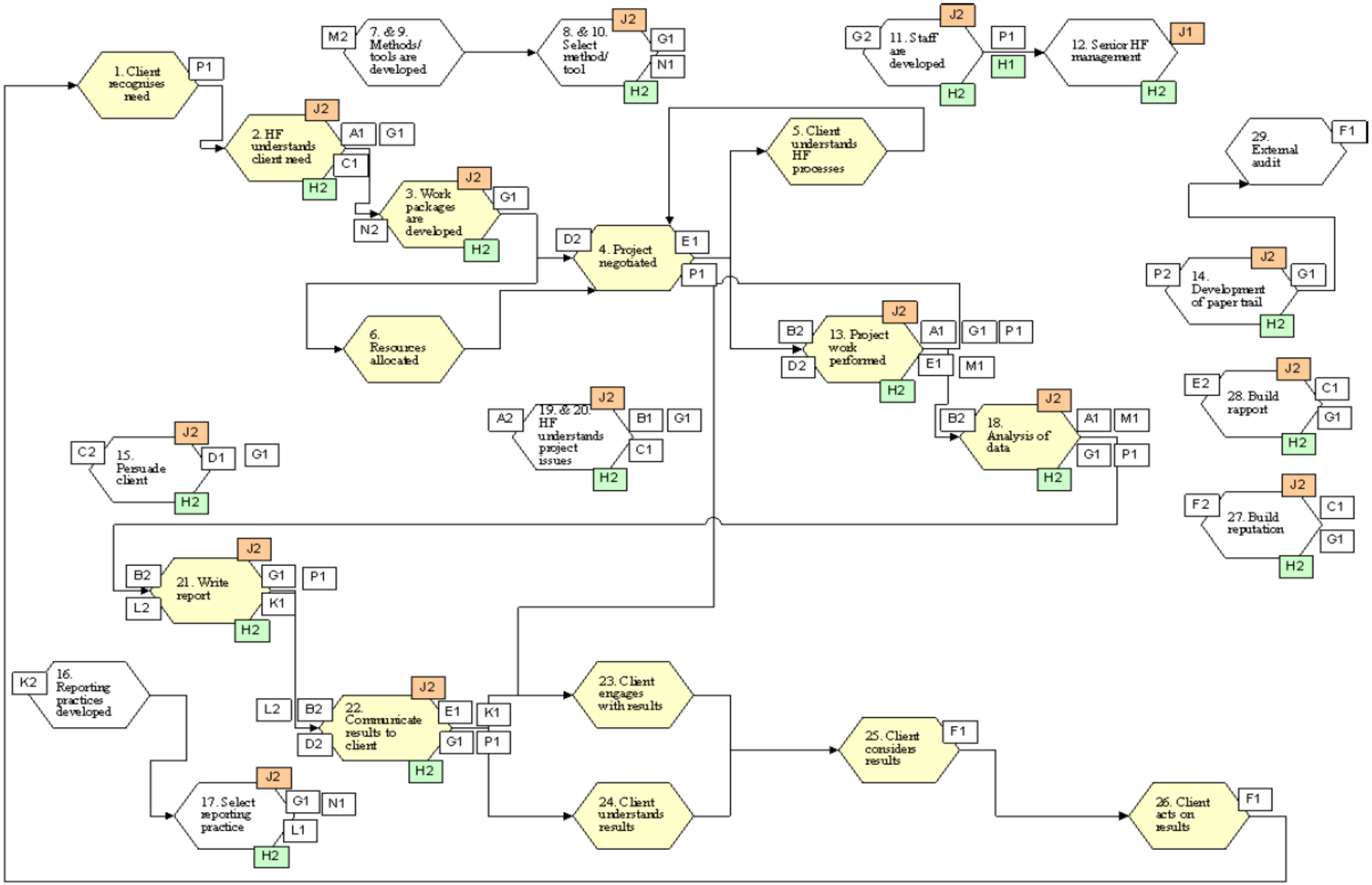
Figure C2.8 shows all the functional couplings that have been described from Figure C2.2 to C2.7. It has the project process as its central core, which is in a 'Z' shape (described in Figure C2.2). The codes are taken from the figures above (Figure C2.3 to C2.7). Where the previous figures have arrows these are now referred to as codes with letters and numbers to reduce the lines. The codes are in alphabetical order in the figures for ease of cross-reference. The codes go from 1 to 2 in each case e.g. A1 goes to A2, and M1 to M2.

This representation allows us to have more of an overview of the system. For example, there is a central project process for project work; this has a softer element in persuasion, report and reputation which impacts at three main functional stages: 4, 13, and 22; HF/usability practitioner understanding plays a functional role in persuasion and is a central process itself with feedback loops with 13 and 18, and links to 2, 21, and 22. Staff are a critical resource throughout the project, and senior members monitor and manage project progress (see J2 and H2). Tools, methods and reporting practices which are developed and selected for implementation in practice, are also developed in practice. However, there is external input in development from academia. It was identified that the selection of tools, methods and practices was strongly based on previous experience to promote predictability, efficiency and effectiveness. There were also specific stages in the project process which would provide opportunity for archiving which is a necessity in some contexts (see P1).

The system of HF/usability practice is in constant flux, and needs to adapt itself to every project. Through this system description we can see how performance of the different parts of the system come together, adapt and bend so the whole stays in a healthy state. For example, staff are constantly developing in different areas, working on different projects and building their rapport and reputation; work packages are being proposed and negotiated with clients but with some opportunities lost to competitors; the company is developing their reputation and expertise through the staff and completed project work; staff are being reflective on the tools, methods and reporting practices they use, some mindful of what academia is producing, some content that they have a set of well developed and successful practices; resources are stretched on some projects and are quite flexible on others; and some clients come back for repeat business, other clients might be approaching the company for the first time. This list of variances is not exhaustive.

The variance which exists in the different parts of the system makes its performance complex, particularly when we consider many parallel projects taking place at the same time: some finishing, some starting, some going well and some with challenges. A big influence in managing and absorbing this complexity comes down to the HF practitioner and staff. Through experience senior HF staff are able to see the past, present and some of the future, to know when things are going right and when they require attention, and what to do to successfully absorb variance.

Figure C2.8: Combined FRAM network [Includes all codes: from A to P]



Positive and Negative Resonance

In the following section we reflect on steps 1, 2 and 3. Table C2.1 lists positive and negative resonance at a system level, which have come from respondent quotations.

Positive resonance is a state whereby system performance is having its maximum effect within the constraints and dynamics of the context. Here non-linear functional couplings coincide and reinforce each other to increase the likelihood of an outcome which surpasses normal performance.

Negative resonance is a state where unwanted outcomes and influence coincide and reinforce each other to increase the likelihood of an unwanted event occurring. To prevent unwanted resonance we can erect barriers and specify performance monitoring practices.

Table C2.1: List of Positive and Negative Resonance from Respondent Quotations, with Comment

Theme	Positive Resonance	Negative Resonance	Comment
Understanding client's need.	Respondent W8 spoke of helping the client understand their need, because they sometimes didn't fully understand it themselves.	W5 satisfied his contacts' need but then found that his contacts' seniors had other concerns which nullified his contribution.	There should be a deep understanding of the client's need even when they don't know what it is.
Understanding project benefit.	W9 said that they would try to recognise and agree measurable improvements for the client as an outcome of proposed project.	Respondent S5 recognised that a client was unhappy because they didn't feel they had received benefit from the work, which was exacerbated by the fact that they had not understood the benefits in the first instance.	The client and HF practitioner should be absolutely clear about what they both expect from the work.
Resource management.	Respondent W2 was satisfied with the way her current work place managed projects.	Respondent W2 left a place of work because they worked their employees too hard, trying to stretch times and budgets so they could make more money at the detriment of the staff.	Projects should be managed appropriately, respecting staff, client, project and business goals.
Methods suitability.	Numerous practitioners reported applying methods which gave successful results, which suited the problem and project constraints.	Respondents W1 and W6 wanted to use more methods but these were often not feasible for their clients' budgets and timescales.	Clients need to be convinced of the worth of doing a particular activity or method.

Theme	Positive Resonance	Negative Resonance	Comment
Practitioner proven track record and reputation.	Respondent S11, spoke of being accepted by her clients once they knew that she had connections to people they respected and were friends with, so they trusted her reputation by acquaintance. Respondents W8 and W9 found it easy to justify usability and had a wealth of practical experience and examples.	Respondent W1, found it hard to justify usability, had little practical experience, and used examples from text books.	HF practitioners with a proven track record are likely to be in a good position to justify their work through real case studies and command more influence than junior members because of this experience.
Formal communication.	Respondent S2 states that a lot of their communication is done via documentation and email thereby creating a paper trail for auditing purposes.	S3 reported trying to evaluate an interface specification from a group outside the UK and they had no documentation on how it was developed. This started a long struggle to get supporting evidence to prove it was suitable.	Communication should be formal and auditable where appropriate.
Frequency of communication.	Respondent W2, who was involved in design work, greatly valued their company's procedure for frequently communicating with the client, to make sure both parties understood each other, so the project could be corrected should it need to be.	Respondent W1 makes comment which contrasts with the way W2 refers to design, saying: "you design it, you ship it out to another team, either they're happy with or they're not, if they're not happy then you argue with them." This is not as communicative or collaborative.	You need the right level and frequency of communication to facilitate successful collaboration.
Respect and rapport.	S5 and S11 both remarked on the importance of building up rapport.	Respondent W1 talks about the degradation of rapport and collaboration within their company, which led to recommendations being ignored and people 'doing their own thing'.	Mutual respect and rapport should facilitate collaboration.
Group work.	Respondent S6 said that they can get work done a lot faster working in groups, and their access to other experts was a great resource.	Respondents W1, W3 and S3 made comment about the advantages of working in groups for idea generation, error checking and learning.	HF group work is preferred for idea generation, error checking and learning.
Tool support to extend abilities.	Some respondents had easy access to tools and technologies which enhanced their offering to clients; for example, testing in a simulator and the development of 3D walkthrough computer models of control rooms.	S7 reported budgetary pressures which prevent them from adopting tools that may not prove their worth in the long term.	Tools and technologies should be employed to extend what practitioners can offer.
Tool support to enhance abilities.	Respondent S10 remarked about the considerable time he could save since the development of a tool which helped him calculate work load analyses.	Respondents W4 and S7 both identified editing video to be a chore.	Tools should make tasks easier and more effortless.

Theme	Positive Resonance	Negative Resonance	Comment
The right message to the right people.	Respondent S10 stated that he had learnt and was still learning that results from reports needed to be filtered back to the right people in the client company that cared about the issues relevant to the recommendation. This was in contrast to clients that could understand the recommendation but wouldn't care about that issue.	Respondent W5 recognised that they had done a project that met their needs of the client they had contact with, but not their higher management which made the decisions. The clients did not have a coherent view and understanding of their needs, so the project suffered.	The right person on the client side should be identified , who should understand and care about the HF issues.
Development of HF/usability output practices.	Respondent W5, was proud of the development work they had done on their reporting procedures. These developments made the reports faster to produce, gave the detail for the people that needed it, and a high level section for those that didn't need it and aren't interested in it. The development also included it being 'pretty' so it was more appealing and engaging as a product.	Respondent W1, didn't feel like they had a suitable way of selecting issues to communicate to the client. There were processes in place but they had no support from senior management and so no one had confidence in them or the motivation to use them.	There should be a well developed and suitable reporting procedure.
Actionable HF/usability output.	Respondent S12 said that they wrote reports making it clear how to exploit the knowledge within them thereby facilitating the client's consideration and actions on results.	Respondent S5 recognised that a client was unhappy because they didn't feel they had received benefit from the work, which was exacerbated by the fact that they had not understood the benefits in the first instance.	Consequences of HF work for the client should be made transparent to be acted upon i.e. as a resource for action.

FRAM Step 4: *Fine tuning and barriers*

This section identifies bullet points for fine tuning the positive resonance in the system, and putting up barriers to prevent negative resonance in it. It has a focus on how methods fit into the system.

Fine tuning to enhance positive resonance

- The client's need should be properly understood, particularly in light of the fact that they might not know the need themselves or there may be different factions within the client organisation that communicate a different need. Methods should be selected to meet this need.
- Staff will be more competent at applying methods which they are experienced at. This will enhance how they see its application, their adaptation of it for the context, the speed and proficiency of its application, and their communication of what the method does and its results to the client.
- Senior staff should plan projects with methods they are experienced at. This will allow them to monitor and supervise the project work better. It will also enhance how they see the project progressing, and their communication of what the method does and its results to the client.
- Time should be given to staff to adequately perform their tasks, monitor and support colleagues.
- Staff should reflect on their own practices so they can be developed and improved.
- The opportunities that particular methods afford such as enhancing persuasion, building rapport, documentation development, and facilitating communication should be exploited. This will include adopting and adapting methods for particular project contexts.
- Following on from methods, reporting processes should be quick, persuasive, clearly communicate crucial aspects, and make it clear how the client is to exploit the results. Results should be tailored to the audience, or the audience should be tailored to the results i.e. communicate to people who will care most about the consequences of these issues in a way they will understand.
- Appropriate tools should be employed to facilitate HF/usability work. This can differentiate offerings by adding something different (i.e. extend abilities), or speed up work and improve its quality thereby reducing its cost and improving the output for the client (i.e. enhancing abilities).
- Routine HF/usability practices should be developed so work is standardised and can be performed faster. Adaptations to the practice can then be made from this to suit the context.

Barriers to prevent negative resonance

- Novel and unpredictable methods should not be tried in important situations, which include most commercial projects where there is little slack. Methods can be tried and tested in academia or in situations where they are not project critical and unpredictable.
- Practitioners should have ample experience and resource to plan and monitor projects effectively, including the choice and use of methods.

- Practitioners should pay close attention to the points in the process where client communication occurs, so any questions or concerns they have can be addressed to ensure they maintain confidence in the processes and people.
- Within any project the negotiation stage should be managed as a critical step as this is where the parties agree on the plan, resources, methods, goals, and priorities. This will have a ripple effect throughout the whole project.
- Within and between different projects practitioners and organisations should take advantage of self-development opportunities to consolidate and diversify different skill sets. This will prepare practitioners and organisations for future projects with their own idiosyncrasies and variances.

Summary comments

In this system of functional resonance we have built an explanation where method selection, use and performance are inextricably linked to the performance of the wider system of HF/usability practice. Either directly or indirectly methods are affected by or affect every node in the FRAM network.

Appendix D: Validation and Feedback

This section shows the validation and feedback that the internal and external members gave on the FRAM analysis (described in Section 12.3). In this section the raw feedback from respondents is collected and reflected upon in the framework of the validation packs they were sent.

Usability Evaluation Methods in Practice: Understanding the Context in which they are Embedded

Thanks for taking the time to look over this document. We have developed a model of human factors and usability practice (HF/usability practice) which we hope you find interesting. Through this model we argue that we can understand factors that influence the adoption and adaptation of methods in practice, and how this impacts on system performance. We hope it may inspire you to think about the work you do in a new way.

This pack is divided into four main sections:

1. Your experience
2. Your current job title and role
3. Thesis abstract
4. Statements extracted from research

We encourage your feedback on the ideas developed in the thesis in Section 4. This will give us more confidence in our claims and inform us of areas that are particularly interesting or need development.

If you would like to see more of the thesis or have any questions please let me know.

Dominic Furniss
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0207 679 5211

N.B. The amount of pages does not accurately reflect the quantity of reading.

Please try to fill in as much of the form as you are able.

If you would prefer to print, fax and send then I will supply you with the details.

1. Your experience

How many years experience do you have in usability and human factors work?

Industry………………….. years

Academia…………………years

2. Your current job title & role

……………………………………………………

3. Thesis Abstract

This is provides an overview of the thesis (**this is included for information, you do not have to read it for the purposes of checking this document**).

Research shows that lots of usability evaluation methods (UEMs) are produced but few make the successful transition from academic research to practice (Bellotti, 1988; O'Neill, 1998). Worse still critics suggest that much of the literature on UEMs is irrelevant to practitioners (Wixon, 2003). Both of these combined suggests there is a gap between UEM research and UEM practice. To address this gap this work investigates the opportunities and barriers for UEMs in industry by developing a grounded understanding of UEM adoption and adaptation in practice. To do this a grounded theory of usability practitioners was developed (9 interviews from the website domain and 13 in the safety-critical domain). The analysis proceeded in bottom-up and top-down stages. The bottom-up stages produced insight from the data in an exploratory and inductive manner. This highlighted the importance of contextual factors and the need for system descriptions: UEM adoption and adaptation cannot be fully understood devoid of context. The top-down stages used Distributed Cognition and Resilience Engineering conceptual frameworks as leverage for exploring the data in a deductive manner. These were chosen for their focus on system performance within context to provide system descriptions. To illustrate the importance of context we describe three models: 1) where previous research has highlighted the downstream utility of UEMs we expand the metaphor to consider the landscape through which the stream flows, where the landscape represents the project's pre-existing context; 2) where information propagation and transformation in a project is influenced by social, information flow, artefact, physical and evolutionary factors; and 3) where the functional couplings between parts the system of usability practice can be managed and monitored to positively resonate with each other, thereby improving the performance of the system overall. The concept of Positive Resonance is introduced to describe how practitioners adapt to the context to maximise their impact under constrained resources. These grounded descriptions show that context is important and, in agreement with Wixon (2003), that research which looks at valuing UEMs using problem identification as a measure is highly limited. UEM adoption and adaptation should be explained within the broader context of practice e.g. the design, business, social and organisational processes. Functional couplings can be monitored and managed to improve system performance, which importantly includes decisions influencing UEM adoption and adaptation in practice.

4. Statements extracted from research

This part of the document contains statements that have been extracted from my research. They are centred on a model describing a system of human factors and usability practice (HF/usability practice). Representations of this model can be found within the descriptive sections. These representations will start to gather meaning when reading the statements that accompany them.

The statements are presented at three different levels of granularity, becoming more abstract from level 1 through to level 3, i.e.

3 steps to guide you in thinking about these statements:

1. Looking at the statements:
    a. Are they generally accurate? Please say a little about why you think so.
    b. Are there important conditions missing on any? If so, where and what?
2. Looking at the representation:
    a. Generally speaking how accurate do you think it is? Please say a little about why you think so.
    b. Are there any important elements missing? List them or draw them on the representation, and explain briefly.
    c. Looking at the boxes are there any that are unimportant, trivial, or have little effect? List them or cross them off the network, and explain briefly.
3. Any other concluding comments or suggestions?

Your reaction to these statements and representation will be of great help in validating them. You can provide us with more confidence in our conclusions, and show us where our explanations are partial or mistaken, and need to be revised for more accuracy.

Please note:

- Checkboxes and a comments section are included below.
- All comments are optional. Please make comments where you feel it is useful and/or necessary.
- We ask whether you think the statements are generally accurate and whether you consider them to play a significant role in your work.

Level 1: Components

The table below refers to the 29 individual components in the system of HF/usability practice. The numbers correspond to the nodes in the representations in Level 2.

	Component name	Statements
1	Client recognises need	Clients vary in their maturity, attitude and knowledge toward HF/usability. They will have different resources, processes and constraints. They will seek HF/usability service for different reasons e.g. financial, product quality, performance and legislative reasons. Is it generally accurate? Yes 16, No 0, Not sure 0. Is it a significant component? Yes 14, No 0, Not sure 1. Comment (optional): "This shapes the nature and delivery of the work, especially if client wants the HF tick in the box" (E1) "Often knowledge very low, not sure whether the different reasons for involving HF has an influence on success of outcome." (E9) "At the end of the day, if the client does not have the resources or the methods do not directly help them achieve their goals, as a consultancy we can't enforce certain methods. ROI (return on investment) from the purchasers as well as the company's perspective must be met." (E12) "Its important but not time consuming" (W7) <u>Reflection on comments:</u> This is generally accurate. Comment E1 and E12 relate more to the system and subsystem level i.e. this component's integration and influence on others.
2	HF understands client need	Clients will not always understand their need and so may need help to do so. Some clients will be quite knowledgeable about what they expect from a project and how it should be performed. Some may not want to understand their need too much, and might just want the problem to be solved. Is it generally accurate? Yes 14, No 0, Not sure 1. Is it a significant component? Yes 14, No 0, Not sure 2. Comment (optional): "Not sure I agree with this one – clients understand their need, but their need may vary. They understand that they have a problem they want solving etc. Clients will have a varied level of understanding about the underlying HF/usability issues contributing to their problems – I think that is the important point." (S3) "It is important that the client has not prematurely decided what needs to be done." (E1) "Lack of understanding can lead of perceived lack of importance" (E9) "There are various stakeholders and decision makers on "client" teams. This makes it easier and more probable for roadblocks to be put up from any number of directions – either in seeking assistance or in agreeing on specific approaches to solving the need." (E6) "A few clients will accept a 'hands off' attitude to something new to them." (E5) "Pinning a client down to what their need actually is, is always a huge part of

		the initial stages of working with a client. A common comment is 'I want to increase my conversions' - too general. Part of our skill as practitioners is to break this 'problem' down into something more manageable and achievable." (E14) "Its important but not time consuming" (W7) <u>Reflection on comments:</u> This is generally accurate; however, it could be reworded for clarity: "Clients will recognise a need but will have a varied level of understanding about the underlying HF/usability issues contributing to their problems. Elaborating and clarifying the need to be addressed in the project can be a major piece of project work. Some clients will be quite knowledgeable about what they expect from a project and how it should be performed. Others may not want to understand their need too much, and taking a 'hands off' approach might just want the problem to be solved."
3	Work packages are developed	Over time practitioners build up a repertoire of work packages which can be tweaked and combined for client projects. Is it generally accurate? Yes 14, No 0, Not sure 1. Is it a significant component? Yes 12, No 0, Not sure 2. Comment (optional): "Not sure I understand this one…" (S3) "Work packages are more relevant to large programmes of work (cost:benefit)" (E1) "Sometimes yes, for example where you work with the same client, on the same product and are looking at newer builds/versions. This is very helpful for benchmarking. Therefore, sometimes this is a yes. However, where you work on different products (eg a mortgage website or an insurance website) the methods may be similar, but the actual test plan, objectives, scenarios, users etc are different, therefore no." (E12) "Also dependent on the experience of the practitioner." (W1) "I think I would label this as part of an HCI practitioners tool kit, this may include simple things like word templates for scripts to more complex things like sample wire frames" (W2) "This is not unlike any practitioner in any position in business, eg. Business analyst, product manager, marketing manager. As for "significance" it is more accurate to say it is an efficiency component for the practitioner to produce such "work packages"." (E6) "This is very accurate." (E13) "Very timesaving" (W7) <u>Reflection on comments:</u> This is generally accurate. Comments from W1, W2 relate more to the subsystem and system level where practitioners' experience is involved. This could be reworded for clarity: "Over time practitioners build up a repertoire of work packages which can be tweaked and combined for client projects. This tweaking can include changing methods, or changing test plans, objectives, scenarios, and users within the same method. These pro-forma work packages organise knowledge and improve efficiency."
4	Project negotiated	The project negotiation stage is a key stage in the project as plans are agreed and resources are allocated. Is it generally accurate? Yes 13, No 1, Not sure 2. Is it a significant component? Yes 16, No 0, Not sure 0. Comment (optional): "The level of resources and activities to be carried out will be determined at this stage and will have a major influence on the work carried out – although their can be opportunities for renegotiation (project variations) or for a scoping

		study prior to firming up what is going to be done." (S3) "But not all clients are willing to enter into this process and have very closed procurement procedures with little communication between client and practitioner or are closed about some factors such as budget." (S2) "Project manager can change resources internally." (W1) "It is significant in that this contribution is often viewed as gravy or an extra in the project as opposed to a must have in the project. Therefore, if it impacts timelines – the usual driver in a project – the practitioner must either make it fit in without adversely impacting the schedule or scale it somehow to fit. That is, speaking from a practitioner permanent at a client site." (E6) "Requires greater flexibility to be a successful project." (E5) "Resource allocation tends to change after the initial negotiation." (E13) "Important but often changes as project goes on" (E9) "It is important but a small part of the project time over all" (W7) Reflection on comments: It is interesting to note that the negotiation process is closed in some contexts (S2) and that other projects revisit the negotiation stage after the project has started (E9). This component does not specify whether resources are negotiated between the practitioner and client, or within the practitioner organisation, so that it covers both. These conflicting comments between contexts fit the discussion of the distinction between the model and instantiations of the model in Chapter 12 of the thesis.
5	Client understands HF processes	Through engagement with HF/usability services and having project options to consider, the client will come to learn more about HF/usability processes. They should be informed enough to make decisions at the project negotiation stage. **Is it generally accurate? Yes 8, No 5, Not sure 1.** **Is it a significant component? Yes 12, No 1, Not sure 2.** **Comment (optional):** "This is client specific – some clients are informed others are not." (S3) "I don't think this knowledge transfer happens as often as it should" (E9) "This only applies for some clients as some don't want to learn much about the processes." (E11) "Also depends on the amount of exposure client has to HF." (W1) "Although there is the caveat that sometimes clients don't know, don't want to know and simply want to be told what is best" (W2) "Not sure what this question is asking. Saying, I think, that the "client" or "they should be informed enough to make decisions…" is true only in that they are deciding to include some UEM step in the process." (E6) "Note: these questions feel as if they are all being asked of a practitioner who works at an agency or as a consultant. In a full time position at a client, a practitioner must provide steps they want input into the project plan in order for the project to be as successful as it can be. They identify what should be included and make a case for it. Other stakeholders or staff may or may understand what is being done and frankly may not care. They care that their goals are met and information provided is correct, helpful, and can be operationalized in the design." (E6) "It is difficult to make decisions at this stage but initial decisions are usually made." (E13) "Clients want their business aims met, they often can not see how usability services will achieve this aim, so we are constantly fighting with clients about the difference between market research and usability research." (E14) "It is important but a small part of the project time over all" (W7)

		Reflection on comments: This component needs to be clarified; it is implicitly coupled to 'Function 1': "Sometimes, through engagement with HF/usability services and having project options to consider, the client will come to learn more about HF/usability processes. They should be informed enough to make decisions at the project negotiation stage. Also, some clients will not care about HF processes but will be focused on whether their aims are met in their terms."
6	Resources allocated	Resource allocation plays a large role in project negotiation. It is rare that resources are abundant and so projects have to be competitive. There will be cheaper and more expensive options with their own pros and cons to consider. **Is it generally accurate? Yes 15, No 1, Not sure 0.** **Is it a significant component? Yes 14, No 1, Not sure 1. Comment (optional):** "The client does not require detailed resource information" (E1) "It is up to the practitioner to present tiered options and the pros and cons of each, with risks to the project in terms of each as well – that is, what can be or won't be accomplished as services or processes or projects are taken away." (E6) "This depends on how large the project is. I have seen many examples that resources are allocated after the project is won and negotiated by senior managers first. Then resource issues are discussion and allocated to appropriate members accordingly." (E13) "Yes there is a lot of competing agencies out there!" (E14) "It is important but a small part of the project time over all" (W7) **Reflection on comments:** This is generally accurate. Resource allocation can happen between practitioner and client, and within the practitioner's organisation. E6's comment can be added for clarification: "Resource allocation plays a large role in project negotiation. It is rare that resources are abundant and so projects have to be competitive. There will be cheaper and more expensive options with their own pros and cons to consider. The practitioner can present tiered options, with pros and cons, and the risks to the project if they are reduced or not carried out. These changes will affect what can be or won't be accomplished."
7	Methods are developed	Methods are developed in academia and in practice. For them to proliferate they need to be sufficiently promoted. **Is it generally accurate? Yes 10, No 3, Not sure 3.** **Is it a significant component? Yes 9, No 2, Not sure 5.** **Comment (optional):** "The methods need to be compatible with how we work in industry- they need to answer the questions we ask in industry and do it in an economical and timely way." (W9) "Cost effective options are often the most favoured, although clients want to see that a robust method has been adopted" (S3) "No such thing as a free lunch – intellectual capital is everything in consultancy – so methods may not be promoted in scientific literature." (E1) "For method proliferation they need to be not only promoted but effective (i.e. have a useful outcome) and usable and have good "face validity" so you can demonstrate why they are good methods to your lay person client." (S2) "Methods come from a wide source, many HF methods also come from the marketing realm. The method itself should not be the focus, but more how the client's objectives/needs are met. I think most clients want to see direct benefits from any method and in that case it is not really promotion so much as experiential." (E12) "It's not just about promotion. A method from academia may not be suitable in

		industry because of time/cost/etc. There is less method development in industry – it's less profitable." (E11) "I think that industry also develops methods but these don't seem to make it back to academia" (W2) "It is significant in that if academia comes up with something new – the ways a practitioner learns of it is through practitioner blogs, conferences, ACM, UPA, etc. However, this is hit and miss. It's difficult to keep up with changes, discoveries in academia and try and sort out how to apply it without a concerted effort to surf the locations mentioned and actively try and assimilate / try it out on the job" (E6) "This is a sticky point - my average project time is 3 days write up of findings - I do not have time to use complicated academic methodologies - this would not be relevant for clients either - they want quick and easy to understand answers." (E14) **Reflection on comments:** There are a few points raised here mainly due to an imbalance between the summaries of Functions 7 and 8 rather than a strong disagreement with the data, so clarification is needed: The adoption of methods is not just about promotion. There are strong pragmatic considerations in industry. Methods are developed in academia and industry, and come from other domains. There are different communication channels between academia and industry; their effectiveness is circumstantial. "Methods are developed in academia and in industry, and some are borrowed from other domains e.g. marketing. Methods are refined for use in practice. For them to proliferate they need to be sufficiently promoted, useful and suitable for use. The communication of novel methods can come from different sources; e.g. colleagues, conferences, meetings, blogs, journals, articles and courses. The effectiveness of this knowledge transfer is circumstantial. The method itself should not be the focus, it is a means of fulfilling the client's need. Method selection is discussed in Function 8."
8	Select method	Once the client need is appropriately understood the right method or methods might be apparent to the experienced practitioner. The selection will be based on different dependencies including: the problem, what the practitioner is used to, the client's preference, organisational practice, time, budget, access to users and prototypes, project stage, communication and persuasion requirements, auditing requirements and tool support. **Is it generally accurate? Yes 16, No 0, Not sure 0.** **Is it a significant component? Yes 16, No 0, Not sure 0.** **Comment (optional):** "Practitioner knowledge/experience is a really important factor. There are so many methods and you tend to stick to what you know. There are not that many easy ways to learn new/emerging methods." (S2) "I think there may be a big difference between in-house teams and client/agency here. There seems to be more rationale for choice in the client/agency project, in-house teams are more likely to stick with what they know rather than use a framework (like D.E.C.I.D.E) to choose." (E9) "Very well stated." (E13) "This is a huge list - sometimes time factors and business needs are more important i.e. a website is about to be released supported by an advertising campaign, this timetable will dictate everything." (E14) **Reflection on comments:** This is generally accurate. E14 emphasises time and business factors; S2 and E9 emphasise 'sticking to what you know'.

		"Once the client need is appropriately understood the right method or methods might be apparent to the experienced practitioner. The selection will be based on different dependencies including: the problem, what the practitioner is used to, the client's preference, organisational practice, time, budget, access to users and prototypes, project stage, communication and persuasion requirements, auditing requirements and tool support. Some methods require great expertise. People will have a tendency to stick to what they know."
9	Tools are developed	Tools are developed in academia and in practice. For them to proliferate they need to be sufficiently promoted. **Is it generally accurate? Yes 12, No 2, Not sure 2.** **Is it a significant component? Yes 8, No 2, Not sure 6.** **Comment (optional):** "The tools need to be compatible with how we work in industry- they need to answer the questions we ask in industry and do it in an economical and timely way." (W9) "Sometimes have to adapt methods and tools" (S3) "No such thing as a free lunch – intellectual capital is everything in consultancy – so methods may not be promoted in scientific literature." (E1) "Comments regarding methods also apply. There is also the question of availability. E.g. not always possible to get scoring criteria for questionnaires, software etc." (S2) "Again, tools come from a wide source, many tools are based on academia/statistics/research methods however, they are refined in practice. All consultancies need a unique selling point and this can come from tools and deliverables. Therefore, I would say that most tools used in industry evolve in practice. It may be worth noting, that I was part of the academic world over 10 years ago when HF was taught in a different way than it is today. Usability tools and methods were based more on ergonomics research – as products and technology evolve, so do tools and methods in practice." (E12) "It's not just about promotion. A method from academia may not be suitable in industry because of time/cost/etc. There is less method development in industry – it's less profitable." (E11) "Not sure of the difference between tools and methods – perhaps one is more tangible than another." (W1) "Tools are usually easier to promote than methods in my work place." (E13) "see above comment about methods (This is a huge list - sometimes time factors and business needs are more important i.e. a website is about to be released supported by an advertising campaign, this timetable will dictate everything.). Also depends what tools you are talking about i.e. eyetracking versus an analysis tool" (E14) **Reflection on comments:** Many of the comments of method development in Function 7 are repeated here, so clarification is required: "Tools are developed in academia and in industry; they are refined in practice. For them to proliferate they need to be sufficiently promoted, useful and suitable for use. The communication of tools can come from different sources; e.g. colleagues, conferences, meetings, blogs, journals, articles and courses. The effectiveness of this knowledge transfer is circumstantial. The tool itself should not be the focus, it is a means of fulfilling the client's need. As products and technologies evolve so will tools, i.e. they will have new requirements to fulfil and new potentials to fulfil those requirements. Tool selection is discussed in Function 10."

10	Select tool	Tools can enhance and extend abilities. Useful tools are assimilated into a practitioner's repertoire. Where there is poor tool support and work is cumbersome other options may be selected. **Is it generally accurate? Yes 12, No 2, Not sure 2.** **Is it a significant component? Yes 10, No 3, Not sure 2.** **Comment (optional):** "Not sure what is meant here" (S3) "I think there may be a big difference between in-house teams and client/agency here. There seems to be more rationale for choice in the client/agency project, in-house teams are more likely to stick with what they know rather than use a framework (like D.E.C.I.D.E) to choose. I think some people will stick with what they know even if it is cumbersome than try something untested (for them) in a live environment." (E9) "Not sure what is meant by "other options may be selected." If you have a job to do and there are only so many recommended methods to use, if you don't have a specific tool, you'll do a watered down version of it perhaps or a long-hand method – and perhaps couple it with a complimentary approach providing another angle." (E6) "Time and client relevance is always paramount - if a tool is time consuming and adds no value to what the client wants, it will not be used." (E14) "Many tools we use aren't "easy"" (W7) **<u>Reflection on comments:</u>** "Tool selection will be based on different dependencies including: the problem, what the practitioner is used to, the client's preference, organisational practice, time, budget, and access to tools. Tools can enhance and extend abilities. Useful tools are assimilated into a practitioner's repertoire/toolkit. Practitioners will develop efficient and effective ways of working. Some tools may be cumbersome but necessary; however, alternative routes to a solution may be selected if trade offs are appropriate e.g. video editing may be avoided if it is cumbersome to do and it isn't felt it would greatly benefit the project. Some tools require great expertise. People will have a tendency to stick to what they know."
11	Staff are developed	Practitioners are a critical resource in HF/usability work who need to be nurtured and developed. As practitioners mature in their careers they will have a wider repertoire of abilities and responsibilities. Practitioners have different preferences, qualities and abilities. **Is it generally accurate? Yes 13, No 1, Not sure 1.** **Is it a significant component? Yes 13, No 0, Not sure 2.** **Comment (optional):** "I think that very often in our field practitioners end up becoming experts in one thing. So instead of the full gambit of user experience they do just usability or just accessibility or just information architecture. Instead of getting a wider repertoire throughout their careers often the repertoire narrows to just their one speciality" (W2) "If you are one of the practitioners working at a client site permanently, you may very well face a career not exactly bathed in nurturing postures from your supervisor or co-workers. You, in fact, must evangelize your efforts, your input, your output, your skill sets daily. Confusion abounds about the benefit your work can bring to a development team. And the reputation for "user experience" people in America is quickly souring with adjectives such as "stubborn" and "inflexible' often used. I have found this during recent interviews and during interviews for my current position. Practitioners, I suspect, spend so much time defending and evangelizing their work they start to appear cross and unyielding during collaboration in projects. I do believe the environment [whether client side or agency side] does impact the practitioner and will necessarily enable widening of their repertoire or stifling them into a narrow, focused role such as only doing usability testing, versus

		employing any number of methodologies as suggested or recommended during a development cycle." (E6) "They should be able to use all/any tools and be prepared to work on the client's platform." (E5) **Reflection on comments:** This is generally accurate but could be embellished to reflect the feedback: "Practitioners are a critical resource in HF/usability work who need to be nurtured and developed - they will have a direct impact on what can be achieved from the project. As practitioners mature in their careers they will have a wider repertoire of abilities and responsibilities. Nurturing opportunities will vary between contexts, and practitioners can push their own development agenda rather than being passive to it. Some practitioners will specialise in a domain or method, others will be more generalist. Practitioners have different preferences, qualities and abilities."
12	Senior HF management	Senior practitioners are in a position to monitor and manage staff and project work. For example, they will know methods, solutions, and potential project pitfalls to monitor effectively. **Is it generally accurate? Yes 14, No 1, Not sure 0.** **Is it a significant component? Yes 8, No 3, Not sure 3.** **Comment (optional):** "Yes, but some knowledge may be out of date. New graduates or new staff from another company may bring new knowledge in with them." (S2) "Being a good practitioner does not necessarily make you a good manager of staff and work." (E9) "Senior people are more savvy in terms of project and client management. Most HF students are not taught such skills, they must learn them. However, recent graduates can share their knowledge from academia to help improve or 'update' methods and tools used by senior practitioners. A good consultancy would ensure that knowledge transfer happens in both directions." (E12) "Just iterating common practice – not specific to HF." (W1) "Transfer of knowledge between more experienced and less is a sticky issue in agencies. Often there is just not enough time to do this, you just have to learn on the job and hope you don't screw up!" (E14) "Not all line managers are HCI practitioners in agencies." (W7) **Reflection on comments:** This is generally accurate. However, there is a sense that new staff need to be accounted for more effectively: "Senior practitioners are in a position to monitor and manage staff, projects and clients. For example, through experience they will know methods, solutions, and potential project pitfalls to monitor work effectively. New staff may bring in alternative approaches that senior practitioners can learn from, making learning and management a two way process. A good HF practitioner may not be a good manager, and managers may not always be HF practitioners."
13	Project work performed	The quality of the project work will be influenced by the skills and experience of the practitioner performing the work. Clients can learn directly about project issues from this stage by observing or taking part in the work. **Is it generally accurate? Yes 14, No 0, Not sure 2.** **Is it a significant component? Yes 13, No 0, Not sure 3.** **Comment (optional):** "Clients can get too close and bias usability study" (E1) "Not just of the practitioner, also of collective knowledge of the organisation, knowledge of their manager, etc." (E11) "See good as client taking part in work. But also bad as it can slow down work

		considerably." (W1) "If this question refers to simply attending update or status meetings or observing tests etc. then perhaps client will learn more about the project directly. However, the first statement is true as on any job – quality is impacted by skills and experience, along with personal communication skills, personality, and work style which is not mentioned." (E6) **<u>Reflection on comments:</u>** This is generally accurate but can be clarified by incorporating the comments: "The quality of the project work will be influenced by the skills and experience of the practitioner performing the work, knowledge of their manager, and the collective knowledge of the organisation. Clients can learn directly about issues observing or taking part in the project work. Closer client involvement has to be traded off with slowing the process down and potentially introducing bias."
14	Development of paper trail	Some contexts value the maintenance of an audit trail more than others: from contexts where clients require it for quality control to where this practice may hinder the ebb and flow of design. Past project reports, information and presentations can be used as a resource for future work. **Is it generally accurate? Yes 12, No 0, Not sure 3.** **Is it a significant component? Yes 9, No 2, Not sure 4.** **Comment (optional):** "In my environment past paperwork is hardly ever re-used" (E9) "Not sure what you mean by 'past projetcts: just from that client, or of other clients" (E11) "I haven't got much experience but haven't come across this." (W1) "Sometimes the paper trail isn't useful and sometimes keeping the documentation becomes a hindrance rather than an aide – I think that its significance will vary greatly by context, project, practitioner and company" (W2) "Creating or perhaps just documenting work as a paper trail is a good idea to aide you and the 'client' or the supervisor for a variety of reasons. Quality control seems like the least of them-whereas for reference later is more the likely reason and of course for analysis purposes. And yes, past projects can be used as a resource for future work – but it's not significant as in critical unless you are in a selling /consultancy where you are constantly proving you know how to do something. In a permanent position, you are not reselling your skills or past projects – just evangelizing that they can contribute and make a difference." (E6) "This is vital as the UX person may not be there for the entire project's duration." (E5) "I don't have experience in audits and quality control and cannot comment on this. I found it difficult to understand this statement." (E13) "Yes, this is critical, ultimately it saves time!" (E14) "Can add significant cost to projects as can be time consuming" (W7) **<u>Reflection on comments:</u>** This is generally accurate but there are differences of opinion because it is more familiar to some practitioners than others, and different practitioners have different uses for it.
15	Persuade client	Persuading and negotiating are key skills in client interaction. **Is it generally accurate? Yes 16, No 0, Not sure 0.** **Is it a significant component? Yes 13, No 3, Not sure 0.** **Comment (optional):** "I would argue that facilitation skills are more significant than persuasion and negotiation." (E12)

		"Especially important in pitching and maybe communicating results as well." (W1) "Communication skills are also important in this context." (E13) "Huge part of my job." (E14) **<u>Reflection on comments:</u>** This is generally accurate. The introduction of further key skills of practitioners could be the topic of future work.
16	Reporting practices developed	Reporting practices are developed in academia and in practice to enhance the transfer of information in different forms: making it more intelligible, faster, persuasive, and fit for purpose. Different audiences of the same report may have different needs and expectations of it; for example: directors need to be sold the overall message, developers will want the detailed recommendations, and the regulators will want convincing that appropriate methodology has been followed. **Is it generally accurate? Yes 14, No 0, Not sure 2.** **Is it a significant component? Yes 13, No 1, Not sure 2.** **Comment (optional):** "Always know your audience" (W9) "Tremendous confidence is placed by the recipients that 'good science' has been used – as they may not have the expertise to judge this." (E1) "Sometimes we are even required to produce different reports for different audiences. Various stakeholders (e.g. road users, rail passengers, media) are also important and not mentioned here." (S2) "Appropriate comms tools are often overlooked." (E9) "I would argue that reporting practices are developed in practice, not in academia… so on that premise I have selected yes to both. Most academics write in a very academic style (eg in North America following APP style). They often miss the connection between the issues, recommendations and what is actually feasible. Writing to meet different styles of readers is better accomplished in practice (eg Executive summary; highlighting key issues instead of focusing on statistical analysis). At least this has been my experience when working with recent graduates." (E12) "You will 100% be expected to regurgitate results in a variety of different outputs with a variety of levels of granularity and content selection dependent upon your audience." (E6) "Have a problem with this statement 'Reporting practices are developed in academia and in practice', in practice yes. You have to pitch your findings etc according to the audience and the time allocated for the presentation in practice, not sure this applies to academia." (E14) **<u>Reflection on comments:</u>** This is generally accurate. I know of research which looks at studies HF reporting practices (e.g. Hornbæk & Frøkjær, 2005) which is an issue for two of the comments. This shows that it should be at least downplayed as it is not an extensive body of knowledge. "Reporting practices are developed in practice to enhance the transfer of information in different forms: making it more intelligible, faster, persuasive, and fit for purpose. Few studies in this area exist in academia (e.g. Hornbæk & Frøkjær, 2005). Different audiences of the same report may have different needs and expectations of it; for example: directors need to be sold the overall message, developers will want the detailed recommendations, and the regulators will want convincing that appropriate methodology has been followed. Different reports may also be written for each audience."
17	Select reporting practice	The selection of the reporting practice will be based on different dependencies including: what the practitioner is used to, the client's preference, organisational practice, time, budget, the sort of insights and data, project

		stage, communication and persuasion requirements, auditing requirements and tool support. **Is it generally accurate? Yes 16, No 0, Not sure 0.** **Is it a significant component? Yes 15, No 1, Not sure 0.** **Comment (optional):** "Always know your audience" (W9) "It is very difficult to depart from your habitual reporting style." (S2) **<u>Reflection on comments:</u>** This is generally accurate.
18	Analysis of data	Analysis will vary depending on the method used and the data that has been gathered. It may be qualitative, quantitative, in-depth or light. **Is it generally accurate? Yes 15, No 0, Not sure 1.** **Is it a significant component? Yes 16, No 0, Not sure 0.** **Comment (optional):** "What depth/range is needed to answer the clients questions (e.g. is it safe? Is it useable? Does it provide optimal performance?)" (E1) "Also depends on budget and time." (W1) "Different goals result in different needs / approaches." (E6) "Some projects require much more detail to reduce risk." (E5) "It can also be both – qualitative and/or quantitative, in-depth and/or light." (E13) "Yes, this is time factored, I do both light and heavy based projects, so the analysis time and data type will depend very much on the time allocated to the project" (E14) **<u>Reflection on comments:</u>** This is generally accurate. The comments relate to other functional influences such as client need and resource allocation.
19	HF understands project issues	Practitioner understanding develops throughout the project. Understanding of the project issues is heavily reliant on the expertise, motivation and insights of the practitioner. Project work is not just about applying the right method; sometimes it is more important to engage with the people and details of the context with an open mind. In the worst cases focusing on a method might mask what the real issues are, which could lead to inappropriate conclusions and recommendations. **Is it generally accurate? Yes 13, No 1, Not sure 2.** **Is it a significant component? Yes 13, No 0, Not sure 3.** **Comment (optional):** "This needs to be done before the solution is proposed." (W9) "The HF practitioner may be particularly interested in a certain area of work (e.g. trust); this may inadvertently lead to undue emphasis on this topic area – through their work. A holistic approach is needed." (E1) "Focusing on the method or any single aspect of the work can have this effect." (E11) "This is an important issue but how is it different from other industries?" (W1) "I am not certain that if you conducted the methodology correctly you would end up with inappropriate conclusions. But what you could end up with is not having answered the question originally needing to be answered. In other words, making a poor methodology selection for the goal." (E6) "Yes, you have to be aware of business needs and concerns all the time, you can't apply usability in isolation." (E14) "Talking to client to acquire domain knowledge is also important" (W7)

		Reflection on comments: This is generally accurate.
20	HF understands domain	Practitioners may develop expertise in a particular domain knowing jargon, issues, contacts, culture, practices and preferences. **Is it generally accurate? Yes 16, No 0, Not sure 0.** **Is it a significant component? Yes 14, No 1, Not sure 1.** **Comment (optional):** "Certain industries e.g. military, require lots of understanding before you can do the work (e.g. working with the user)" (E1) "This is more important in some industries than others. Sometimes the need for domain understanding is more to give confidence to client and stakeholders than because it is strictly necessary for the job." (S2) "Need to understand the domain fairly quickly to get the most out of the research and analysis" (E9) "Important to know who will be good in what type of work. For example, some are better at banking than others, important to know from senior to junior." (W1) "And boy does this jargon cause a lot of confusion, not only in the workplace, but also by those interviewing for these positions, for those writing about these positions, for those trying to enter the profession." (E6) "Vital in my work." (S1) "This often happens by default because of time factors, you keep being put on the same project types because your company knows you can deliver." (E14) **Reflection on comments:** This is generally accurate.
21	Write report	Reports seem a standard part of HF/usability work. However, contributions can happen outside of this through observation and close working relationships. **Is it generally accurate? Yes 13, No 0, Not sure 2.** **Is it a significant component? Yes 12, No 1, Not sure 2.** **Comment (optional):** "The client may want a 'gut feeling' about how the work is progressing – but will want it in writing at the very least." (E1) "I think the learning that happens as the project develops is as important as the report at the end. Clients should not be delivered a report cold." (E9) "Reporting takes many forms… when we report, it may be in the form of a presentation, Q&A session, design type workshop, video etc. If you mean reporting in terms of a word document, then I would disagree with this statement." (E12) "Observation of what?" (W1) ""Errant contributions are important, but not as the primary component. It is icing on the cake. Helps round things out, provide anecdotal references, etc." (E6) "Don't understand the question!" (W7) **Reflection on comments:** This is generally accurate but could be embellished with E12's comments: "Written reports seem a standard part of HF/usability work. Function 22 shows these can be supplemented with a presentation, question and answer session, design type workshop, video footage, etc. However, contributions can happen outside of this, e.g. through the observation of project work and close working relationships. "
22	Communicate to client	Communicating results to clients is a critical part of the project. Communication can be informal and frequent in close working relationships or

		can be formal and infrequent in detached independent evaluations. **Is it generally accurate? Yes 15, No 1, Not sure 0.** **Is it a significant component? Yes 15, No 0, Not sure 1.** **Comment (optional):** "If a close working relationship exists – feedback must be conditional/with caveats (i.e. 'at this point in time, we can say this, but we still need to do X before we can be conclusive…')" (E1) "Not really sure this is much different from 16 & 21. All about communication." (E9) "Has implications to work process and time management – double checking may slow down so pros and cons." (W1) "Expectations must be discussed up front." (E6) "This is highly dependent on the type of project and who you working with." (E13) "In my company, generally formal in the sense they are organised presentations or workshops." (E14) **<u>Reflection on comments:</u>** This has been clarified to distinguish it from Function 21: "Communicating results to clients is a critical part of the project. Communication can be informal and frequent in close working relationships or can be formal and infrequent in detached independent evaluations. Just a written report may be given or it may be supplemented with a presentation, question and answer session, design type workshop, video footage, etc."
23	Client engages with results	If possible it is important to feed back the results to the right person who cares about the issues, and describe the results in such a way that it resonates with the client's values. **Is it generally accurate? Yes 15, No 0, Not sure 1.** **Is it a significant component? Yes 11, No 0, Not sure 1.** **Comment (optional):** "… the role of the stakeholder!!!" (E1) "Not really sure this is much different from 16 & 21. All about communication." (E9) "It is possible if you have a solid understanding of the client's values. This may not always be the case. Be careful about confusing client in this case with the contact person and the contact person's company. Those values and care level about the issues may not be congruent." (E6) "The right people are often the ones who are least interested i.e. higher management, web designs are often the worse to convince about the value of usability." (E14) "The "right" person needs to have influence too, as there are usually costs involved in improving usability" (W7) **<u>Reflection on comments:</u>** This is generally accurate but can be clarified with E6's suggestion: "If possible it is important to feed back the results to the right person who cares about the issues, and describe the results in such a way that it resonates with the client's values. The contact person on the client side may not be the right person. The right person may be the most senior person, or maybe the most senior person that will listen best."

24	Client understands results	Results from a project should be clear and persuasive, in some cases going as far as spelling out how the client should exploit the results. In some cases the client may not wish to understand the results but may just want to act on the recommendations so the issue can be solved. **Is it generally accurate? Yes 15, No 1, Not sure 0.** **Is it a significant component? Yes 14, No 1, Not sure 0.** **Comment (optional):** "I would prefer some cases to be most/all" (E11) "Last statement is very true, clients are always looking for quick inexpensive fixes." (E14) **<u>Reflection on comments:</u>** This is generally accurate but can be clarified With E11's suggestion: "Results from a project should be clear and persuasive, going as far as spelling out how the client should exploit the results. In some cases the client may not wish to understand the results but may just want to act on the recommendations so the issue can be solved."
25	Client considers results	Clients can be complex entities with different people, agendas, remits and values, which can affect their consideration of the results. Some clients may have employed HF/usability services to provide support for their own internal agendas. **Is it generally accurate? Yes 16, No 0, Not sure 0.** **Is it a significant component? Yes 12, No 2, Not sure 1.** **Comment (optional):** "Highlighting the cradle to the grave user acceptance issue – is good practice in situations with clients and their own agendas." (E1) "It can be significant, yes – but not necessarily every time." (E6) "True, a usability agency has to be aware of the internal politics and internal agendas." (E14) **<u>Reflection on comments:</u>** This is generally true. 'Internally politics' seems like a useful addition for the statement: "Clients can be complex entities with their own internal politics: with different people, agendas, remits and values. This can affect their consideration of the results. Some clients may have employed HF/usability services to provide support for their own internal agendas."
26	Client acts on results	The practitioner is often in an advisory role in the client relationship, where the client holds the power. Sometimes practitioners are unaware of client action or inaction; and sometimes they have closer working relationships. In situations where advice is critical practitioners may protect themselves by making sure the advice and decisions are recorded. **Is it generally accurate? Yes 11, No 0, Not sure 5.** **Is it a significant component? Yes 11, No 1, Not sure 3.** **Comment (optional):** "Clients ignore advice quite a lot (probably less in safety-critical situations – one would hope). Critical to understand what the barrier was as ignored recommendations are a bit of a waste of time, money and effort." (E9) "Shouldn't power be in the hands of the consultant as well. Almost like doctor patient relationship." (W1) "I have never been put in this position." (E6) "Protect themselves by using this recording as an evidence of the communication. I tend to use emails than the phone – this helps me keep a record the decisions/requests." (E13) "This is critical, importance of emails and we have a standard agreement

		research planning document which outlines the project responsibilities on both sides - so that there is not disagreement along the way." (E14) "Not sure about this. The client has the option to ignore the advice." (W7) **<u>Reflection on comments:</u>** This is generally accurate.
27	Build reputation	Reputation can be a valuable commodity of the practitioner and/or the HF/usability organisation. Past performance is believed to indicate future performance. Reputation can facilitate project work and recommendations. **Is it generally accurate? Yes 16, No 0, Not sure 0.** **Is it a significant component? Yes 14, No 2, Not sure 0.** **Comment (optional):** "How is this specific to HF?" (W1) "Reputation affects every job role though doesn't it?" (E6) "Particularly for clients that keep returning." (E14) **<u>Reflection on comments:</u>** This is generally accurate.
28	Build rapport	Practitioners can develop rapport intentionally by acting friendly, courteously and engaging with people on a personal level. Different methods can allow more or less opportunity to build rapport e.g. observing user testing or taking part in a workshop can increase contact. Rapport can facilitate winning project work and receptiveness to their recommendations. **Is it generally accurate? Yes 14, No 0, Not sure 1.** **Is it a significant component? Yes 14, No 1, Not sure 0.** **Comment (optional):** "Winning work often comes down to personality fit (ie cv will get you in the door personality will get you the job)." (E9) "I would say approximately 50% of cases, client's will select HF/usability consultancies based on part working relationships. Price is the other factor affecting decisions to select a particular company." (E12) "I would prefer 'acting' to be 'being friendly'" (E11) "Not always the case as it depends what the clients are like as well. If the clients aren't nice they might not be receptive to you, and if the work you do is wrong there's no amount of rapport that will persuade." (W1) "But I think this is true of any profession and any career" (W2) "The human component of communication and rapport is important in any consultancy position, including HF. These statements make it sound a bit product sales in orientation as opposed to need based sales – but perhaps my perspective comes at the luxury of not being currently employed as a consultant fighting for projects, having sales goals, etc." (E6) "True, it is all about being nice to the client" (E14) "There are many factors involved in both building rapport and getting repeat business – and they may not be linked." (W7) **<u>Reflection on comments:</u>** This is generally true but could do with slight rewording: "Practitioners can develop rapport intentionally by being/acting friendly, courteous and engaging with people on a personal level. Different methods can allow more or less opportunity to build rapport e.g. observing user testing or taking part in a workshop can increase contact. Rapport can facilitate winning project work and receptiveness to recommendations."
29	External audit	Auditing is more or less important in different contexts. Sometimes extensive method sections are included in reports even though clients are not interested

		in them. This can be to satisfy regulators and to maintain auditing procedures. **Is it generally accurate? Yes 9, No 2, Not sure 4.** **Is it a significant component? Yes 7, No 3, Not sure 4.** **Comment (optional):** "On large MOD contracts – a 'customer friendly' role may be undertaken – with technical recommendations (including HF) made during the tender and down selection stages of a contract – through audit of methodologies used and work undertaken." (E1) "For us, publishing and peer review is also important so that it part of why detailed methods are included. We also store all the knowledge from previous projects for use in future. Sometimes, the report is the only link back so needs to be comprehensive or the knowledge may be lost." (S2) "I've never been in a situation where audits were done so I'm not really sure how this applies" (W2) "This is totally situational, but can be true yes." (E6) "Although I don't have experience in external audits I still think this statement is accurate. Senior practitioners are more involved in the auditing process." (E13) "Reports must be relevant to the client, also you just don't have time to include irrelevant information in reports - deadlines are always too tight (2-3 days for a report including analysis is typical)." (E14) "No experience of this" (W7) **<u>Reflection on comments:</u>** From the comments this seems very context specific, as practitioners in more informal settings do not have experience of this. It is interesting to note that practitioners can be the ones auditing others work (E1). To clarify: "Auditing is more or less important in different contexts. Where it is important extensive method sections are included in reports to satisfy regulators and to maintain auditing procedures, even though clients are not interested in them. HF practitioners can also be involved in auditing other's work. Formal auditing can be foreign in more informal settings."

I wasn't really sure how to answer the significant question. Not all those I marked as significant are equally so. *(E9)*

Reflection on comment:

This wasn't a general trend, the instructions at the beginning of the document stated: "We ask whether you think the statements are generally accurate and whether you consider them to play a significant role in your work."

Level 2: Subsystems

There are 6 interdependent subsystems to which we refer in this section:

1. Project process
2. HF/usability practitioner understanding
3. Persuasion, rapport and reputation
4. Staff development and management
5. Tools, methods and reporting practices
6. Auditing and documentation

How to read these subsystems

The statements extracted from the subsystems are contained under their heading. These statements correspond to the network diagram on the subsequent page. The little numbers in the descriptions refer to the nodes in the network diagram. This network diagram highlights the subsystem processes within the wider system.

You should not need to refer back to Level 1 to check these statements.

1. Project process

(a representation of this subsystem can be found on the next page)

- The central process roughly includes: the client recognises a need[1], HF understand this need[2], work packages are developed to satisfy this need[3], a project is negotiated[4], work is performed[13], data is analysed[18], a report is written[21], results are communicated to the client[22], they consider the results[25] and how to act on them[26].
- The negotiation of the project work[4] requires that the client understands[5], at least to some degree, what they are agreeing to. This will happen through engagement with the HF/usability practitioner. "This isn't necessarily true. In an agency environment the client may never meet a usability person until the project is underway"" (W7). The negotiation will also involve the allocation of resources[6] on the HF/usability and client sides.
- Doing the project work[13] has a route into the client engaging with[23], and understanding[24], the results because some practitioners will encourage clients to observe user testing, speak to users, watch an expert panel, or work collaboratively so they receive direct communication which is outside the data analysis[18] and project reporting process[21].
- There is a distinction between the client engaging with the results[23] and understanding the results[24], although they are interdependent. The client's engagement with the results[23] is to do with the client caring about and engaging with the issues, whereas understanding the results[24] is more about the cognitive task of actually understanding what is said. For example, people might fully understand but not care about what is communicated and vice versa.

Is it generally accurate? Yes 13, No 1, Not sure 0.

Is it a significant component? Yes 13, No 0, Not sure 1.

Comment (optional):

"This model can be extended to include the implementation and monitoring phases of a project – completing the validation stages of work." (E1)

"This is a very linear explanation of what happens – the client engagement should be happening throughout not just at the end." (E9)

"Maybe oversimplified" (E11)

"6. Resource allocation happens twice: 1) at a general level when the project is scoped; and 2) Specific people etc. are normally only allocated once there's been client sign-off and dates are agreed.

At 2 client need might be redefined or negotiated.

21 and 22/23/24 might be reversed – we might informally talk through or workshop the results and then write them up." (E11)

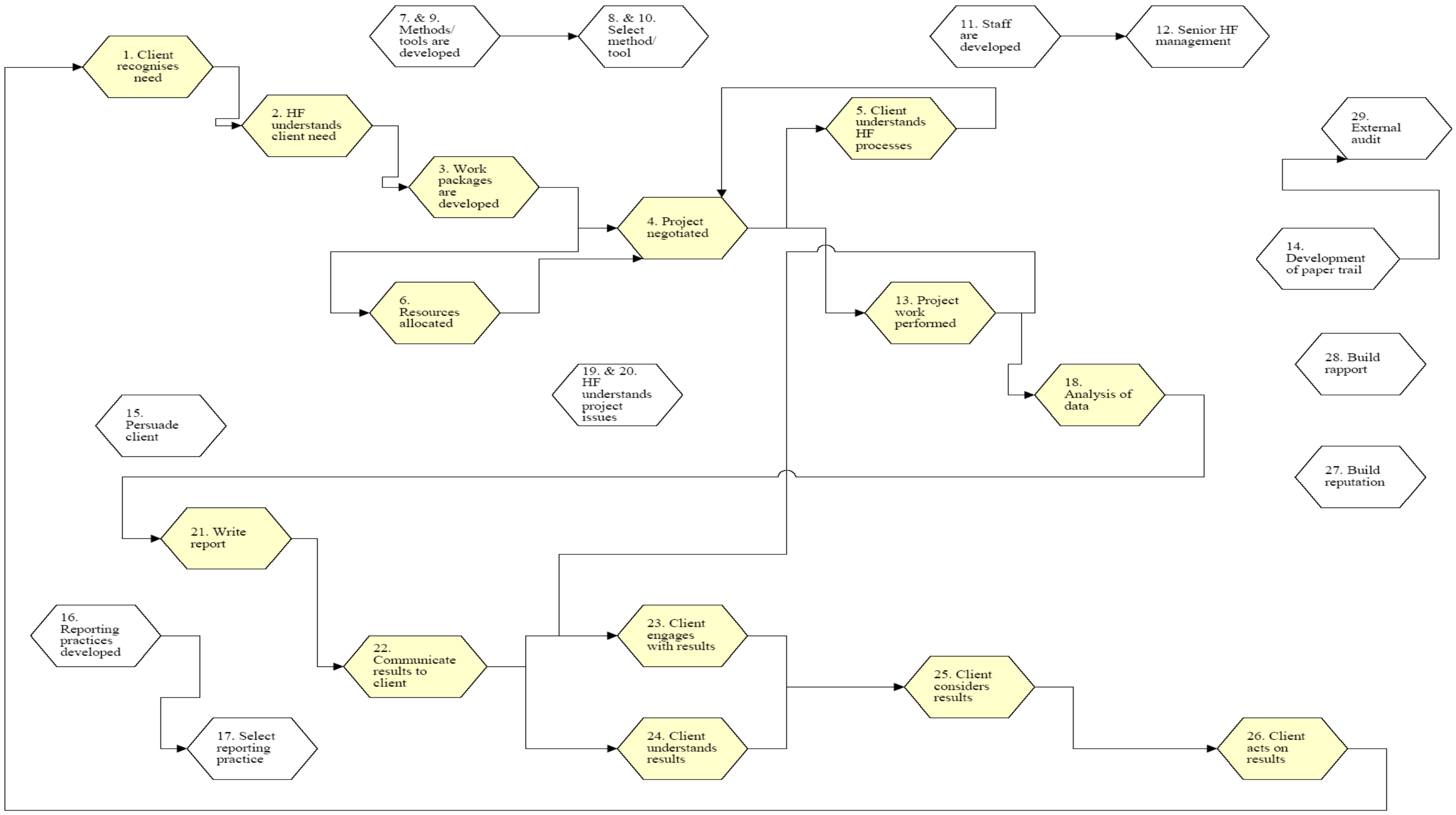
"There could be an extra stage between 25 and 26 [client accepts or rejects results]" (E11)

"The system below is too complicated, an average project turn around is 1 ½ to 2 weeks (including client meeting, participant recruitment, testing, report writing and presentation/workshop). There is just no time for a lot of the above to go on. Particularly client engagement - they usually are more interested in what they are getting for their money and if usability is worth it and if it shows quick returns (i.e. if they implement the recommendations). Below is a representation of how we explain our processes to the client [representation omitted for anonymity]. They are paying for a service; they do not expect to be overly part of the process. (E14)

Reflection on comments:

There are interesting comments on this subsystem. Some suggest it can be simplified (E14), some suggest it is oversimplified (E11), some propose it can be extended (E1), and some propose changes (E11). I think these are all valid comments. I particular welcome the reminder that we should not be too linear in our explanations and understandings of this process (E9). The linearity wasn't meant to be an emphasis but has evolved this way through trying to simplify the description. These comments are dealt with through the distinction between a model and instantiation of the model in the main thesis.

Project process



2. HF/usability practitioner understanding

(a representation of this subsystem can be found on the next page)

- The network represents three main processes that feed into the HF/usability practitioner's understanding of the project and domain issues[19&20]: understanding the client need[2], performing project work[13] and doing the data analysis[18].
- Importantly, understanding the project and domain issues does not start with analysing the data[18], but in performing the method[13] and understanding the client need[2] which happens before data is analysed[18].
- The HF/usability practitioner's experience also plays an important role in their understanding which is a resource[11] and control[12] for understanding project issues[19&20]. This is explained further in subsystem 4. (There is an extra process not covered in systems 2 and 4. Knowledge sharing within organisations. This is not only top-down. As people read about new things, do new project types, etc. Knowledge is gained for all at the organisation. Also, new staff are a good source of knowledge and some can have a real impact on working practices.) (E11)
- Understanding the project and domain issues has two main streams. The first is a feed into performing the method[13] and data analysis[18], this creates a cycle of understanding and then reanalysis. The second is an output more directed at the client in writing the report[21] and communicating results to the client[22].

Is it generally accurate? Yes 11, No 1, Not sure 2.

Is it a significant component? Yes 10, No 2, Not sure 1.

Comment (optional):

"Probably should be more significant I think the client is often unclear about the overall aim/outcome of the project and so does not get the results that they need (a bit like not piloting a questionnaire you thought you were clear but often end up with results that are not useful). Sorry – I seem to have missed the explanation of the A1, D2 etc numbering." (E9)

"In some instances project issues only come to light gradually, Maybe even at stage 22." (E11)

"Again I think this will vary from project to project. Often the understanding of the domain may actually start with data analysis, especially if the analysis includes looking at similar work already done in that domain. So something that feels missing is that previous knowledge brought in by the practitioner and the competitive analysis that may be undertaken to understand the domain. What I mean is if you have built a website for a bank once you may bring in the knowledge to the next bank site you build or you may go see how the other bank sites are built and get ideas." (W2)

"Understanding the domain cannot be underestimated." (E6)

"Domain knowledge is especially important." (S1)

"May also include a lot of explanation of the method and the benefits it will bring e.g. card sorts to define a navigation structure." (E5)

"There is no time for re-analysis, at the start you decide what you can write about in 3 days - and plan this out and then just write. You often have to analysis as you are writing; analysis is rarely done in isolation." (E14)

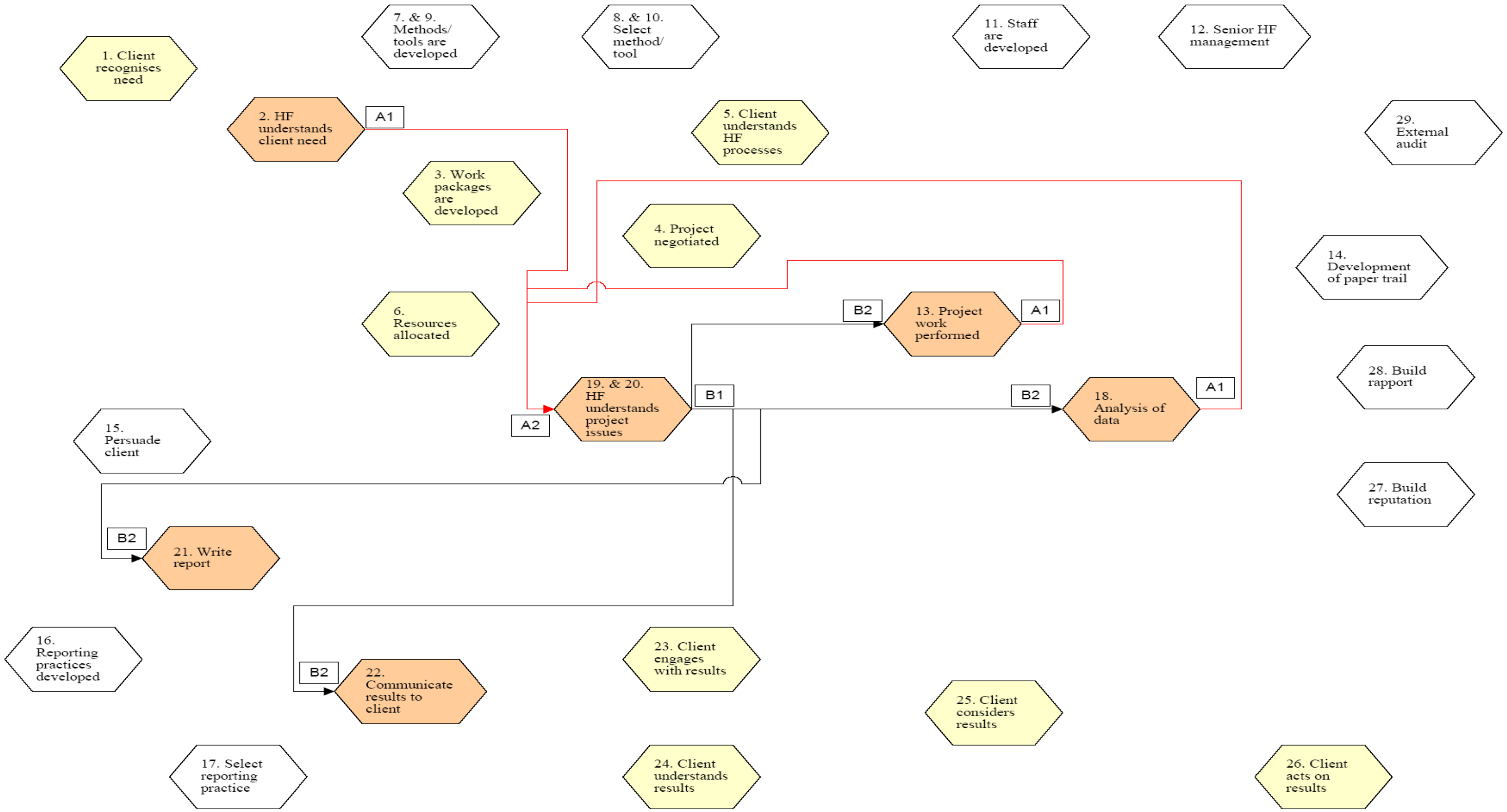
Reflection on comments:

The comment by E11 on knowledge sharing is better placed under Subsystem 4 so is addressed then. Comments by E9 and W2 can be incorporated as follows:

"Importantly, understanding the project and domain issues does not start with analysing the data[18], but in performing the method[13] and understanding the client need[2] which happens before data is analysed[18]. Issues might only come to light gradually, maybe even when communicating the results[22].

The HF/usability practitioner's experience also plays an important role in their understanding which is a resource[11] and control[12] for understanding project issues[19&20]. This is explained further in subsystem 4. Prior work will have influence through practitioners' experience[11], general project work, and documentation of this work[14]."

HF/usability practitioner understanding



3. Persuasion, rapport and reputation

(a representation of this subsystem can be found on the next page)

- Persuading[15] the client plays an influential role in project negotiation[4], project work[13], and communication of results to the client [22]. These three nodes are situations where the HF/usability practitioner is likely to have contact with the client. Here the practitioner can persuade them in agreeing to a project, in observing or participating in HF/usability work directly, or accepting the results of HF/usability work.
- Persuading[15] has five functional inputs which affect it, which are focused on the HF/usability practitioner's understanding of the client need[2], project issues[19] and the domain[20]; and that relate to the softer issues of rapport[28] and reputation[27] which also play a role in persuading[15].
- The rapport[28] between the HF/usability practitioner and the client has opportunity to develop in points of contact in the project: these are project negotiation[4], project work[13] and communication of results to the client[22]. More widely these three contact points make an iterative loop with persuasion[15] and building rapport[28].
- The reputation[27] of the practitioner also affects persuading[15] the client but is qualitatively different for rapport[28]. Whereas the rapport between people is about the relationship between them, reputation is a measure of past success. The main contributors to reputation[27] are the consideration of the results[25], consideration of whether to act on them[26] and external auditing[29] which all relate to the later stages of the process. These three functions reflect the success and impact of the project. Over a period of time there will be a pattern of results which will compose the practitioner's reputation.

Is it generally accurate? Yes 8, No 1, Not sure 6.

Is it a significant component? Yes 9, No 0, Not sure 4.

Comment (optional):

"This is ideal world scenario – but I do not think all these steps occur in practice (particularly the external audit bits)" (E1)

"The term "persuading" suggests that the client and the practitioner tend to be opposed in some way. We prefer to see it as working with the client towards a particular solution in a collaborative way rather than us selling (services and recommendations etc.) and the client buying." (S2)

"Not wrong exactly but doesn't seem enough. It is more than understanding the domain etc it is more closely aligned to organisational psychology. HF practitioners are external (and usually powerless) to organisation factors that can influence success. This is also were I lose the connection between the description above and the diagram. Assume the arrows from 15 are part of the iterative loop described above but not entirely clear. Also the black, red and pink colour coding not explicit." (E9)

"It is sometimes difficult to agree in the accuracy of the statement. For example, I do not believe that reputation is built on the results of a project, whether to act on the results and internal auditing. Reputation is built on the quality of the work which means not only the deliverables, but the process itself where the client is involved." (E12)

"Other influences on reputation:

- the real impact of the results on the products performance.
- clients perception of the quality of the HF staff (articulate, knowledgeable, competent for reputation, for rapport it's more about friendly, helpful, supportive, etc.)

Another component might be 'benchmarking' i.e. measuring product service performance before and after design changes to measure project success. This measurement may be more or less formal and involved." (E11)

"This rapport, as commented earlier, is more necessary in consulting / agency scenarios. In a permanent position, the need for that particular type of stakeholder input and projects was determined as a baseline in the company PLC [product lifecyle process] and/or PDL [product development lifecycle]. Therefore, negotiation as a concept is as critical a potential failure point as in agencies or for free-lancers." (E6)

"Interpersonal skills are a vital part of working with client teams who are often either sceptical or over-confident of their own abilities. We have to educate every single project manager!" (S1)

"I'm not sure about the significance of reputation at this stage." (E5)

"This is quite a complicated system so I am not sure if this reflects the reality of my day to day contact with clients. Client contact can vary between full on or you never see them after an initial meeting. So rapport varys. It is part of my job to be client facing and to be good at this. I have had client's ask for me specifically (based on previous work I have done for them), so in this case personal relationships are very important. Relationships are also very important for contacts to get more or repeat work in the agency." (E14)

"I find that the usability people are not as involved in project negotiation as they could be" (W7)

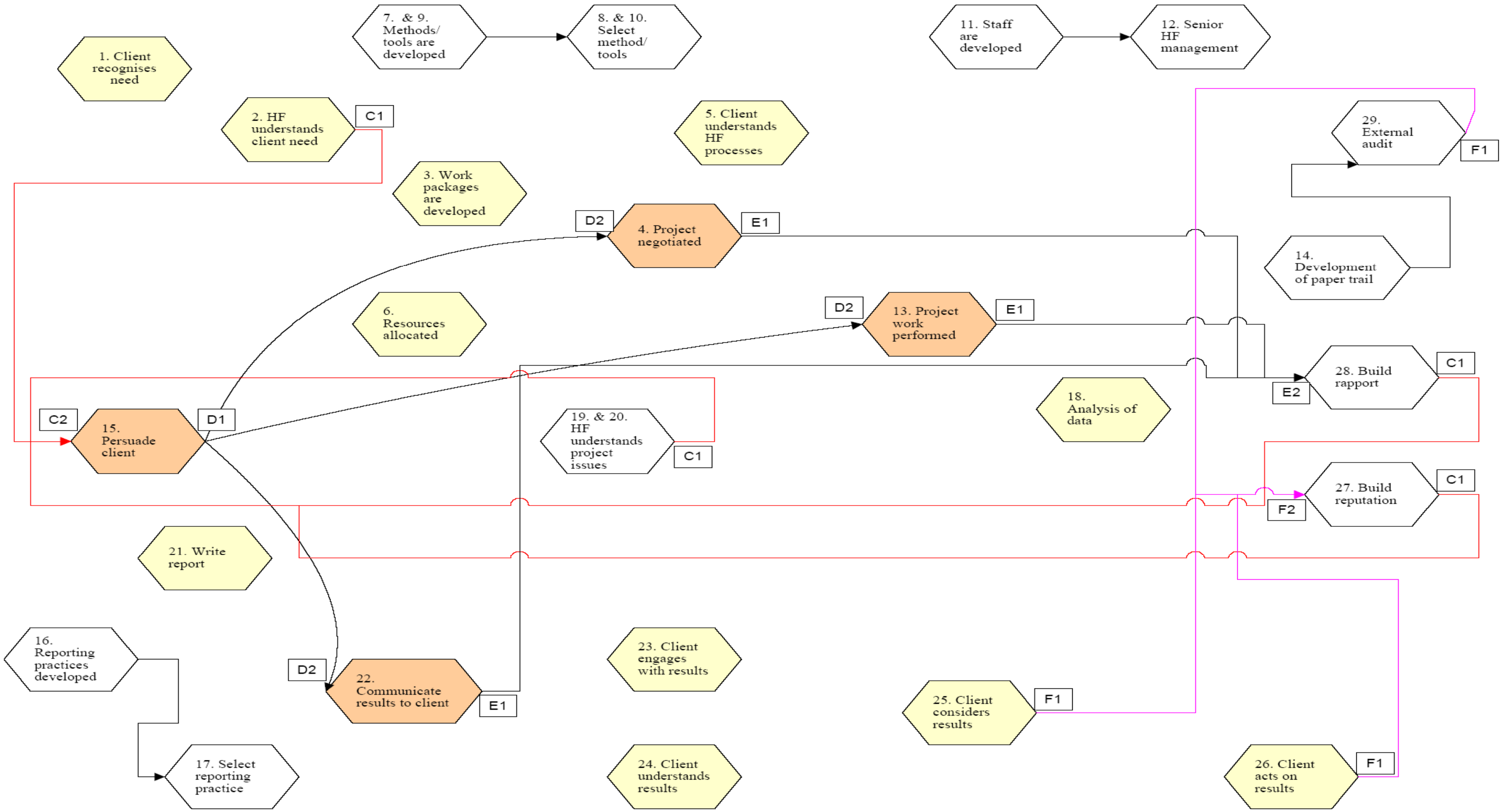
<u>Reflection on comments:</u>

A number of issues are raised in this section:

- S2 reacts against the term 'persuade' as they suggest the practitioner and client are opposed in some way. They prefer to see themselves as collaborating rather than selling in work. Similar sentiments can be seen in when E12 brought up the importance of facilitation in Level 1, component 15, and when E6 commented that the wording used to describe building rapport, Level 1, component 28, made it sound like a product based sales environment rather than needs based sales. Along similar lines in Level 1, component 28, E11 preferred to say being friendly rather than acting friendly. These comments seem to suggest a difference in tone of the description rather than fundamental structure. Some contexts will have a more distant sales orientated tone where people might have to 'act friendly' even when they don't get on with people; other contexts will have a tone which is more based on helping a client through a need and 'being friendly. This difference in tone should be noted in a meta-commentary of the model.

- E9 correctly points out that there is more going on in relationships in practice than I have included here, along the lines of organisational psychology. This is potential future work which is outside the scope of the current thesis.
- E12 and E11 provide comment to enhance the description of how reputation is developed. E12 correctly highlights that reputation is built on the quality of the working process and not just on the deliverables as suggested in the model. E11 suggests adding: the real impact of the results on the products performance, and client's perception of HF staff (articulate, knowledgeable and competent for reputation; for rapport it's more about friendly, helpful and supportive). These factors should be better accounted for in the model:
- "The reputation[27] of the practitioner also affects persuading[15] the client but is qualitatively different for rapport[28]. Whereas the rapport between people is about the relationship between them (including qualities such as being friendly, helpful and supportive), reputation is a measure of past success (including qualities such as being articulate, knowledgeable and competent). The main contributors to reputation[27] in the diagram are the consideration of the results[25], consideration of whether to act on them[26] and external auditing[29] which all relate to the success and impact of the project for the client. Importantly, reputation will also be influenced by the client's perception of the quality in the process of the project and their perception of HF staff. Over a period of time there will be a pattern of results which will compose the practitioner's reputation."

Persuasion, rapport and reputation



4. Staff development and management

(a representation of this subsystem can be found on the next page)

- There are two outputs from staff development[11]: the first is represented as code H1 which represents HF/usability staff as a resource for doing work; the second flows into senior HF management[12] through to code J1, which is senior staff as control. In the representation H1 goes to H2 (both green if in colour), and J1 goes to J2 (both orange if in colour); this hides their connecting lines.
- There are many different parts of the system which are performed by the HF/usability practitioner (represented as code H2). Consequently, practitioners are an important resource for this work. Practice of this work leads to staff development[11]. The further staff develop the more competently and confidently they will be able to perform these varying functions which will play a large role in the performance of the system. For example practice of a particular method will make them better at performing and reporting with relation to that method.
- J2 represents HF/usability practitioners at a more senior level[12]. These senior members of staff are presented as a control for the tasks that the HF/usability practitioners perform. So, the HF/usability practitioner performs many of the tasks in the system, who is monitored and supervised by senior HF/usability practitioners[12].
- There is a cycle between doing, developing and supervising that reinforces practice, which leads to inertia in trying new tools, methods and procedures but stabilises the system. For example, junior members will typically be given limited rein and be told what to do and how to do it. This prescription will be based on the proven experience of the HF supervising staff. As the junior member develops they will become more accustomed to working in the prescribed manner, and be given more responsibility. As they gain seniority they will have learnt the techniques and standards of the supervising staff and be in a position to advise more junior members on what to do. This leads to a system which is stable as one generation passes their practice on to another. The cycle of supervision, doing and developing which reinforces practice can either be seen as a system characteristic that creates inertia to new tools, methods and practices; or as a stabilising feature that provides resistance against risk and promotes the proliferation of proven practice.

Is it generally accurate? Yes 9, No 1, Not sure 4.

Is it a significant component? Yes 9, No 5, Not sure 1.

Comment (optional):

"New HF staff bring fresh skills, tools, and ideas – and can update and expand a pool of expertise." (E1)

"Generally this holds true but because we do whatever work clients want in whatever […] domain, we are sometimes outside our comfort zone or we might be constrained by practical issues. In this situation we might say to a junior person "go and find out what methods there are to do this…" and then they might end up leading the work on a new method that none of the senior people are that familiar with. In this case, the senior people still supervise but it is more of a sanity check role than based on established practice" (S2)

"There is a difference between practitioner systems in an agency and in-house. I think the system is more defined in an agency. In-house there may only be one practitioner so this advising/supervising/passing of practice may not happen in such a mature way." (E9)

"Generally yes this is true. However, it is not always so hierarchichal. Sometimes junior staff have more experience than senior staff. In these cases, junior staff can be the project lead with the senior staff helping." (E12)

"It is generally accurate insofar as it goes but it is incomplete… staff development is essential to the health of the industry. You only have it happening as a consequence of doing projects. Missing mechanisms include:

- reading: books, clogs, articles, etc.
- attending training, conferences, events, etc.
- Knowledge sharing activities within the company.
- Informal chats with colleagues about their experiences.

6 is also a task that people must learn and they learn by doing.

5, 23, 24, 25, 26 – You could argue that these are part of this system. The HF supports the client to do these in many cases – another process where there's learning and gain of domain knowledge.

Resource allocation is also a task people must learn and learn by doing so add J2 and H2 to function 6." (E11)

"A bit too obvious – how is this different from other management practices?" (W1)

"There also needs to be room in your model for formal training in the workplace which does happen often" (W2)

"This whole point is very agency, consulting, freelance in nature. I am in a single practitioner situation on staff with designers, so my role is very targeted. I should like to comment that the potential challenges faces practitioners on staff at a client's office permanently, working day to day with set project managers, R&D staff, QA staff, and product managers face some additional challenges this document doesn't seem to adequately address. Challenges dependent upon what stage in introduction or incorporation the practice of usability, HF etc. are in at that particular company. If at the beginning, evangelizing, educating can be very difficult as there is no safety in numbers and no past projects internally to point to. Only the realization that past projects were not well received [as an example] by the marketplace and your presence is

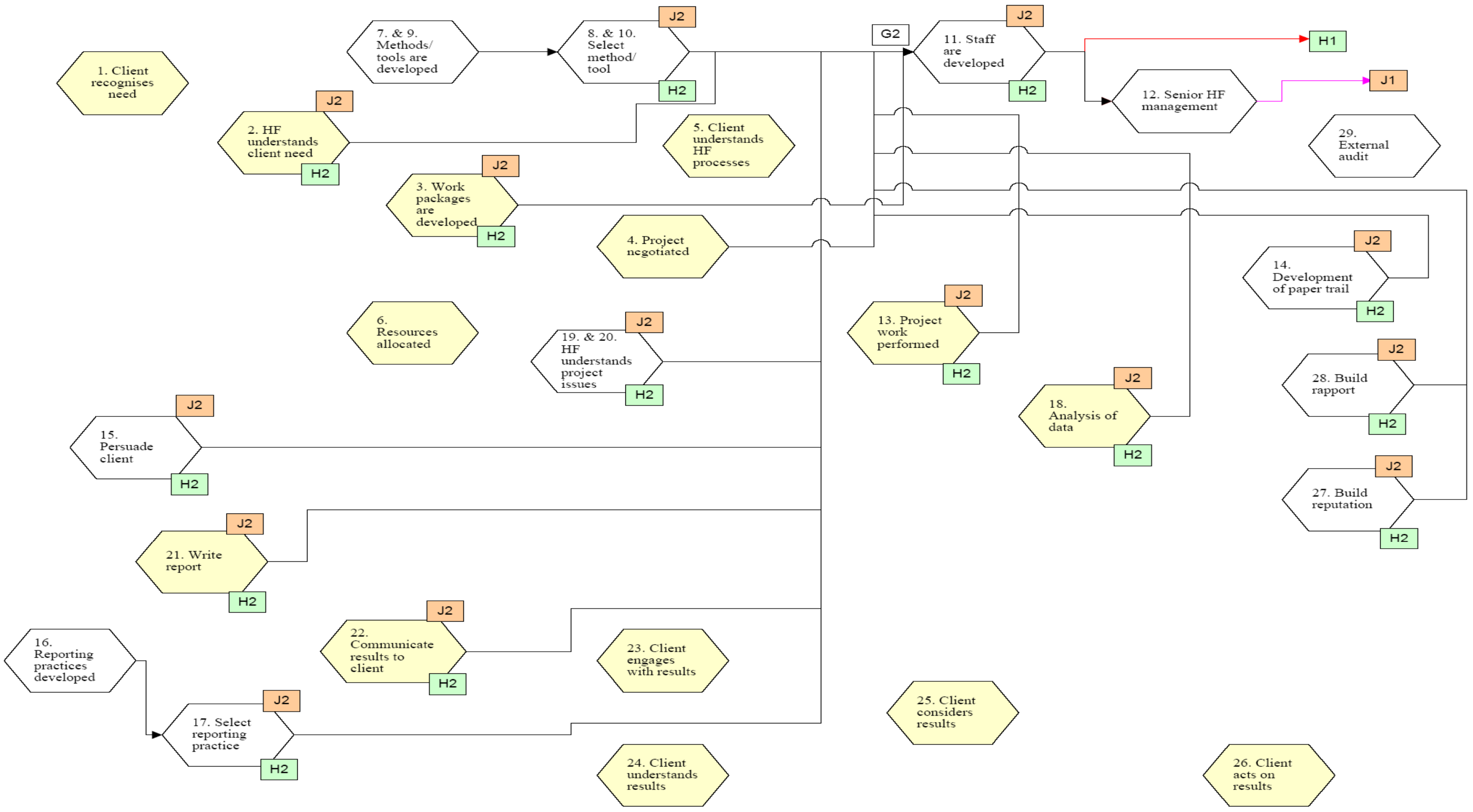
a constant reminder of that. Resistance and lack of understanding of the value can be difficult. Just because the practitioner has been added doesn't mean every one agrees with the reasoning or inclusion of additional steps in future development processes. It can be seen as an interruption, disruption, etc. These same challenges may be faced as a consultant at an agency or working on your own as well, but the day to day dynamic of treading this ground with co-workers definitely introduces further cultural issues." (E6)
"We have a very flat structure with few practitioners and little hierarchy." (S1)
"As a consultant this model is not applicable." (E5)
"For most agencies, you have to learn on the job. Supervision means that an expensive and experienced senior practioner is not working or bringing work into the agency. Supervision is usually piece mean and often just lip service. Although, some agencies do put time aside for self training (on quiet days)." (E14)
"This varies from company to company. As a freelancer, I don't get involved in this now." (W7)

Reflection on comments:

A number of issues are raised in this section:

- E1 comments that the cross-fertilisation of new members of staff is not included in the model.
- S2 explains how junior staff might gain more experience in certain methodologies and lead on projects where this happens. E12 makes similar comment when suggesting that practice is not always so hierarchical.
- S1 comments on the description also being too hierarchical and they do not have many practitioners in their company. E5 and W7 say that it is not applicable to them because they work on their own.
- E11 points to detail which has been left out of the model i.e. that many more processes should have J2 and H2 attached as they can be supported by practitioners; and that staff development has many more influences other than as a consequence of doing work (e.g. W2 also mentions formal training). These details were considered but were left out of the diagram to simplify and emphasise features, but perhaps this needs to be readdressed.
- E6 raises interesting challenges faced by a single in-house practitioner working with the same team of people. E6 suggests that the dynamic of working with co-workers regularly introduces further cultural issues and that this model is more appropriate to the agency context. The sort of challenges mentioned is in part covered by the model e.g. educating and persuading people, and designing projects depending on the problem and project stage. However, similar to the suggestion made by E9, in Subsystem 3, when suggesting there is more going on in terms of organisational psychology than the model describes the real dynamics and details of organisational internal politics is outside the scope of this project.

Staff development and management



5. Tools, methods and reporting practices

(a representation of this subsystem can be found on the next page)

- The development of work packages[3] is a central node in the selection of tools[10], methods[8] and reporting practices[17]. It is here that an experienced practitioner will devise components for a project to help satisfy the client's need. The proposed work packages will feed down into what project work[13] is performed and the subsequent analysis of the data[18]. + reporting format21 + client comms22. (E11)
- The selection of new tools[10] and methods[8], and adaptations made to tools and methods in the project work[13] or data analysis[18] stages of the project, can lead to the development of tools[9] and methods[7] in practice. This provides a cycle of selection, use, reflection and development.
- The selection of the reporting practice will influence how the report is written[21] and how the results are communicated to the client[22]. Similar to tools and methods, new reporting practices can be experimented with and adaptations made to current practices which lead to the development of new reporting practices in practice. This provides a cycle of selection, use, reflection and development.
- External arrows are not included in the representation, but there is involvement from academia in the development of tools[9], methods[7] and reporting practices[16].
- Focusing more on the selection of tools[9], methods[7] and reporting practices[16] we refer back to the description of the 'staff development and management' subsystem. This described the reinforcement of current practice where staff perform a practice, become more experienced at that practice, and then they recommend it which then reinforces that practice for other staff. Here senior staff play a role in shaping and advising how practice should be done, whilst themselves being a product of years of supervision and practice themselves. Staff will do what they are confident in, what they can predict and what they can do faster and better. This means doing the things they are used to, and not new things that they are not used to.
- However, practitioners have been shown to be resourceful and reflective in developing their own tools[9], methods[7] and practices[16] to suit different demands in different contexts. So, there is not stagnation in the face of useful development opportunities, but rather a steadiness which improves predictability, efficiency and effectiveness.

Is it generally accurate? Yes 12, No 1, Not sure 2.

Is it a significant component? Yes 11, No 2, Not sure 1.

Comment (optional):

"Without the external audit or review of success the HF/usability practitioner can advocate using incomplete evidence (usually the next client)." (E1)

"Sometimes the development of a tool or method or the adaptation of a tool or method is a stated objective of our work not just a by-product of the work." (S2)

"I am unsure about this as some bullet points suggest there is development and but bullet 5 says there is not.

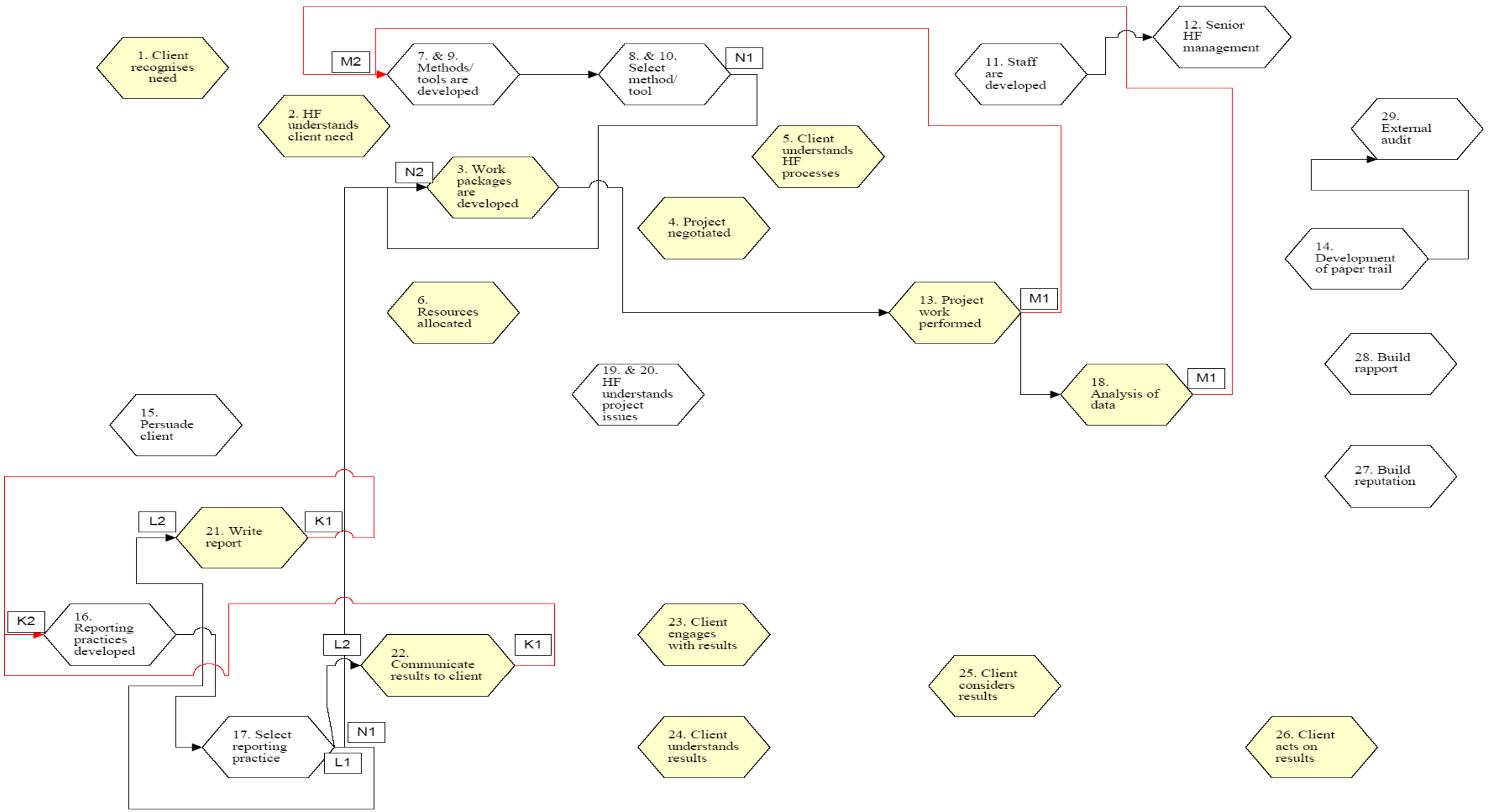
My view is that there is not much trial of new tools/methods etc in practice due to the risk involved in project success (and therefore reputation). Again there may also be a difference between agency and in-house as more experimentation may take place in agencies where new staff come from academia (cross pollination), staff turn-over may be slower in-house and the support network of professional practice and relationship with academia is not so strong.
Not sure about the meaning of M,N,L,K notation. " (E9)
"So what are the motivational factors and reasons to take up new tools and methods in practice." (W1)
"True particularly when you work on a small staff. You must sort it out yourself – there may be NO one to lean on within the office walls! You will look to practitioners in the industry, refer to .org sites for resources, ask blog questions, call peers and so on." (E6)
"It is possible to use only a very limited set of tools or methods in our organisation. Designs rather than reports are the usual output." (S1)
"For most agencies, you have to learn on the job. Supervision means that an expensive and experienced senior practioner is not working or bringing work into the agency. Supervision is usually piece mean and often just lip service. Although, some agencies do put time aside for self training (on quiet days)." (E14)

Reflection on comments:

A number of issues are raised in this section:

- E11 addition to the first bullet point can be included for clarity.
- S2 and S1 give alternative outputs to their work which aren't covered by the model i.e. rather than written reports they may have a design, tool or a method as an output of a project. These should be incorporated.
- E9 highlights the tension conveyed in the last and second to last bullet regarding the stability of sticking to the tried and tested, and adaptability of trying new things. This is a real tension which should be explicitly highlighted. Along a similar thread W1 asks about the motivational factors for taking up a new tool or method. This can be given a rather glib response in terms of adding value and gaining an advantage; or a deeper response which involves all the functional components in the system.
- E6 brings up a similar point to E11 in Subsystem 6 which refers to staff development resources that are outside 'on the job learning', e.g. referring to practitioner blogs, .org sites, and professional networks. E14 states that most learning is on the job due to pragmatic constraints, but again this is a demonstration of the variability in practice.

Tools, methods and reporting practices



6. Auditing and documentation

(a representation of this subsystem can be found on the next page)

- From the HF/usability point of view there appear to be six places in the central project process that produce paper work[14] which can be archived for auditing[29] purposes:
  - The client recognising a need[1] can involve a document which invites bidders and describes the issue, sometimes called a request for service. There are lots of other names for these e.g. invitation to tender, project specification (S2)
  - Before this there tends to be the submission of the "bid" from the practitioner which states what you suggest should be done with a price etc. For us, this is almost always a document that later forms part of a study plan and is the key record of what we are supposed to do. (S2)
  - A contract is normally agreed between the two parties when the project is negotiated[4].
  - Some material is normally produced in sketches, documents, videos, and transcripts in the work of the project[13].
  - The analysis of the data[18] is normally documented.
  - The report[21] and communication to the client[22] can be archived.
  - Staff may have updated CVs and records of their training and development[11].
  - One more, in response to 1, the HF company produces a proposal for the work. This happens between 1 and 4 and includes 2, 3, and 6. (E11)

  All of these points provide opportunity for archiving documentation and auditing.

- Not all contexts will value the auditing process and some may even find the administration involved in keeping such records a hindrance. However, some contexts and clients necessitate the ability to audit and have quality controls which are inspectable. So, depending on the circumstances of the project there may be more or less need for these functions to produce a paper trail.
- The documentation of rationale, methods, results and other project work can be used as leverage for future project work. For example, presentation slides can be reused in pitches, project reports can be used as templates, and project solutions and design proposals can be used for advantage when faced with similar scenarios. This resource can be valuable for organisational memory and expertise.

Is it generally accurate? Yes 13, No 0, Not sure 2.

Is it a significant component? Yes 9, No 2, Not sure 2.

Comment (optional):

"I no longer undertake work for external clients, but have done so previously, with larger projects (time/duration) milestones and deliverables will be used to update and brief the client (Step 13 in your model) – as work (and evidence/knowledge/the design is built up and developed.)" (E1)

"The capture of knowledge for future is a key part of [our] strategy. We also publish in journals/conferences to disseminate to the wider community and similarly, draw on published experience from other organisations. Where possible, every piece of work is seen as adding to our knowledge of whatever particular subject rather than as a stand-alone piece of work for a client. Sometimes we will be trying to weave together knowledge from several distinct projects over a long period of time to work towards a higher strategic aim e.g. learning about [x] distraction in order to (eventually) reduce the number of [x] accidents caused by distraction." (S2)

"Done for auditing purposes rather than lessons learned.

General comment – Central process in yellow and sub processes in orange except in process 5 (my view is the sub process described is more important to highlight than the central process)." (E9)

"All of this provides a record of tools, methods, staff – so it can be used as a resource." (W1)

"This really depends." (E6)

"Never actually an audit trail but future work uses templates and presentation material from past projects." (S1)

"Documentation is significant subsystem in my work but auditing is not. We do have a reviewing process where our line managers have to approve/authorise the results/reports. This is the only section which I found difficult to understand due to not being too familiar with auditing and quality control process within our organisation." (E13)

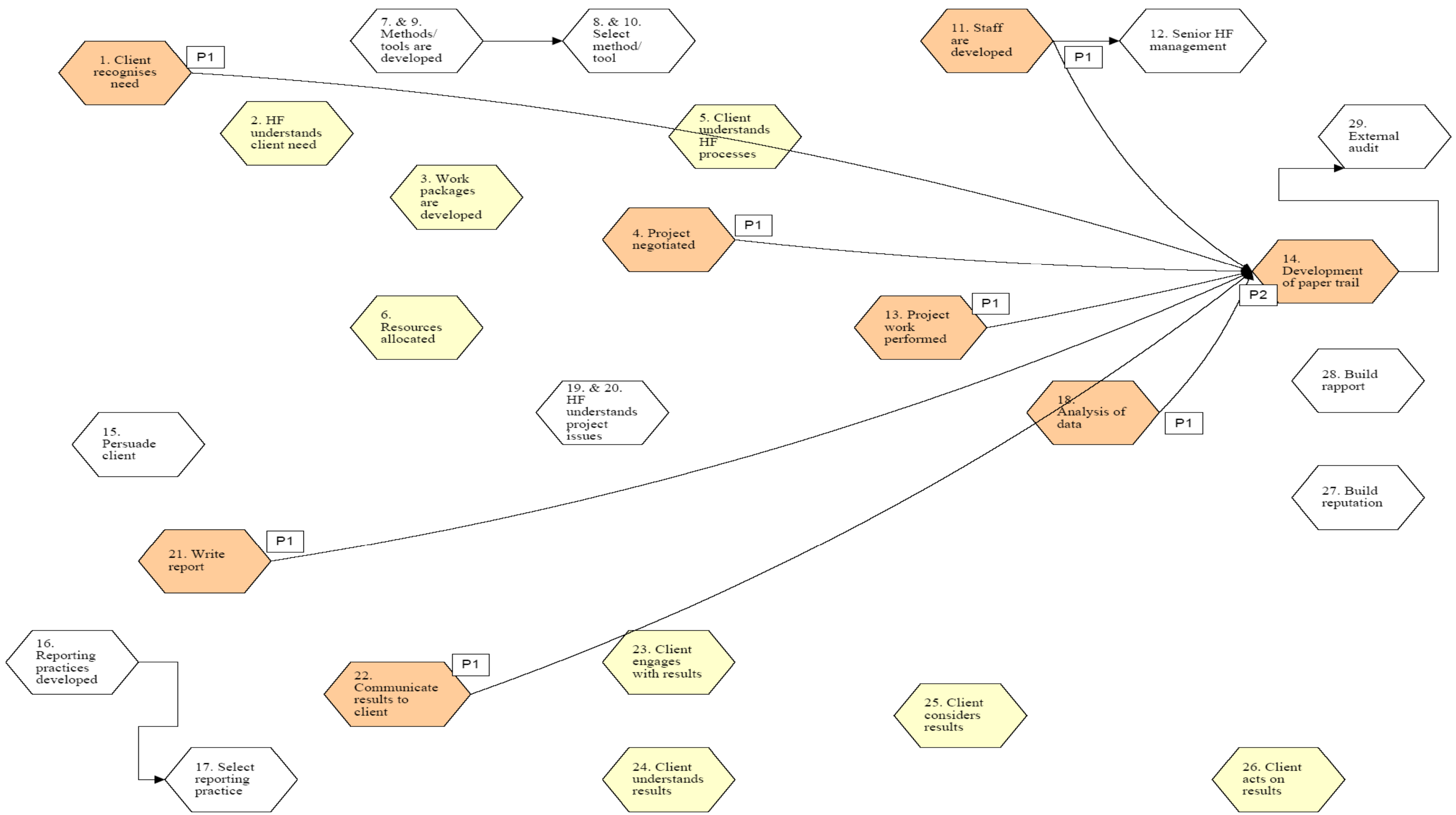
"Yes, this saves time, work and effort." (E14)

Reflection on comments:

A number of issues are raised in this section:

- A new node should be added to account for the production of the HF project proposal between Functions 1 and 4 (E11 and S2).
- E1's comment on client meetings could be subsumed in Function 22.
- S2 shows that some companies are very strategic in the development of their collective knowledge and so the documentation of projects and the publishing of journal papers become a resource and a significant identifier of company expertise.
- E13 raises the point that they have internal reviews and authorisation of work but these are not as strong as external audits. This could be incorporated under a separate node titled, 'internal review'.

Auditing and documentation



Level 3: Overall system

- Between different contexts and projects the different functional parts of the systems will vary (Level 1) as will the different subsystems (Level 2) and these need to be monitored and managed to maintain performance.
- Stability of the system can be increased by establishing standard methods, practices and procedures.
- Adaptability of the system can be maintained by tweaking and developing methods, practices and procedures.
- Practitioners play a key role in monitoring and managing the system. Through their expertise they can be aware of potential pressure points in the system (Level 1) or subsystems (Level 2) and take appropriate action to compensate.
- In the long term every part of the system has some influence or resonance with the other parts either directly or indirectly. We use method selection as an example:
    - Methods will be selected in terms of the client's need and what the practitioner is used to amongst other things.
    - The performance of the method will affect project work, analysis, report writing and communication to the client in the central project process.
    - The performance of the method will also lead to the further development of HF/usability practitioner expertise in its deployment. This will influence senior management development also in monitoring the project.
    - When a similar project comes in practitioners will be more likely to pick those methods that they have practiced in their repertoire. Clients might also recall and remember the methods used making them see potentials more clearly.
    - Repeated success of the method over different projects will have an impact on the practitioner's reputation; this will have a knock on effect in their persuasiveness in gaining work and the receptiveness of their recommendations. Too simplistic. Definitely will influence getting the job but acceptance of recommendations does not necessarily follow easily. (E9)
    - Different methods can be exploited for their characteristics outside technical fault finding. For example, methods that encourage observation or participation can be used to build rapport; or if a situation calls for a lot of persuasion practitioners may opt for choosing a method that can give direct access to user views e.g. through video edits, quotations, and observation.
    - The sort of data gathered will restrict the reporting practices e.g. graphs, statistics, video edits and quotations. This will also impact what is archived for reference and auditing purposes.
    - Tools can have a big influence on method adoption and adaptation as they can enhance and extend practitioner abilities. Where tool support is poor and work cumbersome alternative methods may be selected.

Is it generally accurate? Yes 14, No 0, Not sure 1.

Is it a significant component? Yes 12, No 2, Not sure 0.

Comment (optional):

"While the system makes sense to me and is something I recognise there is not a step in it where I think if I changed that it would solve the problem of transfer between research and practice and acceptance of HF in a work environment. For example having done a very successful project with clearly demonstrated ROI and using an agency with a very

good reputation I can still not guarantee the acceptance of HF in the next project. Generally I think the external factors (time/money/org structure/power/influence etc) are played down here.” (E9)
“I think practices are comfortable with standard e.g. they are reluctant to use new staff.” (W1)
“I do very little documentation for auditing sake. But have worked for companies who provided services to government agencies. The required arduous documentation for RFPs, past project examples, ISO requirements, etc. so I will extrapolate this section could potentially true if I was working in such an environment today.” (E6)
“Process not sufficiently developed in our organisation for much of this to happen in reality.” (S1)
“See my comments about the over complexity of this system.**”** (E14)

Reflection on comments:

E9 raises issues regarding the implications of this work for knowledge transfer from research to practice and the acceptance of HF in a work environment, and the completeness of the model. Where E9 says there isn’t ‘a step’ where they recognise the potential for a successful intervention; what the model emphasises are the many dependencies at play in the system and so interventions are more systemic e.g. between critical functional couplings and across the system. For example, strategies for building rapport through method use should be exploited, and improving staff development could have a significant and broad impact across the system. The main contribution of this model is describing the context in a way that reflects real decisions and dependencies in method use, it is more about understanding the gap between research and practice than bridging it (a similar argument is made by Ackerman, 2000). The second issue raised by E9 is on the completeness of the model as it plays down such factors as time, money, organisational structure, power and influence. These are accounted for to some degree in the model, i.e. time and money in resource allocation, organisational structure in the hierarchy, and influence in rapport and reputation. More could be made of these factors but this is outside the scope of this project, e.g. an organisational psychologist or social scientist could each build up quite different models focusing on power, training, skills, organisational structures, etc. To distinguish between the accuracy and the usefulness of a model we refer back to Box's (1979) dictum: ‘all models are wrong, but some are useful’. The majority of participants believe that the model is generally accurate, we also believe it is useful in demonstrating, the in particularly, why methods should be understood in a system of Hf/usability practice.

Thank-you for your time and help this work, it is greatly appreciated.

Further Comment

“The point to make is that the difference between the typical tool for task analysis which is a sheet of paper/Word Table/Excel Spreadsheet and [specialist software] is millions of pounds and twenty years. A similar story applies to standards.” S5

“I haven't checked the last part. I did look at it, but don't really have an opinion.” S11

“This sample content looks really great........good job.” S13

“I have attached the feedback form - didn't have time to do it all though I'm afraid Looks v interesting work...” S3

“Realised at the end that I mostly commented when I didn't agree which may make it sound overly critical. It isn't I really liked the model and thought is was robust. Hope this is helpful - please let me know if anything doesn't make sense or if I have misunderstood.” E9

“To be honest I don’t really have much reaction to the component and subsystems!
I don’t know if they’re true or not – I think that level of critical thinking is beyond me.” W3

Reflection on comments:

These do not entail changes for the model.

Appendix E: Qualitative Analysis of CHI Workshop

A Qualitative Analysis of the Papers at the CHI 2007 Workshop: Increasing the impact of usability work in software development

Introduction

A workshop on increasing the impact of usability work in software development was held at CHI 2007. 16 papers were accepted to the workshop, 14 of which form part of this study as two arrived after its completion. The papers ranged from authors' practical experience, specific case studies, a survey, and introducing new methods to practice.

These papers were analyzed using Grounded Theory to spot recurrent themes and to build up a picture of what the papers are saying in a collective voice. The papers were also commented on individually to provide more detail and to act as a comparison for a summary technique. Collectively the results present a form of summary of the papers in the workshop, a summary that can be used to compare to my research with practitioners, to spot commonalities and gaps in both.

Method

Elements of Grounded Theory were used to analyze the 14 papers that were accepted to the CHI 2007 workshop, "Increasing the impact of usability work in software development." First a summary of each of the 14 papers is presented, followed by the Grounded Theory. The discussion section talks about the major themes of these two summary approaches, compares them and talks about the quality of the data.

Summary of Each Paper

The following table contains the abstract and a comment on each of the papers. The papers vary in what they say, and what has led them to their conclusions and advice. From this overview it is evident that there are common themes: particularly notable is the recognised need to integrate usability practice better into the software development and organisational processes; and the issues that occur when groups with different cultures, backgrounds and knowledge come together – this manifests itself in issues of communication and understanding.

Paper title	Author(s)	Abstract	Comment
Increasing the impact of usability work in software development	Tobias Uldall-Espersen	This paper reports a case study of a software development project where an insurance sales system was developed. Two key persons in the project enforced usability work into the development process and usability work became a key success factor. The usability work was comprehensive and became a significant and integrated part of the development project, and it informed both the end product quality and the organization in which the system was implemented. The case study is based on interviews with six key persons in the project.	It was essential that there were two usability champions that were centrally located within the project. They bullied their way in to the project process and a sense of pride motivated them. They communicated a lot with stakeholders, it was demanding work and they made compromises in the use of techniques to get the work done. Role playing was a method used to solve a particular problem. Involving so many people also influenced product acceptance because it got people to buy-in to it. Usability was recognised as a key success factor even though it was not formalised or measured.
Integrating usability work in a software development process: a case study on Claims Analysis	Ann Blandford	In the project reported here, we set out to adapt Claims Analysis specifically to suit the design of Digital Library systems. The work involved embellishing CA with an explicit interaction model and information seeking scenarios and expressing it in a form that was accessible to software developers with no background in usability work. While scenarios were valued by the development teams we worked with, Claims were not, being considered “too academic”. The work highlighted different value systems and priorities of human factors specialists and software developers, including prioritizing user problems or design solutions, and different ways of thinking in terms of interactions and functions.	The author tried to introduce scenarios and claims analysis to development teams. There was motivation to create common ground between developers and HF. Developers were interested in solutions not problems. There is a challenge to bring people together with different values, language, etc.

Paper title	Author(s)	Abstract	Comment
Evaluating Ripple: Experiences from a Cross Pollinated SE-UE Study	Pardha S. Pyla1, H. Rex Hartson, James D. Arthur1, Tonya L. Smith-Jackson, & Manuel A. Pérez-Quiñones1	The disciplines of software engineering (SE) and usability engineering (UE) have reached substantial levels of maturity, each now with its own well-established life cycle processes, activities, and techniques. The usability engineering life cycle process guides the design and evaluation of user interaction design of an interactive software system. The software engineering life cycle guides the development of the functional core (the non-user interface functionality) and the implementation of user interface according to the specifications created by usability engineers. Given that the user interface and the functional core are two closely coupled components of any system, one would expect close connections between the two development life cycle processes. Unfortunately, the two disciplines are practiced almost independently – missing opportunities to collaborate, coordinate and communicate about the overall design - often leading to project failures. In response, we created the Ripple framework that provides a development infrastructure to foster communication between software and usability engineers thereby connecting usability and software engineering life cycles in cooperative and complementary roles. This position paper describes eight case studies from the evaluation of the Ripple Implementation Framework instantiated within an educational setting and the preliminary findings from this study.	They quote technical details as to why UE and SE are not more closely related e.g. time constraints and methods of each, however, I think the softer-side should be acknowledged more upfront. The outcome of their study was not as predicted due to non-technical issues: one person was a leader and ignored usability; three other people had a good working relationship and invested more time in the project; another project was rated highly because it was deemed cool; and the team that had dual responsibilities to design and build chose the easiest options to implement. Communication was meant to be tested in design, instead respect, willingness, different roles, leadership and rapport proved to have significant influence.
The Impact of Usability on Supernova Discovery	Cecilia R. Aragon, Sarah S. Poon	Much of the discussion of the importance of usability to software development has been focused on commercial software. However, large scientific software projects can also greatly benefit from the application of usability engineering principles. This case study describes software developed for astrophysicists studying supernovae with the goal of measuring the expansion history of the universe. By performing iterative software design and other usability engineering techniques throughout the project, we were successful in developing a supernova data catalog and workflow management tool that improved scientists' efficiency, situational awareness, and productivity. Special care was taken to involve the scientist users in all aspects of and at all stages of the design, implementation, and testing. Integrating usability design throughout the project had a significant impact on its success.	They developed software to help scientists. They worked closely with the scientists/user group and successfully affected integration of usability.

Paper title	Author(s)	Abstract	Comment
The impact of usability work in software development experiences of Finnish usability practitioners	Jenni Anttonen	We conducted a survey among Finnish usability practitioners to gain a preliminary understanding on how usability work is practiced, what kind of impact it has, and what factors affect the impact. The greatest challenges for the impact of usability work were practitioners' communication skills, management's support for usability issues, integration of usability activities into the software development process, and time and resource constraints.	They did a survey and found that communication, management support, getting people to understand the role of usability, and to have usability written into development processes are all important.
Usability Process Improvement	Nigel Bevan	ISO TR 18529 "Human-centred lifecycle process descriptions" contains a detailed set of human centred activities derived from ISO 13407 that are potentially needed to implement human centred design in systems development. Two case studies are given of using ISO TR 18529 to assess usability maturity and to provide the basis for integrating user centred design methods into systems development.	Bevan talks about UCMs (Usability Capability Models). The process of carrying out an assessment into a company's usability capability raises awareness of its maturity which can lead to change.
Innovation in Testing; Innovation in Design	Hernandez, B. & Scott, J.	NO DETAIL	They used an innovative technique to test at an early stage which fed into a new design idea. They successfully sold the idea to management who were initially sceptical of usability. They now plan to implement it more. They also refer to a leapfrog process whereby usability work is done in between development processes to get in the way less.
Impacts of Classification of Usability Problems (CUP) on System Redesign	Effie Lai-Chong Law Sigurbjörg Gróa Vilbergsdóttir Ebba Thora Hvannberg	We report a case study about the application of CUP - a scheme for classifying usability problems - to redesign a learning management system named Owl in a software development organization. The impacts of CUP on understanding usability problems identified in user tests, prioritizing and fixing them were analyzed.	This is an analysis of CUP which looks to improve the way people handle usability problems e.g. by prioritising them and getting people to understand them. Unfortunately the paper doesn't say too much about what people actually thought of it. It is nevertheless a worthy area of investigation - although practitioners constantly say they don't just give a list of problems.

Paper title	Author(s)	Abstract	Comment
Increasing the Impact of Usability Work by Focusing on System Level Solutions	Eija Kaasinen and Marketta Niemelä	We describe a case study in which the impact of usability work was increased by focusing on system level solutions. These include solutions that pertain to platforms, architectures and middleware, and that influence many features of forthcoming applications and thus also usability. The focus of our work has been a mobile platform architecture that enables different ubiquitous applications. We got early user feedback on usability issues that affect the architecture by illustrating the forthcoming applications in various ways and evaluating the illustrations with potential users. Our experiences indicate that several architectural design decisions have impact on the usability of applications.	They claim there are no methods for the architectural level where you would analyse a few early conceptual designs and abstract system level insights to aim for. In a way this is more conceptual but I'm not sure I would say that it is tremendously novel. They position it at a system level and try to say it is new but is it really? I'm sceptical as practitioners are tasked with getting feedback from users at a conceptual phase. They have done this themselves and so you don't get too much out of the problems of applying it in practice.
HCI + SE Integration - Case Studies from Offshore Development Projects	Anirudha Joshi	The author reviewed and participated in several case studies from the Indian IT industry to study the integration of human-computer interaction (HCI) design into software development by process-conscious Indian software vendors. Several problems seem to occur because HCI skills were either not used, or were not used early enough in a project or when the HCI professional lacked process support to carry out all HCI activities in the project. In the one case where HCI professionals were indeed used early and with a multi-disciplinary team, the results were positive. The case studies point to a greater need to integrate HCI into existing SE process models and establishing benchmarks that are widely acceptable.	This is an overview of a number of case studies which basically conclude that HCI processes should be better integrated with SE processes e.g. earlier on, with management support, properly budgeted and with a multidisciplinary team.
Position Paper for Workshop Increasing the Impact of Usability Work in Software Development	Rolf Molich	Much usability work is ignored. This position paper presents results from the Comparative Usability Evaluation (CUE) studies that substantiate this claim. The paper also presents a number of politically oriented techniques that have worked for the author in promoting usability results. Key techniques are that in order to increase the impact of their usability work, usability professionals must master the politics of usability, work closely with product teams, actively "sell" their results, and set a good example for the organization by ensuring that their own products are highly useful and usable.	Molich focuses on why usability practitioners are ignored and believes they need to be more aware of the political processes. Short reports, involve team members and get buy-in, get them to watch tests, etc.! This is definitely away from problem finding and is about making the output effective - but, importantly, this is done throughout the process and not just at the end!!

Paper title	Author(s)	Abstract	Comment
Arriving at Shared Perspectives on Software through User-Centred Design Processes	Robert Gillham	User-centred design is often little more than an afterthought in traditional software development processes. Development projects meanwhile often suffer from poor communication between stakeholders and a lack of shared vision. This paper describe a case study where user centred design was brought to the forefront of a development effort to address both issues.	They recommend different tools for communication for different people - not everyone wants to know the same thing and people are interested in different bits. Again traditional software development processes are seen to exclude HCI activities. Getting different groups to communicate together is key.
The Cross-Functional Challenge of Usability Work in New Packaged Software Development	Tonja Molin-Juustila	This paper presents a case study of usability work in the context of developing packaged software applications. It will be shown that within such a context, the impact of usability work faced the organizational challenge of cross-functional interaction. The paper provides practical experience from a concrete case of improving the status of usability work in one company. The case provides better understanding of how usability work - within the context of packaged software development - is clearly a cross-functional issue. In addition to software development processes, in order to impact new product development usability work needs to be better integrated to the activities of other organizational functions as well.	They seemed to be wanting to introduce a new process including UCD but there was already some UCD processes, this was a special context and again the different sides found it hard to communicate and reach common ground. The integration of usability into normal companies' processes was again the key concern.
Usability in e-Science: The eDiaMoND Case Study	Andrew Warr, Grace de la Flor, Marina Jirotka, Sharon Lloyd	The vision of e-Science aims to bring about new forms of science by allowing the sharing of skills, data and computing resources across institutions and disciplines. Many challenges have been identified in realizing this vision: one of which is usability. In this paper we present a case study of a flagship e-Science project namely eDiaMoND. We describe the usability work adopted and the usability issues encountered in the project. Finally, we conclude with lessons learnt for future e-Science and similar large-scale projects.	They explored 3 factors that had a negative effect on usability in the eDiaMoND project: ambiguity, project management and the clashing of cultures.

The Grounded Theory

The Grounded Theory analysis comprised the 14 workshop papers. It is presented here under the three main themes: communication; usability and project plan (coordination); and different sides. These themes are described with reference to other codes which are highlighted in **bold**.

Communication (28 Quotations)

Design and business is not normally a one man endeavour but instead involves many **different sides** with different **experiences** and **skills**. From a system point of view we may look at how different components function, their boundary, and how they interface with other components. This interface between the different components or **different sides** of the system is central to **communication**. **Communication** is a central theme of the workshop papers.

It is recognised that you may need to communicate in different ways to different people e.g. the **business side** and the **technical side**. These sides have their own concepts and vocabulary, but also, importantly, they are interested in different things and probably not interested in usability per se. Here we touch on the fact that these different groups have different value systems.

Competing value systems between groups will often entail a **political side**. It is recognised that insufficient understanding of this side might lead to usability being **ignored**, which one might presume would have a detrimental impact on the **project success** and the **end product quality**. **Management support** is seen as having a big influence on the integration of usability. Particular individuals might also have a large impact depending on their **motivation** toward usability i.e. **leaders** may be able to increase or decrease integration. Other factors that will bear influence on the political integration of usability are **personal/issues and rapport** between the individuals involved. The amount of **respect** that usability is given will be dependent on these soft factors and also on the harder factors of how it contributes and performs within its budget and other **resource constraints**. Usability should always be looking to promote this rapport and respect through **selling** itself.

Communication is seen as a **skill**, and an important part of getting these **different sides** to a common understanding. This doesn't always mean conceding to their point of view, but may mean 'sparring' to come to a satisfactory resolution. Usability is also seen as a bridge between different stakeholders e.g. techies and users, to facilitate **communication** between each. An example of this facilitation is that scenarios were viewed as vehicles for building common ground between the **different sides**.

A dimension in **communication** is **closeness**. The closer that usability is to engaging and appreciating the real **business side** and **technical side** issues i.e. getting **in the trenches** and understanding real concerns the more value it will be given. There is also **closeness** in the sense of getting the client/stakeholders to see the raw behaviour rather than read a recommendation which can affect their appreciation of the issue e.g. watching a **user test** and taking part in analysis will be more convincing than throwing a report over the wall. So, one extreme of closeness is actually working through things together with users, domain experts, technical experts and other stakeholders; the other extreme might be to an emailed Word report with no other communication. You can improve **closeness** in terms of understanding usability by demystifying it – it isn't rocket science.

Another dimension in **communication** is **formality**. This can influence the sort of work done and the communication of that work e.g. if it is not formally planned than it may be more sketchy than a planned measurable study. Informal communication over lunchtime and chats is another way of winning people over, convincing people – it doesn't have to be a formal report. Formal input might be considered more explicit, whereas informal more implicit.

Communication issues are important throughout the interaction but there is an emphasis on the **output** toward the end of the project. The papers probably neglect the very beginning of usability projects e.g. how you negotiate a work package and decide what is to be done. It is recommended that problems are not just identified but they are **prioritised**, **design suggestions** are made where appropriate, and **praise** is given where it is deserved. Reports should have one page summaries and be short. The output to communicate recommendations and issues can be in the form of **documentation**, a **workshop**, watching **user tests**, **video**, in **meetings**, or in **PowerPoint** form. There may be different communication styles and content to different stakeholders to suit their interest e.g. business side and techie side might not like the same thing and require different details. Communication in these different forms can have different levels of **closeness** and **formality**. This can have a big impact on buy-in and ownership of the issues which will hopefully mean recommendations are less likely to be **ignored**.

<u>Usability and project plan (23 Quotations) – coordination</u>

The coordination of usability activity within the project is another key theme across the papers. Some suggest that usability should be better integrated into the **formal** project plan; and this involvement should not be left too late.

There is a cost in doing usability work, and **management support** is needed to put it on the agenda. There might not be a tradition of doing it in the company and so change is necessary. These decisions involve the **political side**.

Where usability hasn't been involved, or isn't planned, **leaders** can influence whether it is used and to what extent.

When usability is involved it is important that it is not too late and preferably at the 'optimum time'.

This theme also has the dimensions of **closeness** and **formality**. **Closeness** would be how close the usability work and people operate to the users or the developers for example. And **formality** would be how much preplanning has gone into the plan.

Usability should not just be well integrated with the project plan, but also the organizational functions e.g. the **business side** and **technical side**. The **closeness** of this integration will mean that they engage with the real issues more i.e. **in the trenches,** and hopefully gain more **respect**.

<u>Different sides (20 Quotations)</u>

Central to the above two theme of **communication** and **coordination** is the fact that there is the challenge of getting **different sides** to interface effectively and efficiently for project work.

Different sides include usability, the **business side** and **technical side;** and academia and industry**.** Each side has their own backgrounds, culture and jargon; values also differ e.g. the academics might want publications out of a project whereas industry partners want a working system they can use or sell; business is worried about cost and ROI, techies are worried about bugs and redesigns, and usability is worried about the end user (techies were observed to be solution focused and usability people wanted to understand the problem more). It is recognised that bridging the gulf between different sides can be **demanding**. Again, **different sides** with competing value systems will involve the **political side**.

The idea of **closeness** can be used to visualise how the different sides work together or further apart e.g. in one project a user was employed to advise the design team – this brings the user group much closer i.e. bringing one of them into the design camp.

Communication and **coordination** are central to the management of **different sides**.

Discussion

Both the summaries of the papers and the Grounded Theory show that the workshop papers are generally about getting usability practice integrated more through effective coordination and communication strategies – one affecting the other. Although 'communication and coordination' provide a nice short tagline it comprises many interrelated factors and facets e.g.: the softer side of culture, value systems, vocabulary, emotions, motivations and politics; and the harder side of resource constraints, goals, procedures, measures, deadlines, methods, skills, and knowledge. It should be noted that these issues can change/fluctuate depending on the specific context, people and project; and that strategies can be suggested that tackle a number of them at the same time e.g. the KJ method where a meeting is held after testing to collective analyse and agree on priorities – leading to buy-in, closer communication and working, and shortened reporting time.

The summaries of the papers (their abstract and comment) give a better idea of the variety of contribution across the papers. The Grounded Theory provides a much better integration of the issues across the papers, although it loses the uniqueness of the different contributions which makes it harder to tell how many people said what and why. Comparing the two approaches it appears that the Grounded Theory provides a better general picture across the papers which is easier to understand and communicate; but it loses out on some of the detail and is much less tractable in determining who has said what and with what authority.

The quality and depth of information that the papers provide varies quite a lot for gaining insight into real practitioners' strategies and issues e.g. it is much more revealing dealing with a survey or case study of real project experiences, or the distillation of somebody's years of expertise, than it is to have a details and controlled studies of a new method that someone is trying to promote. It also appears that there is a focus on doing the usability work and getting recommendations listened to, but this neglects the precursor of organising the work which is an extremely important stage. When we speak of increasing the impact of usability work we should not go straight to the hand-off and work backwards, but start upfront where the project resources, plans and expectations are negotiated. There is also little in the way of longitudinal observations i.e. we are often given a snapshot of a case study but how do individual and organisational attitudes toward usability change over exposure and time.

The themes and details that were reported in the workshop seem to concur with my ongoing findings of my own PhD e.g. communication and coordination. This provides some form of cross validation.

Take Home Points of Appendix E

- Grounded Theory seems more suitable to give an aggregated understanding of a collection of data points, rather than a summary of each of those data points. However, the two summary techniques could compliment each other – one showing the aggregate and the other providing an indication of the variety.
- Communication and coordination are central themes in improving the impact of usability in software development. Their component factors and facets need better explanation and more validation (particularly in bringing them together in a unified theory).
- Focus on real practitioner experiences and opinions of projects is beneficial for painting a picture which is ecologically valid
- Take the whole usability process into account from beginning to end i.e. project planning to hand-off.
- Take longitudinal changes in usability practice into account over many projects and years of work.
- Make specific recommendations in the details of practice and make contributions clear.

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