MAKING MOBILE MEANING

– expectations and experiences of mobile computing usefulness in construction site management practice

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"Weaseling out of things is important to learn.
It's what separates us from the animals… except the weasel."
– Homer Simpson

ABSTRACT

During the last decade, anticipated and realized benefits of mobile and wireless information and communication technology (ICT) for different business purposes have been widely explored and evaluated. Also, the significance of 'user acceptance' mechanisms through 'perceived usefulness' of ICT applications has gained broad recognition among business organizations in developing and adopting new ICT capabilities. However, even though technology usefulness is regularly highlighted as an important factor in ICT projects, there is often a lack of understanding of what the concept involves in the practical work context of the actual users, and how to deal with the issues of usefulness in organizational ICT development processes.

This doctoral thesis covers a 1,5 year case study of a mobile computing development project at a Swedish international construction enterprise. The company's mobile ICT venture addressed the deficient ICT use situation of management practitioners in construction site operations. The study portrays the overall socially shaped development process of the chosen technology and its evolving issues of usefulness for existing construction site management practice. The perceived usefulness of mobile computing tools among the 'user-practitioners' is described as emergence of 'meaningful use' based on initial expectations and actual experiences of the technology in their situated fieldwork context. The studied case depicts the ongoing and open-ended conversational nature of understanding adequate ICT requirements in work practice, and the negotiation of mobile computing technology design properties between users and developers over time towards the alignment of diverse personal, professional and organizational needs and purposes of ICT use. The studied introduction of mobile computing technology in construction site management fieldwork practice serves as an illustrative actual example of how to interpret, understand and approach issues of usefulness and user acceptance of ICT resources in operative work contexts when managing ICT development processes in organizations.

Keywords: Mobile computing, Construction site management practice, ICT development, Usefulness, User acceptance, Learning, Meaning

PREFACE

An ever increasing amount of businesses and industries are structured and executed in different temporary project constellations, often with inter-organizational setups (see for example Midler, 1995; Lundin and Söderholm, 1995). Also, during the last two decades the dependency on a variety of Information and Communication Technology (ICT) systems and applications has increased enormously and ICT has become an absolute necessity for conducting business in any industry. In project organizations, where people work together towards a common goal during a limited period of time, there are intricate problems of exchanging data, sharing information and collaborating via a mutual ICT platform. The communication is regularly going on at two levels at once. The formal, controlled exchange of data and computer documents is taking place on one level, while informal and interactive human problem solving is taking place on another. Even though ICT plays an important role, communication cannot be fully overlooked and is impossible to control through formal tools and systems. ICT offers tools to keep track of an entire information base, but it can also give rise to information anarchy prevailing in many projects (Wikforss, 2006). When ICT systems are used in their practical work contexts, they do not always produce the expected benefits. Since ICT system design is mainly based on formal structure and linear workflow, it differs from the informal and spontaneous social interaction in collaborative project work. If the intended collaborative ICT platform of a project is not perceived as useful or accepted by the intended users, the real exchange of information often takes place via other informal channels such as e-mail, SMS and mobile telephony. This kind of communication behavior can enable a more natural direct contact between project participants, but may result in limited abilities to ensure proper organization and coordination of data and electronic information needed in project teamwork (Wikforss, 2006).

The research presented in this doctoral thesis relates to the problem described above and has been conducted within the subject field of 'project communication' at the Department of Industrial Economics and Management (INDEK) at the Royal Institute of Technology (KTH) in Stockholm, Sweden. Wikforss (2006) is one example of previous project communication studies that seeks to develop improved

understanding of different forms of information exchange and communication processes that are able to cross the many professional, disciplinary and geographical boundaries regularly encountered in project work settings. The study presented in this thesis, however, relates to the management of design, implementation and use of ICT resources in project based organizations, and how information and communication systems both can facilitate and hinder effective work among project participants.

The thesis is empirically grounded in the project based construction industry. But the starting point of the study was my interest in mobile computing and mobility enabling ICT for enterprise users after finishing my master degree in industrial management and telecommunication systems at KTH in 2004. The corporate end user perspective of integrating mobile and wireless ICT capabilities into companies' existing business enterprise ICT platforms caught my attention. What industries would benefit from making their existing business information systems and communication tools more flexible and mobile? What companies have recognized the business potential of mobile and wireless ICT and have the drive and determination to carry out such a technological expansion? Who are really the potential user groups of mobile computing resources? What is the value that the technology is supposed to bring to these users in supporting and enhancing their everyday professional practice?

I got aware of some of the existing performance issues in the construction industry, and especially information and communication processes in production site operations. The geographically distributed construction site is a work environment that involves a lot of complexity and diversity in the collaborative activities between involved participants, as well as unpredictability and uncertainty of its physical production processes. These characteristics put particular requirements on end user ICT tools to support construction site management professionals' changing information and communication needs of their work activities in the field. The potential of mobile and wireless ICT for this dynamic work environment appeared to be promising. But then questions emerged such as: What ICT tools are construction site managers requesting? What is useful mobile computing in the context of their everyday work?

The study of this thesis involves usefulness development of mobile computing and ICT in the professional work context of construction site management practice. Construction sites are the kind of field based work environments that are often described as a prime application area of mobility enabling ICT for business purposes. Field based work practice is also a challenge when it comes to designing useful and accepted ICT support systems. ICT use is increasingly becoming a considerable element of these work contexts, but is often perceived by practitioners as something that is not a part of their 'real work' such as coordinating and supervising activities in the field. The complex and sometimes conflicting relationship between ICT use and field based work practice is one of the central analytical aspects of this study.

The empirical material analyzed and discussed in this thesis consists of a two part case study made at the Sweden based global construction company Skanska AB during August 2005 to January 2007. The first part covered an observational study of a large residential housing project in northern Stockholm, during the fall of 2005. The everyday work of a construction site management team was followed on a daily basis with the purpose of trying to capture the information and communication needs and the use of ICT in their work environment. The second part of the case study followed a pilot project at Skanska involving new mobile computing tools for construction site management professionals in the company's effort of trying to improve the use of ICT in the field.

Previous results of the study have been presented in my licentiate thesis (Löfgren, 2006), and in various papers relating to it (see for example Löfgren, 2005, 2007). The initial research scope included the dynamic nature of building site operations, the important role of informal communication in construction projects and the lack of appropriate ICT to support collaborative production processes. The licentiate thesis described the then ongoing case study at Skanska and mapped its early results with a broad conceptual framework to show interdependencies between the creation of usefulness and the resulting benefits of mobile ICT in the production environment. The results in Löfgren (2006) emphasized socio-technical user oriented implementation as the enabling process for realizing technology fit and user acceptance of the mobile computing tools, as well as for achieving long term benefit and business value of the ICT investment. The implementation process was

described as a continuous struggle to align the technology with its social work practice, and demanded comprehensive understanding of the operative work context and extensive involvement by the intended users in adapting the technology. The licentiate thesis also highlighted active workforce participation in both development and implementation of mobile computing tools at Skanska as a central contributor to the creation of usefulness of the technology in everyday construction work. The role of user champions and cross professional project teams appeared to be key functions in bridging the perspectives of technology design and its use in practice to communicate what needed to be accomplished in moving forward in the process. New changes, large or small, introduced in an operative work context are unlikely to turn into immediate successes. Tweaking both organization and technology is often necessary to achieve a configuration that is sufficient and acceptable. This doctoral thesis builds further on the results in Löfgren (2006), but takes a more focused approach of trying to achieve deeper understanding of usefulness of mobility enabling ICT in the specific fieldwork context of construction site management practitioners.

In the following thesis, the concept of usefulness is broadly defined and employed, and includes both usability and utility aspects of the term. A basic description of the concept can be found in for example Davis (1989) and Nielsen (1993). Usefulness is then described from different viewpoints to reflect the multifaceted meaning of the concept including perspectives of individual 'user-practitioners', technology developers and the social learning processes towards 'meaningful use' of mobile computing in practice. The works of Schön (1983), Suchman (1987), Dahlbom and Mathiassen (1993), Pickering (1995), Weick (1995), Wenger (1998), Heath and Luff (2000) and Fonseca (2002) have been particularly influential to better understand the observations made in the studied case, and the fundamental complexity of individual, technical and social factors positively and negatively affecting the usefulness development of the technology in the practical fieldwork environment.

Design oriented ICT research disciplines relating to human, social and organizational factors of ICT use have contributed with valuable complementary insights to the notion of usefulness. The most prominent of those disciplines are 'computer supported cooperative work', 'human computer interaction', 'mobile informatics' and 'information management'. Recent doctoral dissertations such as

the works of Mähring (2002), Weilenmann (2003), Boivie (2005) and Valiente (2006) are partly belonging to the research domains just mentioned, and have in different aspects been inspirational for the contents of this thesis.

Before we begin the expedition of this thesis, I would like to acknowledge the people who in different ways have contributed and inspired me in my research. My head supervisor Professor Örjan Wikforss (KTH) and my co-supervisor Professor Staffan Laestadius (KTH) have eagerly shared their competences and experiences as well as provided the best possible encouragement, inspiration and support throughout my whole research journey. During my doctoral studies I have also worked very closely with Örjan in numerous educational activities and undergraduate courses at KTH, which have given me invaluable experiences in pedagogy and mentorship. I want to express my gratitude to the Development Fund of the Swedish Construction Industry (SBUF) and Skanska who have supported my research project financially. I am also deeply thankful to all people at Skanska who let me access and take part in their daily work, as well as took the time to meet with me for interviews. Dr. Inger Boivie carefully reviewed my first full thesis draft and provided a summarized proposal of vital final improvements of the text. Professor Per Andersson at the Stockholm School of Economics was the opponent of my licentiate thesis, and have contributed with valuable conversations about the research along the way. I am grateful to all people who came to my final critical thesis seminar and gave their comments and improvement suggestions. Also, several fellow colleagues at INDEK made my time at KTH extra enjoyable and fun. In particular, I will certainly remember and cherish inspiring conversations and sharing of experiences in St. Petersburg, Madrid and Södertuna that were 'on top of it all'.

Family and friends – breathe, I care.

Stockholm, September 2008
Alexander Löfgren

CONTENTS

1 INTRODUCTION

ICT usefulness and work practice

Since several decades, developing existing ICT systems and enhancing the use of ICT platforms with new technical capabilities are crucial strategic issues within businesses and work organizations. Studies of governance and management of ICT often deal with central technical and economic aspects of design, implementation, adoption, maintenance and renewal of ICT in organizations. Commonly, they include legacy problems of integrating new systems in existing structures, phasing out old systems, project management frameworks for effective introduction and acceptance of new technology, feasibility studies of ICT applications for various business purposes, cost appraisal and benefit evaluation of ICT systems in different work and business contexts. These studies often highlight the benefit potential of certain technology choices and try to develop, discuss and evaluate process oriented frameworks for improved governance and management of design, introduction and use of ICT systems to create business value (for more thorough acquaintance with the field of ICT management and ICT project governance in business organizations, see for example Mähring, 2002; Hedman and Kalling, 2002; Chaffey and Wood, 2005; Pearlson and Saunders, 2006; Lundeberg et al., 2006, Laudon and Laudon, 2007).

Achieving usefulness and user acceptance of ICT systems is frequently highlighted as important 'key factors' for successful outcome of ICT projects and for long term use of ICT resources that deliver benefit value to the organization and its business processes. Ideas of usefulness, usability and ease of use of system applications are often communicated as important objectives in ICT projects without really knowing what these concepts actually mean in the work environment where the technology in fact is used. Basic models for appraising perceived usefulness and user acceptance of ICT systems within organizations are sometimes employed, but few of these methods are actually able to plot the characteristics of useful ICT from the users' perspectives in their practical work context. This 'real life' understanding of ICT use in organizations is often missed because the issue, intentionally or not, generally receives low attention and priority in ICT projects (Boivie, 2005). Part of the

problem is that it is difficult and cumbersome to identify the usefulness aspects of ICT in its situated and varying context of use. An ICT system may include a proper combination of the right content, functionality and a user friendly interface for certain use purposes. But the complexity of situations, actions and dynamics of professional practice where ICT is used is often not comprehended, which result in more or less mismatched assumptions and simplifications about these factors when the technology is designed and introduced into work organizations. A system that has all the right ingredients to constitute a useful and accepted system may in reality be a frustrating and obstructing element for professional practitioners in their daily work. Wrong ideas about design and use of ICT in professional practice may result in negative effects on the performance of work because practitioners spend too much time struggling with ICT systems instead of generating value of business activities. ICT users in an organizational work environment are not simply 'users' of ICT, but rather 'user-practitioners' of ICT in a complex social setting of work practice.

Usefulness is an ambiguous word, a concept with different interpretations depending on who is using it. In governance and management of ICT resources in business organizations, usefulness and ease of use of technology is often communicated as vital components for achieving improved integration and performance of ICT in business activities and processes. As most companies have made large investments in ICT and are dependent on the alignment of business processes and ICT systems in the course of work, it is of course important that the technology is accepted and utilized effectively by all individuals of the organization. In this context, the perspective on ICT system usefulness can be regarded almost as an equivalent to the business benefit generated through the actual use of the technology. Issues of usefulness and user acceptance in business organizations are then commonly translated by ICT management staff as more or less technical design specifications of certain ICT systems regarding integration of infrastructure, data content and interfaces. But what about usefulness seen from the individuals who actually are supposed to use the ICT systems in their everyday work environment? What is really the concept of usefulness for the so called 'users'?

Understanding the tangible needs and demands of ICT use in everyday work is still a fundamental problem of ICT management in many organizations. Users have to

be understood in order to manage ICT use, and user context has to the understood in order to develop ICT content. Or in other words – users and their work context have to be understood in conjunction in order to develop and provide sufficient content of ICT use. This can be described as a matter of managing the socio-technical gaps between design and use of ICT (see for example Ackerman, 2000). Meeting individual needs and behaviors in realizing user acceptance, understanding the fundamental differences between what is required socially within professional work and what can be done technically with ICT systems, as well as bridging separate organizational perspectives of technology use are central issues in managing the development process of ICT usefulness.

Time and again, introductions of new ICT systems in organizations fail because applications are not accepted and used by the intended users. In many cases it seems as the typical way of thinking is that with a 'user friendly' powerful technical design of an ICT platform in place and with 'agile' governance and management processes surrounding it, the acceptance and adoption of the technology by the users will come automatically (see for example Markus and Keil, 1994). But is the practical work context in which ICT systems is supposed to be used actually understood? How are professional practitioners expected to use the system? Are the managerial expectations in line with how the intended practitioners view the usefulness of ICT in their work environment? Improved understanding of ICT usefulness in professional practice relating to this kind of questions is a strategic issue for governance and management of ICT resources within business organizations. In a time when the integration of ICT in business processes is pervasive and critical for essentially all activities of a firm and when most professional work is highly dependent on the use of ICT, usefulness and acceptance of ICT are important managerial issues in order to create and improve business value of ICT investments.

Framing the thesis

This doctoral thesis portrays the incremental evolvement of usefulness issues when existing ICT resources within an organization are extended with new technical capabilities and used by practitioners in their everyday work context. The new technical capabilities of concern are mobile computing and mobility enabling ICT, and the work context involved is construction site management practice. The thesis tries to illustrate what usefulness, described as 'meaningful use', of mobile computing in construction site management practice is about from the viewpoint of the fieldwork professionals and in relation to technology design properties. With this broad purpose of the thesis, further definition of its scope and intended contribution will now be explained.

The study presented in this thesis can first of all be related to the research field of 'social shaping of technology', and specifically 'social shaping of ICT' (see for example Williams and Edge, 1996). In studies of social complexity of technology development the respective roles of users and supplying developers of technology are often highlighted, as well as the explorations of possible implications of different choices during development processes. In for example technology 'implementation research' (see Linton, 2002 for an overview), development is commonly seen as a struggling and spiraling process that is persistently taking place throughout the design, implementation and use of the technology (see for example Leonard-Barton, 1988; Fleck, 1994). The implementation perspective shifts focus from technology supply to instead highlight the contribution of users and the importance of supplier-user and developer-user interactions in the development process. Williams and Edge (1996) explain ICT systems development as an essential process of supplier and developer offerings interacting with user needs, where general purpose ICT applications are customized for use based upon local understanding of the specific context of use and user groups. Integrated ICT systems and advanced ICT platforms are essentially 'configurational technology' that must be adapted and customized to fit the particular structure, working methods and requirements of the practical context of use (Fleck, 1994). The consequence of this is that no single ICT developer or supplier initially has the complete local understanding needed to design and install a technology configuration that is adequate for the specific operative work setting and its users. The users therefore provide a test ground for learning

about the usefulness and problems of using the technology as well as about user requirements. This information may then be fed back to the developers and suppliers involved to serve as input to further development and adaptation of the technology. In this social shaping of ICT systems, development is therefore considered as a struggling learning process of technology design and the use context, involving roles of different actors and the flows of information and communication between them (Williams and Edge, 1996).

Many studies in social shaping of ICT focus on a overall macro perspective of development processes concerning extraordinary events and innovative moments involving a broad range of institutional actors and policy perspectives. Even though these kinds of studies contribute with valuable insights of the overall patterns of development and change in ICT innovation, they regularly say very little about the operative setting in which ICT is used and do not directly consider usefulness aspects in the context of work practice. This has often resulted in incomplete, inattentive and stereotypical descriptions of 'the user' that merely have focused on formal roles and functions, which have lead to deficient and ineffective ICT system designs in practice (Williams and Edge, 1996). 'Ethnomethodological' approaches of studying use of computing systems in real life practice primarily stemming from Suchman (1987) are therefore valuable methods to overcome this problem and to focus on the usefulness of ICT in situated human action (see for example Heath and Luff, 2000). The research presented in this thesis is inspired by these approaches, but is not focused on representing the specific actions of ICT use per se, but on the overall development of usefulness in practice as a result of use and adaptation of the technology over time.

Micro level studies of socially shaped technology development processes concerning interpretive flexibility of ambiguity and involvement of local actors have produced interesting contributions for the discussion of this thesis, for example in the research communities of 'social construction of technology' (see for example Bijker et al., 1987) and 'actor network theory' (see for example Latour, 1987). The starting point for these streams of research is that technology can be designed, implemented and used in more than one way, which generate a range of choices between different technological options among the participants involved in the development process. This is rarely a simple technical issue, but is patterned and shaped by the particular

selection environment and the specific social context of local actors. The analysis of such studies often proceeds outwards from the technology to the human context shaping it, or starting with the basic level of interactions among local individuals and groups which are then scaled up to obtain broader explanations. Williams and Edge (1996) argue that micro level research approaches of socially shaped technology development often have difficulty of reaching closure and stabilization of artifacts as the question of 'choice' is almost endless, and that these studies sometimes have a too narrow scope of only considering local actors of a development process as the main influence and contributor, and thus ignoring the effects of broader institutional structures on the local context. These critical viewpoints are important to acknowledge, but will not be further argued here. Nevertheless, micro level social constructs and local actor perspectives in technological development processes can provide approaches and concepts to further understand the issues of usefulness of mobile computing and ICT in the studied case of this thesis. The local micro level focus assists in concentrating the issues of the study on the usefulness aspects of the technology seen from the perspective of the users and their practical work. The findings of the research presented in this thesis are then related to the adaptation of ICT design properties for practitioners' ICT needs in their particular work setting.

Before the usefulness of mobile computing can be described, the unique operative work context in which the technology is introduced and used has to be fundamentally understood. The studied ICT use context of this thesis is production management at construction sites. The empirical material consists of a case study made at the global construction enterprise Skanska AB during 1,5 years, resulting in extensive interpretive journal notes and transcripts from participant observations and performed interviews. The case study initially portrays the professional information and communication environment relating to the use of ICT tools of production site management practitioners at a construction site in Stockholm. A major part of the case study then describes the evolvement of usefulness issues of an ICT pilot project, where a mobile computing device was introduced to and used by construction site management practitioners in the field at Skanska in the USA and in Sweden. Similar to studies of ambiguity in ICT adaptation in work settings such as Henfridsson (1999, 2000), the thesis describes the explorative assessment of the technology among the involved participants of the pilot project, and their search to find out what useful mobile computing and ICT consists of in the context of

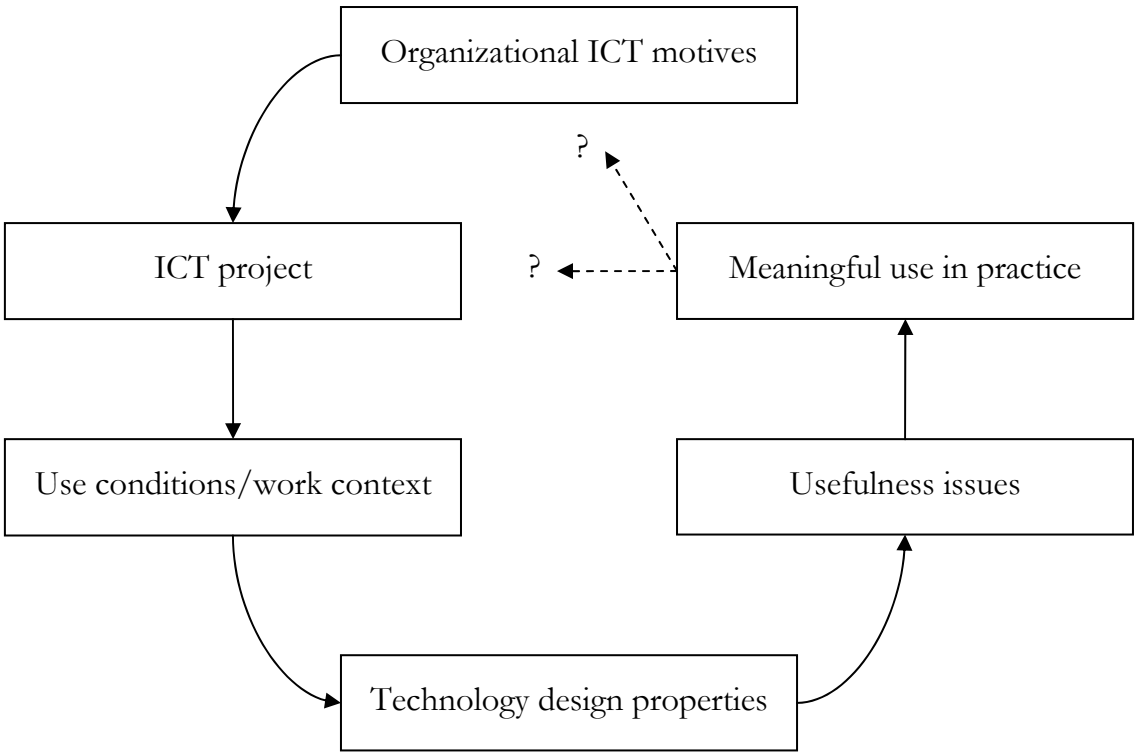
construction site management practice. The communication of usefulness issues of the technology between users and system developers in the studied mobile ICT pilot project is also depicted, and how these conversations and discussions over time were linked to the technical design properties of the mobile computing system. The thesis elaborates in detail the dynamics of practitioners' exploration and creation of meaningful use of mobile ICT in their situated fieldwork, as well as the communication of usefulness issues between users and developers towards adaptation of the technology design properties to fit professional practice. These mechanisms of ICT usefulness development will be referred to as complex intertwined processes of individual and social 'sensemaking' (Weick, 1995) of technology use, as well as 'negotiation of meaning' (Wenger, 1998) of technology design.

Consequently, the case study evolves around the developing concepts of meaningful use of ICT and mobile computing in the fieldwork practice context, and the ongoing conversation and social negotiation of technology usefulness between the studied participants. However, the thesis does not explicitly describe how specific use situations, conversations and negotiations of usefulness took place and were conducted in the studied case, but rather focuses on the overall development process of usefulness through these activities over time. Additionally, while some studies of socially shaped technology development processes 'semiotically' treat human actors and non-human material agents symmetrically and equally, this thesis instead agrees with Pickering's (1995) views on that human and material agency are not equivalent entities. Instead, the interaction between ICT, developers and users in forming useful technology design and meaningful use exists in a complex, diverse, emergent and socially shaped parallel intertwining in practice, and its situated conditions can therefore not be considered to be neutral or known in advance. Additionally, the thesis is not going into details of technical specifications of ICT system design configuration, or specific user applications and their sequences and procedures of use. The term 'technology design properties' is used only as a way of synoptically and conceptually relate various functionalities of the technology to its usefulness and 'meaningful use' perceived by the user-practitioners in their everyday work environment.

All ICT projects inherently have conflicting political agendas of goals and outcomes from different professional and organizational standpoints, including the intended usefulness of a system (see for example Mähring, 2002). The introduction of new ICT in an organization can be used for many other purposes than to achieve appropriate supportive information and communication tools in a work context. Boosting individual careers, making ICT a tool for improving management control over subordinate employees, as well as professional struggles between collaborating business partners of ownership and control of mutual information can be some of the underlying conflicting political agendas of introduction and use of ICT in organizations. These kinds of issues relating to for example hierarchical power relations, professional struggles, organizational conflicts and union politics of development, introduction and use of ICT have not been in the scope of the study, and will therefore not be described, analyzed or discussed.

However, the introduction of new ICT applications in business organizations is regularly not done because of the 'mere fun of it'. Some overall organizational motives are usually predominant and superior reasons to why new technology is developed, implemented and used in the business environment of a firm. Without going into details, organizational motives of an ICT project may for example be an incremental step of supporting and enhancing existing business practice, or could be a part of an intentional disruptive management decision with the purpose of trying to radically change current ways of working with assistance of new technology. The major part of the case study presented in this thesis comprises development, implementation and use of new mobile computing capabilities within an organization with ICT motives mainly belonging to the former category – supporting and enhancing existing work practice. In other words, the studied mobile ICT project at Skanska both acknowledged the current ways of working, as well as recognized the potential of further improvement of work practice with the use of mobile computing technology. In line with the research of Wiredu (2007), this thesis considers mobile computing usefulness largely as a matter of creating user acceptance by making users' personal motives of using mobile computing in their practice of work coincide with organizational motives, use conditions of the work context and technology design properties.

Based on the viewpoints presented in this introductory section, the scope of the thesis is illustrated in the figure below.



Defining the scope and the journey of the thesis

The figure tries to show both the theoretical and empirical 'journey' that is made in this thesis. The involved contexts and concepts in the figure is further elaborated and explained in chapter 2. The case study at Skanska and the employed 'interpretive' method for the research are described in chapter 3. Chapter 4 portrays the case study material. Chapter 5 discusses the case study findings in relation to initial and evolving theoretical and analytical perspectives. The epilogue in chapter 6 links the research analysis back to a discussion of usefulness in the context of initial organizational ICT motives and formation of ICT projects, illustrated with the dashed arrows in the figure above. Inspired by works such as Dahlbom and Mathiassen (1993), the ambition of this thesis is to contribute with insights and reflections about managing usefulness issues of ICT resources in operative work organizations in general, and particularly the handling of mobile computing usefulness in fieldwork environments such as construction sites.

Finally, the thesis will not include an extensive analysis of the revolutionary potential of mobile computing technology for business purposes. During the last decade it

has been popular to conduct visionary studies of mobility, ICT, work and business value. Many of these studies often cover conceptual frameworks for information management and communication 'anytime, anywhere, any device' and predictions of future mobile capabilities of business enterprises (see Andersson et al., 2007 for a comprehensive overview of some of the content of this research field). Even though this thesis recognizes the revolutionary potential of mobility enabling ICT, it does not go any further in trying to foresee the future of the technology for organizational business purposes. As already been said, the focus is on the concept of meaningful use of mobile ICT perceived by a specific group of fieldwork professionals in their situated work environment.

2 CONTEXTS AND CONCEPTS

Mobile computing and enterprise users

Mobility and geographic distribution of organizations are increasingly becoming significant components of work itself in many industries and businesses, and therefore also a challenging component to include in strategies for developing organizations and their supporting ICT platforms (Barnes, 2003; Barnes, 2004). It can even be argued that mobility enabling ICT to support mobile workforces is becoming a requirement for businesses to survive (Umar, 2005). Successful business organizations will most likely continue to embrace new ICT opportunities of simultaneously employ real time operations, business activity monitoring and mobility resources to conduct business as well as handle planned and unplanned activities in the work organization (Umar, 2005).

From studies such as Dahlbom and Ljungberg (1998), Luff and Heath (1998), Kristoffersen and Ljungberg, (1999a, 1999b), Dahlberg (2003), Weilenmann (2003), Kakihara (2003), and Kakihara and Sørensen (2004), ICT enabled mobility in professional work contexts can be more explicitly defined, involving job activity and participants, human interaction and ICT use. First of all, mobility enabling ICT is of course ICT which is designed to be mobile. This includes technology which is intended for individuals to carry around with them and to be used both while in motion or standing still. It is sometimes important to distinguish ICT that is 'portable' but mainly used for stationary purposes, for example a laptop computer, and technology that is 'fully mobile', for example a handheld device intended for use while individuals are engaging in moving activities. In this context, 'mobile computing' is often used as a generic term for the ability to wirelessly communicate with distributed parties and resources, and access and process remotely located information through small sized, portable and wireless computer devices. The term 'mobile workforce' is regularly used to denote people who are mobile as a result of their work. Mobile work could include remoteness, which means separation from a 'home base', or truly mobile work which involves both remoteness and motion. But a person that is interacting remotely using mobile computing technology does not necessarily mean that the person is moving while doing this. There are a variety of

work environments that can be described as 'mobile work settings'. However, for the purpose of this thesis a mobile work setting denotes a professional practice environment where mobility, movement and remoteness are natural components of the work itself, for example a construction site. A vast amount of research has been made in studying development, adoption and use of a wide range of mobile computing applications in different professional work settings. Just naming a few, some of these studies have addressed ICT mobility in general fieldwork (Pascoe et al., 2000), mobile ICT support for blue collar practitioners (Brodie and Perry, 2001) and white collar workers (Davis, 2002), mobile computing for ski instructors (Weilenmann, 2001), in healthcare practice (Bardram and Bossen, 2005; Bardram, 2005; Scheepers et al., 2006) and police work (Sørensen and Pica, 2005).

It is often claimed that the use of mobile computing technology enables ubiquity and simultaneity for the individual, often referred to as nomadic 'anytime anywhere' computing (Kleinrock, 1996). This is generally proposed to imply increased flexibility of information exchange and communication activities which no longer need to be carried out in a specific place, and being able to accomplish more or doing better in the same time frame due to better planning, organization and execution of tasks at hand, especially in unstable situations and settings (Jauréguiberry, 2000). This is not only a matter of substituting one activity for another, or handling a task more quickly, but also a simultaneous utilization of time in both the physical and the communicational space through the mobile computing technology (Jauréguiberry, 2000). The effects of mobility enabling ICT in business organizations are not clear, and the impacts of the technology vary by firm and industry depending on how it is developed, implemented and used. There are indications of that changes generated by mobile technology over time regardless of business context may include increased pace of work activities, altered communicational roles and behaviors between actors, and transformed organizational boundaries (see for example Smith et al, 2002). However, for individual firms a fundamental challenge lies in exploring the balance between opportunities offered by mobile ICT capabilities and the risks of introducing the technology that in different ways can be harmful for the long term development of business activities and organization. Therefore, improved understanding of the possible business value of mobile computing involves a demanding and devoted

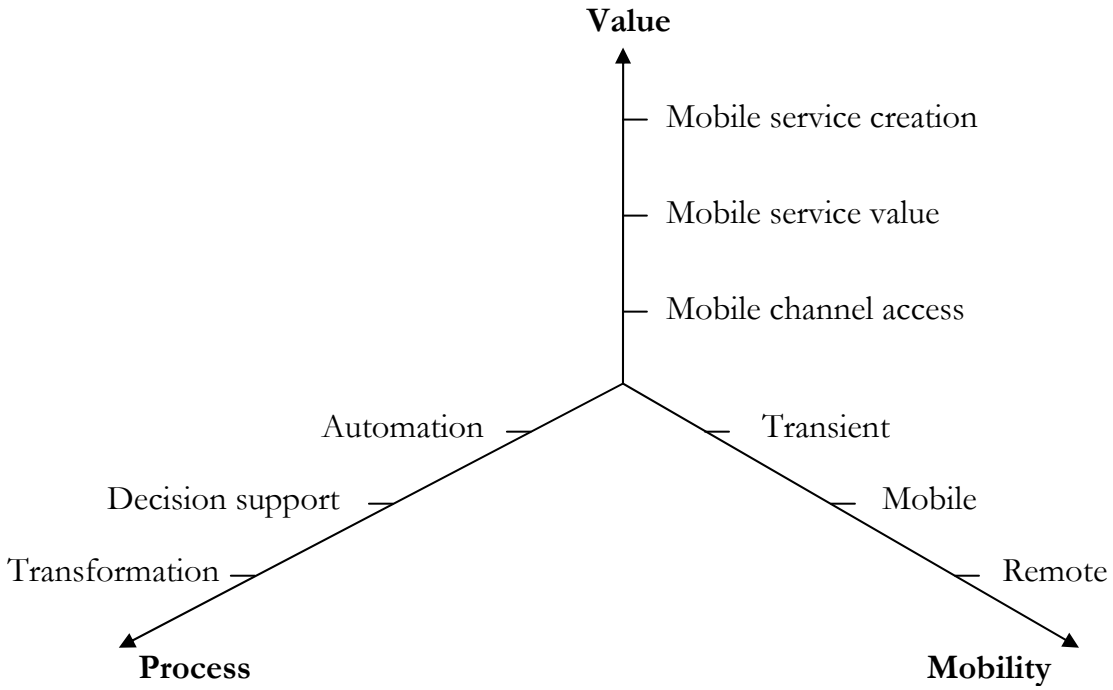
learning process of seeking benefit from its potential and to avoid the negative outcomes of its risks.

Nah et al. (2005) describe the overall opportunities of mobile computing technology in business and work contexts in terms of mobility, flexibility and dissemination. The direct mobility effects of the technology refer to improved ability of users to conduct business more or less anytime and anywhere. The flexibility aspect relates to that users can engage in other activities while communicating through their wirelessly connected mobile devices. The benefits of dissemination involve the support for simultaneous wireless delivery of data, efficient exchange of updated information and real time communication between mobile and geographically distributed workforces. Further, Sheng et al. (2005) argue that mobile computing technology can also enable an improvement in business communication, organizational information sharing and coordination activities through enhanced accessibility and flexibility of both ICT system resources and individuals within a work organization.

Davis (2002) highlights the positive effects of anytime anywhere mobile computing within an organization as enhanced capabilities and removal of time and space constraints for information exchange, communication, coordination and collaboration. However, always ongoing communication processes, mobility and availability of ICT can also result in negative effects on organizational behavior and decision making as well as undesirable boundaries between work and personal life (Davis, 2002). Mobile computing technology is contributing to an already present social pattern within organizations where more and more time is spent responding to urgent and unanticipated matters. This accelerates the pace of work and increases the demands on people to be able to handle simultaneous activities, a constant flow of information and to react and make even more rapid decisions (Jauréguiberry, 2000). The increasing ever present mobile connectivity and urgency may not only be a feature of the work environment. It may also intrude on the private sphere as well, negatively affecting an individual's personal time and problems of distancing oneself from both work activities and technology (Jauréguiberry, 2000). At the same time as the outspread use of mobile ICT has improved convenience, flexibility and connectivity of information and communication, this new freedom and mobility can also create conflicting situations when using mobile ICT that result in actions that

go against users' original intentions or expectations of the technology (Jarvenpaa and Lang, 2005).

Nevertheless, one of the central anticipated contributions of mobile and wireless ICT for business purposes is to facilitate an extension of an organization's existing ICT systems infrastructure into the hands of remote and distributed personnel, enabling a virtual office for mobile workforces to access more or less at anytime and anyplace (Barnes, 2003). The 'mobile work model' (Barnes, 2004) can be used to map out the opportunities of mobile computing for different requirements of work organizations, shown in the figure below.



The mobile work model (Barnes, 2004)

The mobile work model and its three axes of mobility, process and value can be used to schematically position an organization's work mobility and how mobile computing technology possibly could enable changes in work processes and create value for a firm and its associated partner organizations. The lowest level of work mobility is 'transient', describing people who basically are geographically tied to the locations between which they move. The second level is 'mobile', where people have higher geographic independence from the enterprise, regularly for prolonged periods of time, but commonly return to some home base to perform certain actions. Finally, the highest level of work mobility is 'remote'. At this level,

employees of an organization are almost completely independent of a certain location or home base. The initial level of process change that may be enabled by mobile computing technology is 'automation', which refers to efficiency gains in existing processes through access of ICT resources via wirelessly connected mobile computing devices. Further improvements can include 'decision support', which brings a higher degree of effectiveness through the development and use of new mobile computing applications for specific work purposes. Finally, 'transformation' describes a radical change in organizational work processes where the use of advanced mobile computing and ICT resources is an integral part of business activities. At this level, the nature of work activities, sequences of business processes and collaborative professional roles are partially transformed by the use of the mobile computing technology. In the mobile work model, the resulting value of mobility enabling ICT is then mapped on a holistic firm level or within a network of organizations working together. Typically this value is related to the changes in products, services and relationships with customers, but it may also contain shifts in partnering constellations between suppliers and business partners. At the lowest level of value generation, 'mobile channel access', mobile computing is being used largely as a tool for mobile workers within the organization to access existing ICT resources, without any significant changes of its applications and services. At the midlevel, 'mobile service value', the mobile and wireless technology is being used to add value to business activities such as production and marketing through new system applications and services, as well as creating new mobile ICT tools for various professional groups within the organization and its collaborating partner firms and customers. 'Mobile service creation' refers to an even more sophisticated level of value creation where mobile ICT is being used in a radical and innovative way to create partly changed business logic through new service offerings or products, along with strategically integrated information and communication platforms and processes with partnering firms and customers.

Barnes (2004) employs the mobile work model to identify and plot three distinct positions of work organizations where business processes to different extent are enabled by and dependent on the use of mobile ICT. 'Mobile workforce linkage' is the initial position of ICT enabled mobile work which focuses on establishing appropriate wireless and mobile infrastructure to improve accessibility of ICT for transient workers in order to address efficiency issues of existing work processes.

This is plotted as a triangle in the mobile work model combining transient mobility, process automation and mobile channel access. 'Mobile workforce empowerment' is the midlevel position of an established mobile work organization where its business processes and activities are more dependent on the availability of ICT resources through broad use of mobile computing. Mobile workforce empowerment implies that users are able to improve the effectiveness of their work processes by direct utilization of new mobile ICT capabilities and applications. This is plotted as a triangle in the mobile work model combining mobile mobility, process decision support and mobile service value. 'Mobile enterprise creation' is the most advanced position of mobile work where the organization and all its business processes are profoundly supported and enhanced by the use of mobile computing. People can work separately and independently of the geographic constraints of the organization, supported by mobile and wireless technology. The nature of work, the roles of individuals, partnering networks, collaborative activities and the whole business model of offerings of products and services is significantly transformed to take advantage of the opportunities enabled by the mobile technology. This is plotted as a triangle in the mobile work model combining remote mobility, process transformation and mobile service creation value. Later on in this thesis, the midlevel position of 'mobile workforce empowerment' will be discussed further in relation to organizational ICT motives of the studied mobile computing case in construction site management practice at Skanska.

Construction site management and ICT use

In the construction industry, building projects are carefully planned into the last detail. Project participants, often from different organizations with separate professional backgrounds and competences, are brought together under a limited period of time to jointly carry out a specific task. Construction projects demand high level of integration and understanding between the involved parties and persistent coordination of people, information, tasks, technology, and material recourses to achieve a satisfactory project outcome. At the initial design and planning stages of a construction project, architects, design engineers and production teams may spend months or years on specifying and drawing blueprints, setting up time plans, calculating budget figures and coordinating collaborative project processes. Functioning shared use of project specific ICT systems are

nowadays vital for maintaining the persistent communication between participants of a construction project. Project organizations are often geographically distributed and different project work roles and professional groups have diverse needs concerning their use of ICT tools. Many of them require a high level of communication mobility and instant information accessibility, while others do not have these requirements at all. No matter how much effort is put into the design and planning process of a construction project, as soon as the site based production operations begins a continuous flow of unexpected issues and alterations of plans arises that calls for immediate attention. A construction site can to some extent be described as a reactive fieldwork environment, where the relentless handling of problem situations results in natural communication patterns that are dynamic, spontaneous and informal (Dainty et al., 2006). Unplanned changes of work, unexpected events and temporary critical problems are inevitably occurring due to the inherent complexity and dynamics of construction site operations (Magdič et al., 2004; Ward et al., 2004).

Informal interaction and communication between project participants plays an important role in handling unanticipated events and critical problems in the construction site environment. Informal communication is not a planned activity with a set agenda or fixed location. It occurs spontaneously, almost everywhere and has a large impact on work processes and outcomes that can be even greater than formal communication (Johansson and Törlind, 2004). The spontaneous interactions in informal communication enable frequent and instant exchange of useful information, resulting in issues being discussed and resolved as they occur, instead of waiting for a suitable and scheduled time to make a formal decision (Johansson and Törlind, 2004). Informal communication supports organizational and group coordination, especially under conditions of uncertainty. It helps members of a group learn and understand each others roles, personalities, competences and work activities. Informal communication supports both the actual production and the social relations that underlie work, and is a critical activity to initiate collaboration, maintain it, and drive it to a common goal (Kraut et al., 1990). Informal interactions are also important in getting people to know each other in person and create united contexts and perspectives to achieve better planning and coordination in group work. Collaboration will less likely commence and become productive if informal dimensions of communication between participants are not

present (Kraut et al., 1990). Informal communication is distance sensitive and happens most often 'face-to-face' between people who are physically close to each other (Kraut et al., 1990). Designing ICT systems that enable better support for informal interactions in geographically distributed work organizations such as construction site operations is a great challenge. Systems that do not create a 'virtual shortcut' that improves the flow of information or enable better support for interpersonal communication, will most probably make communication even more complicated. The risk of ICT tools that are supposed to support informal communication is that social collaboration processes may be reduced to a formal process in practice. Extra formality and inflexibility should not be introduced into distributed collaborative teamwork without special consideration (Larsson, 2002).

In the construction industry, much effort has been made to improve project collaboration and business processes with the help of ICT, but the industry has historically not achieved increased productivity to the same extent as other industries. Samuelson (2003) showed that while the utilization of ICT is high in the design phase and in facility management in the Swedish construction industry, the use of ICT by contractors in the site production process is surprisingly low. However, most of the available project oriented ICT tools are meant for formalized office use. These tools give modest support to the unpredictable, dynamic, spontaneous and mobile environment that site practitioners work in. Construction activities are geographically dispersed and site work locations frequently change, which is problematic when giving construction sites sufficient ICT support. The required ICT resources are often deployed to the site office, but rarely reach the construction site itself (Čuš Babič et al., 2003). In addition, when areas of ICT based communication are developed, discussed and managed in construction it often only comprises the technical aspects of information handling, such as modeling, classification and standardization, and seldom include the development and use of ICT in the practical and social project work context (Wikforss and Löfgren, 2007).

The often tight time schedule of building production requires full attention to planning, coordination and completion of construction work activities of fieldwork management personnel. Production managers, superintendents and site work supervisors are needed on site to coordinate work, do inspections, conduct environment and safety rounds, document and follow up ongoing and completed

construction activities. The very same persons are also needed to be located at their computers inside the site office ordering equipment and building materials, exchanging digital drawings between architects and design engineers, e-mail subcontractors about upcoming work, follow up budget figures and invoices as well as prepare deviation reports on construction work with unsatisfactory result. In addition to this, there are daily production meetings that afterwards need to be transcribed in computer documents and e-mailed to all involved parties. In today's construction site environment, production problems and critical work issues in the field require quick ICT access to necessary project information. To solve site work problems, fieldwork management personnel commonly have to run back and forth between the construction site and their computers inside the site office. Production management teams often experience that they have to be at two places at the same time – at the site office doing administrative work at their computer as well as being out on the site coordinating work (Löfgren, 2006). Documentation of site work activities, production meetings and various inspections often have to be carried out twice; once when they are actually occurring and then again at the computer. This results in low efficiency of ICT use because of the gap in time and space between the paper based administrative tasks in the field and the subsequent computer work back at the site office (de la Garza and Howitt, 1998; Kimoto et al., 2005). Even though the intensions of ICT use in this fieldwork environment is to support and improve information and communication processes in construction projects, it has lead to that production managers, superintendents and site work supervisors are experiencing that they are doing the wrong things. For example, whole days are sometimes spent in front of the computer writing protocols from previous meetings. This has resulted in obstructive and ineffective administrative work routines, as well as negative effects on site management practitioner's physical presence and leadership in production activities in the construction site environment (Löfgren, 2006).

Since the end of the 1990's both academic researchers and industry professionals in construction and civil engineering have recognized the opportunities of mobile and wireless ICT, especially for various field based production environments such as house building sites and road construction work. A lot of efforts have been made in evaluating the feasibility of mobile and wireless technology for construction purposes, as well as developing and testing innovative mobile and wireless devices

and applications in the field in search of improving efficiency and productivity of building activities (see for example De la Garza and Howitt, 1998; Bowden and Thorpe, 2002; Čuš Babič et al., 2003; Nilsson et al., 2003; Magdič et al., 2004; Menzel et al., 2004; Kimoto et al., 2005; Thorpe et al., 2005; Aziz et al., 2006; Tsai et al., 2007; Izkara et al., 2007).

The enthusiasm of mobility enabling ICT and mobile computing in the construction industry can also be observed in the national ICT survey carried out in the Swedish construction sector in 2007 (see Samuelson, 2008). Among other survey questions, the respondents, which were professionals and decision makers across the whole industry, were asked to state in which ICT areas they were planning to increase investments and use in the next two years. The respondents were able to select at most three defined alternatives which were then ranked in the order of priority. The collected result of the survey showed that the area 'portable equipment/mobile systems' was ranked number one. The importance of communicating and having access to information anytime and anywhere seem to be a central ICT issue for the industry. The survey also showed that companies in the Swedish construction sector have become increasingly aware of the possibilities of ICT to support new ways of working and enable new forms of collaboration and business processes in construction projects. Additionally, Swedish construction companies seem to develop and implement new ICT in small steps, and in their future development and extension plans they are focusing on well known systems already existing within the organization such as document management and accounting systems, combined with for example mobile solutions and Internet services to enhance their ICT business platforms (Samuelson, 2008). Interestingly, radical innovative technology applications such as process and product modeling and virtual reality applications appear to receive low attention and priority by professionals in the Swedish construction sector (Samuelson, 2008). Many firms in the construction industry have invested large amounts of money and effort on their existing legacy ICT platforms, which they now are critically dependent on for their everyday business conduct. Any ICT development effort is therefore likely to build further on these path-dependent technical prerequisites. This involves both a matter of developing and making better use of existing legacy ICT systems as well as a process of slowly abandoning older technology systems and applications while incrementally replacing

it with new ones, which can be described a process of 're-innovating the existing' (Valiente, 2006).

The rapid development of mobile and wireless ICT and handheld computer devices is now facilitating new possibilities of portability and on demand access of information systems and communication tools that field based production management professionals are requesting (Löfgren, 2006). But wirelessly extending needed ICT resources into the fieldwork environment using certain mobile computing devices will probably not be a sufficient solution of these problems in the long run. A legacy office based system design will then be forced into a mobile ICT platform that might need an alternative design to better fit the mobile work context. There are differences in how ICT is related to different work types. In office work the computer is often the main tool for performing work, and functions virtually as the workplace itself. In mobile work, such as construction site management practice, the main job activities are regularly taking place external of the computer, and often demand high level of visual attention and hands on execution (Kristoffersen and Ljungberg, 1999b).

However, there is currently a gap between the vision of what mobile computing technology is supposed to deliver to mobile work environments, and what it is offering today (Bernard et al., 2007). Part of this problem is due to that the 'desktop metaphor' has for a long time influenced the design of all digital computing technology (Luff and Heath, 1998; Kristoffersen and Ljungberg, 1999b). Compared to desktop computing office work, designing hardware and software for a field based mobile work setting involves other kinds of challenges concerning factors such as location, environment, activities and connectivity that are often more unpredictable and dynamic. Also, work mobility itself is often seen as transportation between places of work, for example wandering, visiting and traveling (Kristoffersen and Ljungberg, 1999a). This view regards mobility as a relation to a place, from which workers move to and from. Designing mobile ICT is then a matter of giving people the same possibilities in the field as they have at some sort of home base, for example a desk or an office. But many fieldwork environments, such as construction sites, involve more fluid forms of activity where people are mobile as the work activities occur and they are not mobile in order to transport themselves to some place to perform the work. This constant 'inbetween-ness' (Weilenmann,

2003) is regularly an integral part of mobile fieldwork settings. This view on mobility poses new challenges of understanding what mobile computing is supposed to deliver in terms of appropriate technology design and its practical usefulness in the specific mobile fieldwork context. In the end, the appropriateness of mobility enabling ICT for construction site management purposes is ultimately judged by the practitioners who are supposed to use the technology in their everyday work.

Usefulness and acceptance of ICT

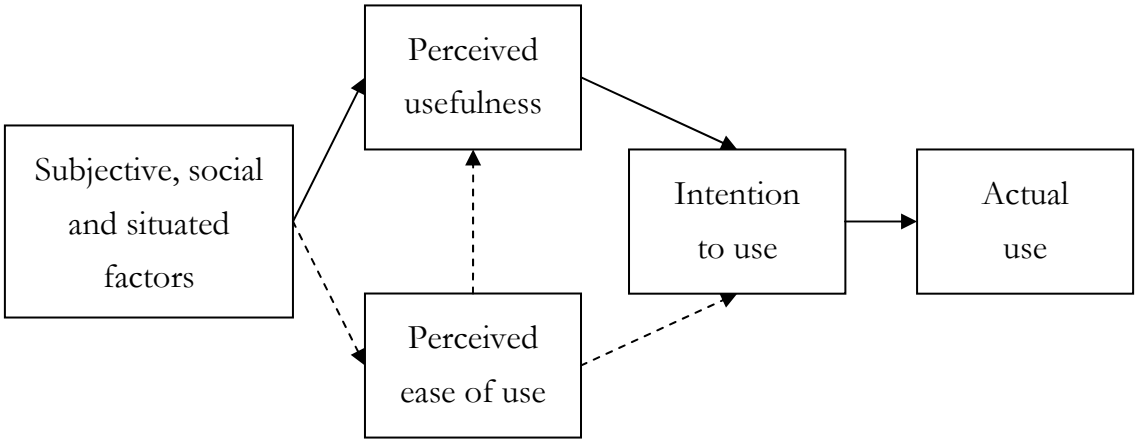
Before going further in outlining the specific analytical framework of the case study, the following section presents a brief overview of research relating to usefulness and user acceptance of ICT in organizational settings. A broad definition of the usefulness concept can be found in Nielsen (1993). The usefulness of a technology or system can be described as whether the technology or system can be used to achieve some desired goal (Nielsen, 1993). It includes both utility and usability aspects, where 'utility' is the question whether the functionality of the technology or system can do what is needed in relation to a particular task, and 'usability' is the question of how well users can use that functionality (Nielsen, 1993). The usefulness concept should not be confused with 'ease of use' of technical design and interface issues. Usefulness is essentially about how to make the technology fit the social organizational context, its business activities and professional practice of individual users. From that perspective it is not a very bold statement to say that business benefit of ICT use within an organization is dependent on whether the technology is perceived as useful and is accepted by the practitioners in their everyday work.

The 'technology acceptance model' (Davis, 1989; Davis et al., 1989), has been influential and widely used in research of organizational ICT adoption and utilization. A key purpose of the model is to provide a basis for tracing the impact of external factors on individual beliefs, attitudes and intentions towards accepting and using ICT. Building further on concepts from the 'theory of reasoned action' (Fishbein and Ajzen, 1975), the technology acceptance model proposes that a person's behavioral intention to use an ICT system is expected to lead to actual use. Attitude formation, the use context and the expected outcome of using the technology shape the behavioral intention. According to the technology acceptance model, both 'perceived usefulness' and 'perceived ease of use' of ICT shape

behavioral intention towards actual use. Davis (1989) defines perceived usefulness as the degree to which a person believes that using a particular system would enhance his or her job performance, and perceived ease of use as the degree to which a person believes that using a particular system would be free of effort. The ease of use construct has also a direct influence on perceived usefulness. The easier it is to use a technology, the greater are the expected benefits of the technology in relation to performance enhancement. Perceived usefulness is therefore the most influential factor of the model towards user acceptance of technology.

The technology acceptance model assumes that technology will be accepted if people's attitudes and beliefs support its use. User involvement is also often linked to the model, implying that favorable user perceptions of an ICT system is created by having target users participating in its design and implementation processes (see for example Barki and Hartwick, 1989; Alavi and Joachimthaler, 1992; Amoako-Gyampah and White, 1993; Jackson et al., 1997). The idea of user involvement is that users get the opportunity to tell system developers what they need from the system in their work. Involvement in the development also makes users more aware of the tradeoffs in practical usefulness and ease of use of the system that most likely is inherent in its design and implementation. Through involvement in system design and implementation users may feel that they can influence the development processes and are therefore more willing to accept the resulting system with its flaws and tradeoffs. Also, being involved in development allows users to better understand how the system works and thereby possibly making it easier to start using the technology.

The technology acceptance model has been revised over the years as new empirical support of different factors affecting perceived usefulness and perceived ease of use have been found. These modifications of the model have highlighted for example user behavior relating to prior technology use experience (Taylor and Todd, 1995; Szajna, 1996), the effects of motivation and training for user acceptance (Venkatesh, 1999), social and subjective influences of usefulness (Venkatesh and Davis, 2000), and attempts to formulate a unified theory of user acceptance of ICT from competing models (Venkatesh et al., 2003). Even though many variants of the technology acceptance model have been produced over the years, the essence of the model is summarized in the next figure.



The technology acceptance model

The dashed lines in the figure indicate weaker or indirect linkages between certain factors of the model. As illustrated, the perceived usefulness construct have proved to be a much more fundamental driver of user intensions in shaping and achieving technology acceptance compared to perceived ease of use (Venkatesh and Davis, 2000). In early empirical studies of the technology acceptance model, it was popular to explore the determinants of perceived ease of use (see for example Venkatesh and Davis, 1996). Since ease of use is a phenomenon that does not consider the situated context of ICT use, but only considers the use logic that relates to the design of an ICT system per se, these factors can efficiently be identified and studied in isolation. Therefore, aspects of perceived ease of use have been thoroughly researched and are quite well understood while the determinants of perceived usefulness have been relatively overlooked (Venkatesh and Davis, 2000). Part of this problem can be derived from the fact that perceived usefulness have shown to be a much more complex concept compared to how it was originally defined. Issues of for example prior ICT experience, social influences, subjective norms, technology relevance, situatedness and voluntariness of use have showed to directly influence how people perceive the usefulness of ICT systems in the practical use context of their work environment (Venkatesh and Davis, 2000).

The technology acceptance model has become a well established model for appraising aggregated measures of user acceptance of ICT systems. Still, the determinants of what constructs perceived usefulness in the model is far from clear. There are important aspects of usefulness yet to be understood relating both to

individual use of ICT in actual work practice as well as how the use of ICT is adapted to changing work contexts and new organizational settings (Venkatesh and Davis, 2000). Enabled by the rapid developments of ICT, many business organizations have moved from hierarchical and centrally localized structures to more flexible and mobile network organizations that enable geographically distributed teams and global business units, often organized in temporary projects. In these work environments, the use of ICT has both become an absolute necessity from the individual work perspective, and a compulsory component in information sharing and communication between groups of people in dynamic business networks. This also puts new requirements on the design of ICT systems to serve the purposes and needs of the people working in these organizational settings. How aspects of changing and dynamic work conditions affect the use of ICT and how usefulness of the technology is perceived by the people working in such environments are far from fully comprehended (Venkatesh and Davis, 2000).

The relevance of ICT use for specific work activities has increasingly been discussed in relation to usefulness and technology acceptance. Work relevance of ICT can be defined as an individual's perception of to what extent an ICT system is applicable to his or her work (Venkatesh and Davis, 2000), and can be viewed from many standpoints. Hartwick and Barki (1994) highlight personal relevance factors in technology use, while other studies are more focused on task-technology fitness between work activities and ICT use (see for example Davis et al., 1992; Goodhue 1995; Goodhue and Thompson, 1995). Not surprisingly, both emotional and rational perceptions of technology use affect the resulting experience of relevance and usefulness of ICT in the performance of work. Davis et al. (1992) and Venkatesh (1999) refer to these perceptions as intrinsic and extrinsic motivational drivers. The 'intrinsic' motivational factors refer to the personal pleasure and emotional satisfaction delivered from a specific activity, for example using an ICT system. The 'extrinsic' motivational factors emphasize rational performance and behavior of an activity towards achieving a specific goal, for example the positive effects on work by using ICT.

Wiredu (2007) looks specifically on user acceptance mechanisms of mobility enabling ICT in mobile work, and elaborates further on motivational factors based on assumptions from 'activity theory' (Leont'ev, 1978; Vygotsky, 1978; Engeström,

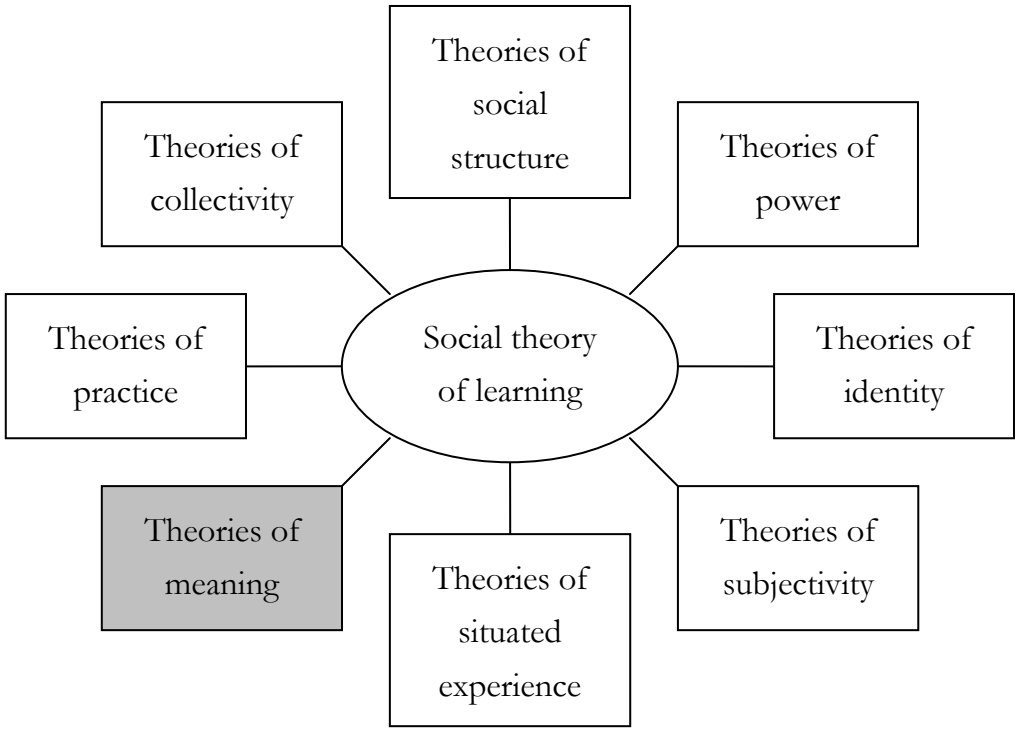
1987). In essence, Wiredu argues that the target work environments that mobile computing technology generally is aimed to support include natural dynamic, reactive and variable contextual conditions, which have direct implications for the perceived usefulness and user acceptance of mobile ICT. Under favorable work conditions a mobile computing device can be used as a tool to produce a perceived useful outcome in the performance of work activities. In adverse work conditions mobile computing may constitute an action of its own and perceived as an entire negative activity that draws attention, time and effort away from the actual work context and its activities (Wiredu, 2007). Wiredu argues that users' 'success and failure perceptions' of using mobile computing in a work setting have direct influence on the acceptance of the technology, and is primarily based on the situated conditions of use, the design properties of the technology, as well as its ability to serve both organizational and personal ICT motives.

The study of Wiredu (2007) addresses the inherent paradoxical components of ICT use in work contexts, and that usefulness and user acceptance of the technology is both individually and socially constructed. Users' judgment of mobile computing are premised on both organizational and personal contexts, and useful technology must be able to serve both organizational and personal motives under various conditions (Wiredu, 2007). Since perceived usefulness and technology acceptance are fundamentally based on individuals' judgment of the functional essence of using mobile ICT in relation to the motives it serves in their work, it is possible for the judgments of several individuals of a user group to coincide. If this group interacts to communicate their perceptions, their individual judgments can produce a 'social construction' (see for example Berger and Luckmann, 1966; Bijker et al., 1987). In other words, a group's shared judgment of motives, purposes and functional essence of the technology is determined by the context in which it is used and the sense the group makes of it within that context. This also illustrates the difference between an 'intended design' of an ICT system and its 'actual use' by people in practice. An interesting point in Wiredu (2007) is that perceived usefulness and users' acceptance of mobile ICT, expressed as 'appropriation of technology', are essentially triggered from the individual user perspective before it becomes a collective perception and a social construct.

Wiredu (2007) highlights that even though mobile computing is used in an organizational setting, it is not merely the contextual factors of work that are affecting usefulness and acceptance of technology. In a dynamic work setting, the use conditions of mobile computing will also vary between the practical work context and the personal context, which create a continuous interplay between organizational situations and individual situations of use. Wiredu (2007) therefore points out that the design of mobile ICT systems for dynamic fieldwork contexts must be able to balance and align personal and emotional drivers with organizational and rational purposes of technology use. From a technical design perspective this is essentially about creating a mobile computing system that targets individuals' personal motives in their work context in a way that their acceptance and use of the technology serves organizational motives. Users' perceived usefulness and acceptance of mobile computing in a dynamic fieldwork environment are therefore firmly linked to different forms of 'personalization' of the technology in order to make the use of it 'their own' (Wiredu, 2007).

Situated work practice and meaning of mobile computing

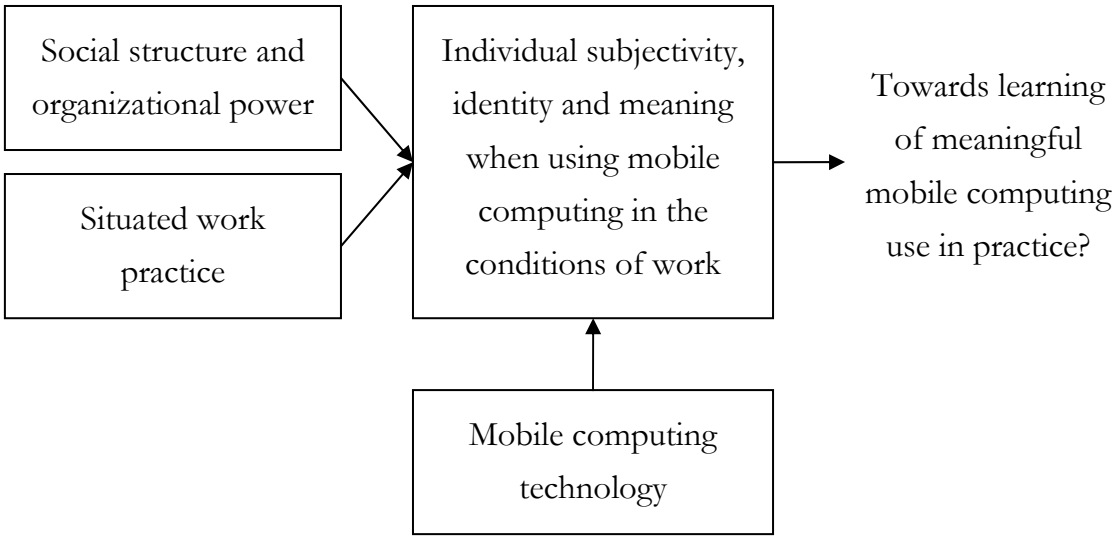
The following section seeks to broaden the some of the perspectives presented in studies such as Scheepers et al. (2006) and Wiredu (2007) on how and why personal and contextual situations of use shape users' perceptions of usefulness of mobile computing in fieldwork practice. A fundamental standpoint is that personal motives of using mobile computing is based on extrinsic and intrinsic factors of both rational objectives of work and emotional perceptions of the technology as such. Users' perceptions of useful mobile computing in the context and content of professional practice can be interpreted and expressed both in terms of 'pragmatic use' relating to the performance of work, as well as feelings of 'personal fulfillment' of using the technology as such. The essence of the usefulness concept can be described as a fundamental 'experience of meaningfulness' (Wenger, 1998) when engaging with the technology in different ways. The discussion of the usefulness concept can therefore be related to the notion of 'meaning' in the 'social theory of learning' presented in Wenger (1998), shown in the next figure.



The position of meaning in social theory of learning (Wenger, 1998)

As illustrated in the figure above, the concept of 'meaning' is located between theories of 'practice' and 'situated experience'. This social learning perspective of meaning is a good starting point towards forming the analytical framework of this thesis because it includes views of pragmatism such as learning as doing (Dewey, 1922) and human perception as socially shaped meaning through interaction (Mead, 1934), reflective action in professional practice (Schön, 1983), as well as studies of adaptive situated actions and learning as practical experience (Garfinkel, 1967; Suchman, 1987). 'Situated work practice' is frequently used in this thesis as a term that tries to combine Wenger's (1998) perspectives of practice and situated experience. Situated work practice implies that the context of professional work simultaneously involves routines, techniques, social systems and shared resources to engage in and organize work, as well as complexity, uncertainty, deviation, improvisation and human interactional dynamics of everyday work activities (similar to Schön, 1983). Meaningful use of mobile computing in situated work practice may therefore generally be described as the ability of the technology to support user-practitioners' ICT requirements in the context of planned work processes as well as unexpected situated actions in their professional practice (compare with Suchman, 1987; Heath and Luff, 2000).

An individual practitioner is of course a part of social practice and the continuously ongoing developments of it. At same time, the practitioner simply has to acknowledge a broad range of beforehand constituted circumstances of practice in order to engage in the work context. Some structural and contextual components relating to organization, artifacts, activities, actors and communities of practice 'are what they are' seen from the individual perspective and belong to the legacy and culture of work that are beyond their influence and control. Likewise, the use of mobile computing and ICT in work may be a circumstance that is not decided or even asked for by practitioners, but is still something that individuals have to accept and adapt to in the same way as professional traditions and the very constitution of the social work setting in which practitioners operate. Mobile computing technology may be technically advanced with a user friendly design and have all the accommodating functionalities to support both individual and collaborative work. But a handheld device may still not be used because there may be a fundamental divergence between the capabilities of the technology and its complex and dynamic use context in practice. Both technology and work practice contain complementary structuring elements, sets of norms, rules and procedures that affect the course of meaningful action of individuals within the organizational context (Orlikowski, 1992). Therefore, part of the situated work practice context and the social structure of the organization can be perceived as a fixed set of institutional 'rules of play' for using mobile computing, which user-practitioners simply have to accept and adapt to when exploring the meaning of using the technology in their everyday work. On a general level, individuals' perceived meaningfulness of using ICT in a work setting is both enabled and restricted by external and underlying social structures such as professional practice and organizational hierarchy (see for example Henfridsson, 2000). The mutually dependent individual and social mechanisms affecting the evolvement of meaningful use of mobile computing and ICT in practice can be adapted to study context of this thesis, and summarized using Wenger's (1998) social learning framework, illustrated in the next figure.



Adaptation of Wenger (1998) to the context of the study

As shown in the figure above, individual user-practitioners' perceived meaning of using mobile computing is a consequence of their open-ended adaptation and sensemaking of the technology design intertwined with seemingly 'given' social and contextual preconditions of situated work practice and organizational structures in which the technology is used. This can be related to the shaping of individual and social 'frames of reference' of ICT use (Orlikowski and Gash, 1994). To use ICT, people have to make sense of it in their context of use, and in this process they develop particular expectations and perceptions of the technology which then shape their actions toward it in practice (Ginzberg, 1981; Orlikowski and Gash, 1994). 'Organizational frames' of reference held by people working in an organization consist of implicit guidelines that both facilitate and constrain individuals in perceiving and interpreting contexts, events and actions of work practice and giving them meaning. 'Technological frames' describe individuals' subset of organizational frames that concern the meaning of technology use in work practice. These individually based cognitive structures do not only include the nature and role of technology use itself, but also the specific conditions, applications and consequences of it in its practical context and naturally involve variation of frames between individuals (Orlikowski and Gash, 1994). The concept of 'frames' is then an extension of individual cognitive structures into shared ones through social interaction over time. These socially shared cognitive structures have some similarities to the notion of 'paradigms' (Kuhn, 1962) and reflect how people in organizations collectively make sense of and perceive mutual meaning of their environment, activities, artifacts and behavior (see also for example Argyris and

Schön, 1978; Calder and Schurr, 1981; Daft and Weick, 1984; Gray et al., 1985). Although not explicitly discussed further in this thesis, these concepts can also be related to studies of social, situated and distributed cognitive processes in organizations that reflect both individual and shared perceptions, as well as representations of meaning, understanding and 'group performance' as it takes place in real life settings (see for example Lave, 1988; Salomon, 1993; Hutchins, 1995; Clancey, 1997). The intertwined individual and social learning perspectives towards meaningful technology use in practice are highlighted in this thesis, rather than its cognitive dimensions.

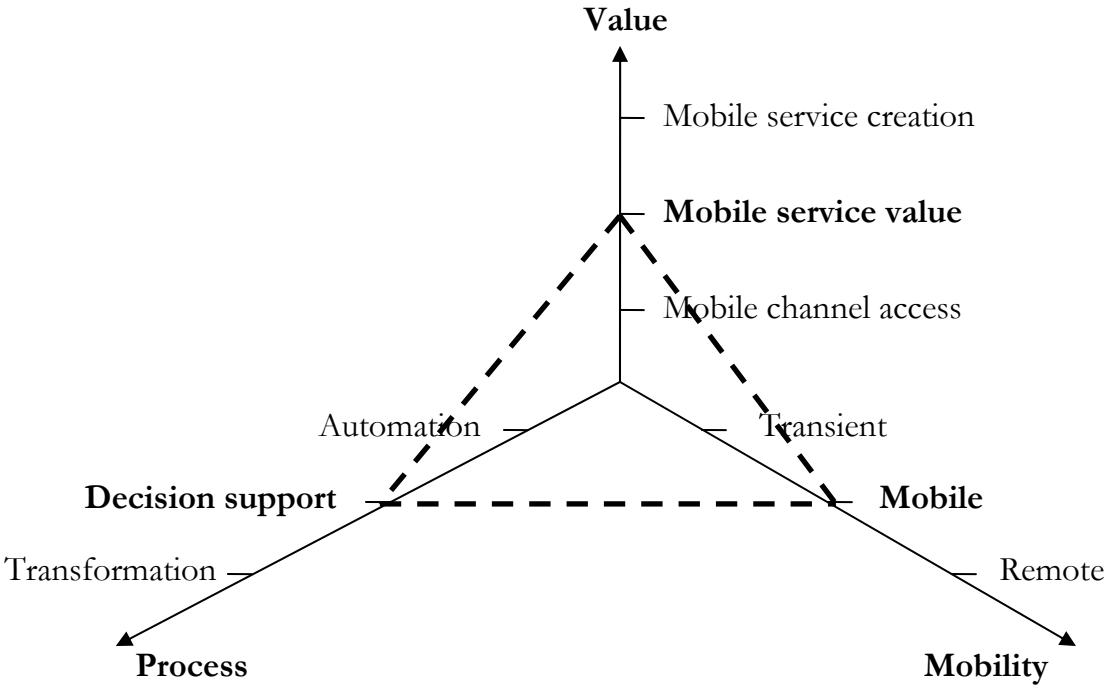
Continuing further on aspects of collective learning in usefulness development of mobile computing and ICT, socially shaped 'negotiation of meaning' of technology use can be described as a fundamental interplay between 'participation' and 'reification' (Wenger, 1998). Participation is the engagement and experience in social interaction, and reification is the processes and artifacts in which the negotiation of meaning becomes organized. Starting with the individually perceived views of meaning of using technology, user-practitioners can then express their opinions among other user colleagues and to technical developers. User-practitioners participate in this way in a continuously ongoing social learning process of further understanding meaningful use of mobile computing in their fieldwork context, towards a reification process of adapting design properties of the technology to serve the situated professional practice. In this participative process the social negotiation of individual perceptions of meaning to form a collective sense of meaningfulness is central. Even though a single person or a group of individuals have a clear perception of their individually shaped meaning which they honestly want to express, often they are not able to just express it so that it is understood by everyone in their social context. People commonly encounter problems in expressing what they mean, because what they mean have to be negotiated (Wenger, 1998). Negotiation of meaning is not a separate and planned goal oriented activity, but an ongoing process in everyday life. Negotiation of meaning may therefore end up in an experience of 'meaninglessness' (Wenger, 1998). However, situations that bring learning into focus are not necessarily those in which we learn most. Failing to learn what is expected from for example use of mobile computing technology in fieldwork practice may involve learning something else instead (Wenger, 1998).

Participation and reification processes of negotiation of meaning do not oppose each other. Rather, they construct a duality that reflects complementary aspects. Neither participation nor reification can be regarded as contrasts between the individual and the collective. Participation is a social process, but also a personal experience. Reification allows people to coordinate their actions and is therefore of a collective character, but it also shapes individual perceptions of the context of meaning and personal identity relating to it (Wenger, 1998). Also, participation is not just about informal social interaction, and reification does not only include and produce tangible objects and outcomes, but the two perspectives are tightly interwoven. Participation ranges from passively taking part in a social setting to include conversational and teaching actions that reflect individuals' motives and perceived structures of meaning in the associated context. Reification ranges from implicit and informal processes of expressions of meaning to reification as explicit and formal design tasks to shape technology. In this tightly intertwined duality and complementarity of participation and reification, the role of ordinary conversations is the vital form of communication in the social negotiation of meaning (Wenger, 1998).

The negotiation of meaning in the case study portrayed in this thesis is striving towards a rather extreme form of reification, namely adaptation of design properties of a mobile computing system to better fit its situated fieldwork practice of use. From the perspective of technical developers, the term 'use' is often seen as a relation between a generic user and the ICT system. But the so called 'users' are simultaneously engaged in the events and activities of their work. The challenge of designing mobile computing for a work setting is therefore essentially about designing an ICT system that serves participation in practice rather than just using technology. Systematic user-centered and participatory approaches when designing ICT systems may assist the exploration of ICT requirements between technical developers and user-practitioners towards adapting design properties of the technology to its context of use in situated work practice (see for example Ehn, 1988; Greenbaum and Kyng, 1991; Bødker, 1996). The details of such user-centered and participatory ICT system design methods are however slightly beyond the scope of the discussion pursued in this thesis.

Mobile meaning and site management practice

To conclude the contextual and conceptual chapter of this thesis, an initial analytical framework of the studied case at the construction company Skanska will now be formalized. Returning to the mobile work model (Barnes, 2004), it can be applied to the case study context of construction site operations to schematically map out the studied company's the organizational motives (Wiredu, 2007) to develop and use mobile computing in site production. The mobile work model is thereby used to reflect the potential of mobile ICT from a pure business perspective, without considering varying use conditions of the fieldwork context, individual motives for use or the actual design properties of the technology itself.

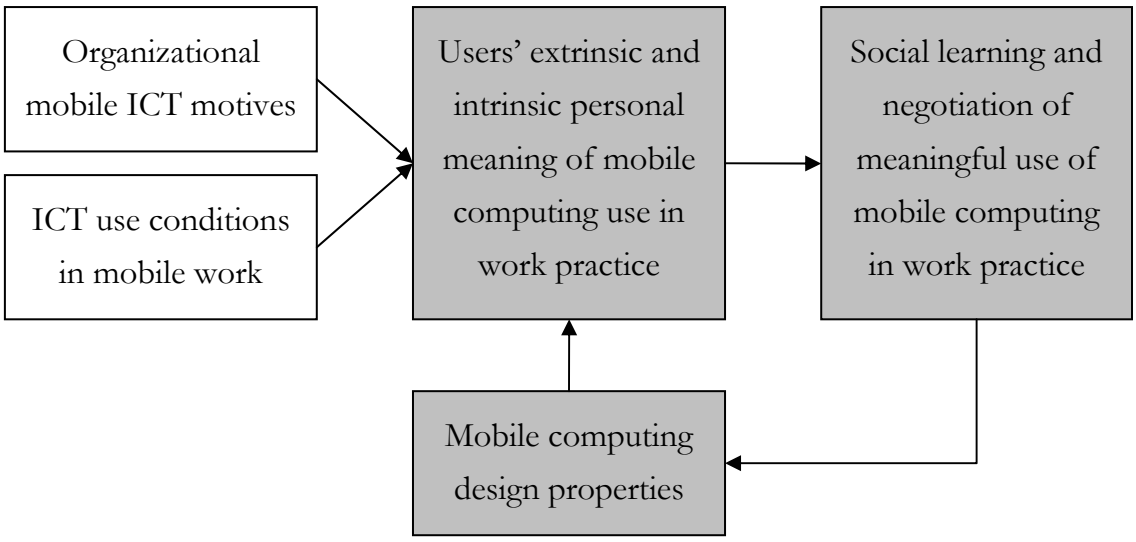


Mobile workforce empowerment (Barnes, 2004)

As shown in the figure above, a reasonable representation of organizational ICT motives for using mobile computing in construction site operations can be described as a strive towards enabling 'mobile workforce empowerment' (Barnes, 2004). The targeted construction site management workforce at the studied construction company Skanska has thereby a midlevel demand of mobility in their work, meaning that these mobile professionals need to be out on site coordinating work, as well as at their computer terminals inside the site office and in meetings on location or elsewhere. In this fieldwork context, there is a need for improved

decision support and portability of information and communication resources. The organizational motives of the studied mobile computing case at Skanska plotted in the mobile work model therefore reflect the overall corporate expectations of the new technology to enable innovative and accessible mobile ICT applications and services to empower site management workforces in improving decision making, performance and quality of construction work of production operations.

Further concretizing the adaptation of Wenger (1998) made in the previous section, the perspectives of social structure and organizational power of the studied case is related to the organizational ICT motives of introducing mobile computing in construction site operations described above. The situated work practice perspective is primarily focusing on the practical use conditions of mobile computing in the dynamic fieldwork setting of construction site management. The perspectives of the individual of the study relate to site management professionals' personal meaning of using mobile computing in their work based on extrinsic and intrinsic motivational factors. Extrinsic personal meaning of mobile computing in practice involves user-practitioners' sensemaking of organizational mobile ICT motives, the technology itself and the changing use conditions of the work context in the search of improving the performance of work. Intrinsic personal meaning reflects practitioners' perceptions of meaningful use derived from individual satisfaction and enjoyment of using the technology in itself. The overall analytical framework of the study in this thesis is illustrated in the figure below.

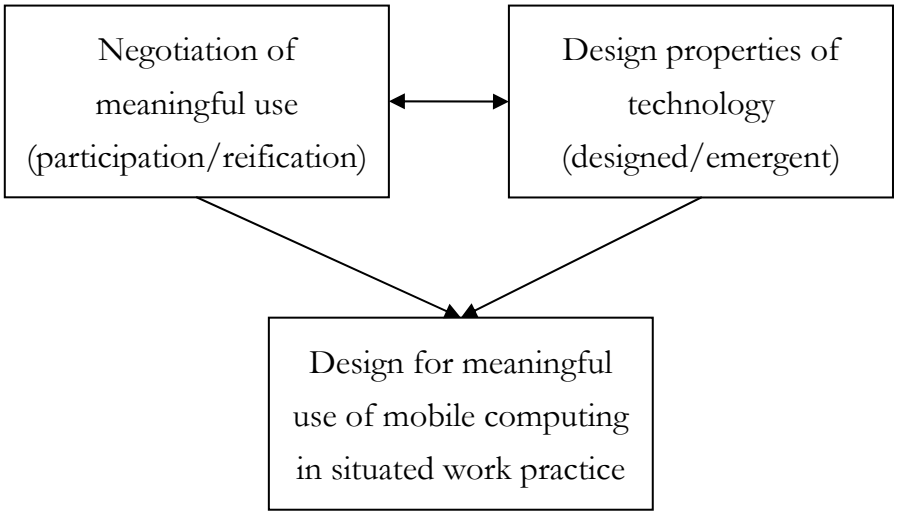


The analytical framework of the study

As shown in the previous figure, users' sensemaking of organizational ICT motives and ICT use conditions in the mobile work context is essentially an accepting and adapting process to external factors that the user generally has little influence over. These factors are to a large extent prerequisites which are beyond the direct control of the individual practitioner. The use of mobile computing in everyday work simply has to be adapted to serve these preconditions. Users' personal meaning of using mobile computing in work practice, the design properties of the technology and the communication between users and developers in negotiating meaningful use form a continuous learning feedback loop of adapting the mobile computing design. This evolving learning feedback loop of usefulness issues of mobile computing in construction site management practice is the primary focus of discussion and analysis of the studied case in this thesis, highlighted in grey in the previous figure.

The learning process studied intertwines both individually and collectively shaped meaning. This process makes direct connections with the technology design properties of mobile computing mainly through the correlation between prior expectations and the actual experiences of meaningful use of mobile ICT in everyday work. The connections between expectations and experiences enable a targeted user group of practitioners to express whether the technology is suited for their professional needs and behaviors, or if the technology requires technical design changes and adaptations to achieve meaningful use in practice. The case study presented and analyzed in the following chapters tries to describe and interpret the complex development processes over time of user-practitioners' personally formed perceptions of meaning of mobile computing use and the ongoing negotiation between users and developers relating to aspects of mobile computing system design properties towards the search of improved fit of the technology for the mobile fieldwork environment. Relating to Wiredu's (2007) concepts of users' success and failure perceptions of mobile computing, the case study represents to some extent the alignment and adaptation processes of personal and organizational intentions of meaningful mobile computing use in construction site management practice, based on both extrinsic goal oriented and intrinsic open-ended motivational factors. Partly inspired by Weick's (1995) ideas of 'sensemaking', the study looks closer into the overall development of 'meaningfully consistent connections' between organizational ICT motives of mobile computing use in construction site operations and the site management practitioners' own adaptation

of these motives to create meaningful use of the technology serve the performance of their work. Further, these connections include adaptation processes between changing use conditions in the dynamic fieldwork context and the user design of mobile computing to serve these varying work situations, as well as formation of personal fulfillment and content of using the technology. From the learning and negotiating processes between users and developers, a central development and design challenge then arises of how to enable new approaches of adapting design properties of the mobile computing technology to better serve the actual work context of use, illustrated in the figure below.



A technology design perspective of meaningful use

As described earlier, even though situated work practice has its own logic, legacy as well as institutional and social structures, it is also ongoing, emergent and dynamic in its everyday events and actions. Unexpected adaptations to the course of practice are natural responses to the inherently vague and unplanned circumstances of unique and specific situations. Situated work practice is therefore never fully designed, but rather an ongoing response to design (Wenger, 1998). Likewise, there is a natural ambiguity between the conceptual design of a mobile computing system and its actual realization and meaningful use in its operative work context, since the use in practice is not a result of the intended user design but a rather a continuous adaptation to it that serves user-practitioners' participation in the complex real life work setting. The challenge of the adaptive design process is therefore to recognize and include the inherent complexity of mobile computing use in its work context and making it an opportunity for developing fitting technology for user-

practitioners. In the same way as an organization consists of two basic sources of structure, formal design and emergent practice, designing mobile computing must acknowledge the complex prerequisites of real life use of the technology and translate these into what components can be specified and designed in ICT applications and what parts of the technology intentionally should be left unspecified and emergent to serve open-ended multipurpose use of mobile computing in the real work environment. The complexity between mobile computing design and its actual use in situated work practice naturally define a range of different possible configuration approaches of the technology, often called 'design hierarchies' or 'design spaces' (see for example Clark, 1985; Wenger, 1998). A regular challenge of the design process is the often limited understanding of the technology itself as well as its appropriateness for the specific work environment. Overcoming these design problems is therefore to a great extent a social process, where the realization of an acceptable technology configuration depends on whether the communicative processes between the involved participants of the development process are enabling improved understanding of how to create better fit between technology and practice. Experience with the technology, both direct and indirect, is the basis for adapting it to its practical environment of use (see also Rosenberg, 1982; Clark, 1985; Von Hippel, 1988).

To conclude the initial conceptual and analytical standpoints of this thesis, a reflection can be made analogous to Wenger's (1998) reasoning on learning:
Meaningful use of mobile computing in its practical work context cannot be designed, it can only be designed for, that is facilitated or frustrated.

3 RESEARCH

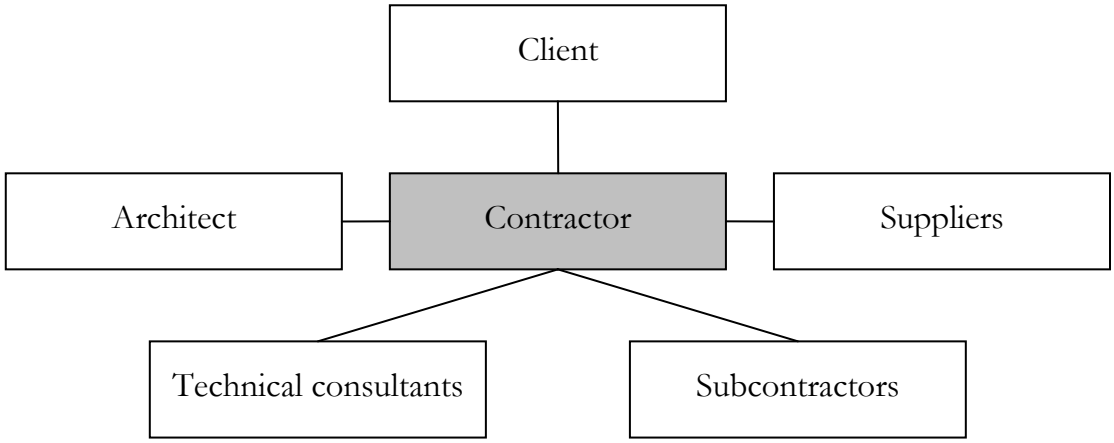
Case study

Skanska AB is Sweden's largest construction company and one of the top ten largest revenue making building and engineering firms in the world (Engineering News-Record, 2007). With around 60 000 employees, mainly in northern Europe and in North and South America, Skanska has wide ranging operations in construction as well as in development of infrastructure and residential and commercial buildings. The focus of business and type of construction projects varies within the company between its business units in different countries. In recent years, Skanska, like many other larger construction enterprises, has recognized the issues of inefficient ICT use of its site production operations and the potential of a mobile computing technology for overcoming these issues. The case study presented in this thesis involves ICT use at construction sites in two regional construction business units at Skanska in two separate countries, namely in Stockholm Sweden and in North Carolina USA.

The empirical material of this thesis was collected at Skanska during a total time period of 1,5 years, between August 2005 and January 2007. The case study consisted of two parts. The first part, 'Filmstaden', encompassed a participant observation study of the use of ICT in the everyday work of a production management team at a construction site in northern Stockholm during August 2005 to December 2005. The second part of the case study, called the 'tablet projects', consisted of following the development and use of a mobile computing system for production site management purposes at Skanska in North Carolina and in Stockholm during October 2005 to January 2007. The overall context of the case and what was studied at Filmstaden and in the tablet projects will now be described.

Filmstaden

The research at Skanska started with an observational study during August 2005 to December 2005 at the construction site Filmstaden, a large residential housing project in northern Stockholm. Filmstaden was a so-called 'design-build' project which has become a common contract form for large construction projects in Sweden and therefore an important business model for the major Swedish construction companies, especially for business units and production operations in larger metropolitan areas. A design-build project setup implies that the contractor, Skanska in this case, is 'owning' the whole execution chain of the project and is thereby responsible and in full control of the construction process from design planning through production to the handover of the facility to the client who has ordered the building. The contractor has thereby received the full mandate from the client to carry out the project from start to finish, normally after a bid phase among selected contractors who are capable of carrying out a complete design-build project delivery. There are many variants of design-build construction projects, but a typical setup with the leading and commanding role of the builder contractor is schematically illustrated in the figure below.



A design-build construction project setup

In the case of Filmstaden, Skanska as the design-build contractor was working together with a client residential housing organization in a partnering collaboration to build several blocks of tenant-ownership apartment buildings. The client's main responsibility in the project delivery was to set up tenant-ownership associations and sell the apartments to future residents. Skanska was responsible for the whole construction delivery, and all involved work efforts by other participants in this

process, such as architects, subcontractors, consultants and suppliers, were under Skanska's direct control. During the production phase of the Filmstaden project, Skanska supplied the construction site work activities to a large extent with its own workforces. The overall design-build process was reviewed by representatives of the client through continuous audits and regular checkpoints to verify that the planned buildings were designed and built according to the expected costs as well as properties of quality, function and esthetics.

The project manager of the Filmstaden project carried the overall responsibilities of the project's planned activities, execution and outcome, and handled the always ongoing negotiating dialogue of different professional, political and economic interests and demands between involved actors such as the client, the business unit at Skanska, governmental authorities, local policy makers and the surrounding community in general. The project manager was a Skanska employee and reported business results and issues directly to a district manager of the Stockholm region house building business unit within the company. Even though the project manager was mostly located at the site office at Filmstaden, the work of this individual can be labeled as traditional 'desktop office work' and is therefore not of main interest for this study.

Common for large scale house building projects, such as Filmstaden, design and production are concurrently ongoing processes. At Filmstaden, blocks of apartments were designed and built in separate stages which resulted in that one completed building structure was affecting the requirements for further extension of the building complex as a whole. Therefore, the building design coordinator function was an important role in linking together design and production phases of the Filmstaden project. There were two building design coordinators from Skanska assigned to the Filmstaden project during the time it was studied. These two individuals coordinated the construction design activities of two separate apartment blocks, which included negotiation and procurement of responsibilities between architects and design engineers, and made sure that each of the involved actors delivered their plans and specifications of the buildings on time and with satisfactory format, outline and quality of the design documentation to the production team at the Filmstaden construction site. During the case study at Filmstaden, the work of the building design coordinators were only followed implicitly and generally,

involving the part of their work that was directly interconnected with the ongoing production work out on site. These interdependencies between design and production of the Filmstaden project was observed primarily through various kinds of production meetings which involved design issues and changes of plans and drawings that required presence and competent support from the building design coordinators.

Construction projects at Skanska Sweden regularly include one or a few project engineers. The role and responsibility of a project engineer are loosely defined within the company and is ultimately decided depending on the setup and characteristics of the project and its unique requirements. Nevertheless, the generic function of a project engineer is to support and link together business activities of design and production of a construction project setup. In the Filmstaden project worked one project engineer who mainly had the role of planning and coordinating procurement of production workforce, machinery and building material, as well as follow up budget figures, evaluating current status and forecasting outcomes of the project. At the Filmstaden site, the work of the project engineer was stationary and office based. Most project engineer related work assignments were either physically brought to this person's desk, or were received as e-mails or regular phone calls to the project engineer's office. This particular professional role and work situation was not of further interest for the case study at Filmstaden.

Moving down in the hierarchy of Skanska's internal project organization at Filmstaden, we have now arrived at describing the mobile work context and professional practice that this research project is about – the construction site management team of the field based production. The construction site management team at Filmstaden consisted of two production managers with the shared overall responsibility of the parallel completion of the different apartment buildings according their respective requirements, two superintendents who coordinated the large amount of concurrent construction activities between site work teams, and four site work supervisors in charge of instructing and managing the physical job activities carried out by subcontractors and Skanska's own skilled construction workers. At the time of the study, this core production management team of eight individuals was in charge of all construction activities out on site including the coordination of about 20 Skanska workers, including personnel for managing

delivery and supply of building material, tools and machinery, and about 40 individuals from different subcontractor organizations.

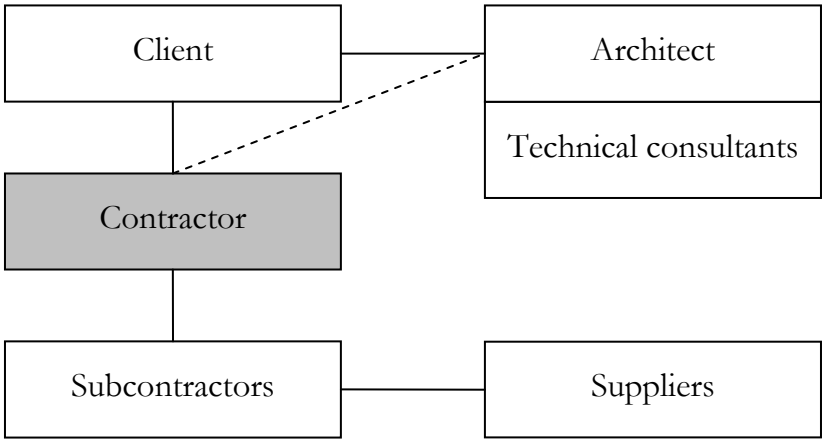
The ICT systems environment used at Filmstaden was more or less Skanska Sweden's standard ICT platform for managing construction projects, which was developed and maintained by the ICT unit in Stockholm. The backbone structure of the platform was an 'enterprise resource planning' system which was simply called 'the business system' within Skanska Sweden. The business system was a complex of ICT systems that had many different application modules integrated with various databases, from which data then was processed, stored and structured centrally. User applications that were integrated with this complex database structure included activity based project management tools and a web based procurement system. From the business system a lot of complex and aggregated operations data could then be retrieved and various kinds of reports reflecting the statuses and outcomes of individual projects, construction regions or business units as a whole could be generated. Skanska Sweden also had an 'intranet knowledgebase' to support management of construction projects. The intranet project management knowledgebase mainly consisted of standardized document templates for project reporting and an instructive administrative framework for setting up and executing defined project activities, which can be described as a sort of 'way of working' for construction projects at Skanska Sweden. The intranet knowledgebase resource was frequently used by the production managers and superintendents at Filmstaden, especially the use of document templates for writing meeting minutes, deviation reports and work safety audits, as well as setting up project plan documents. Apart form the Skanska's internally networked ICT platform consisting of the more or less integrated application modules of the business system and the intranet knowledgebase, projects in general at Skanska also used independent Internet based 'project collaboration extranets' which mainly included storing, distributing and sharing design drawings and project documentation among all involved participants. Using these project collaboration extranets for document management was also an efficient way for the contracting organization Skanska to separate the corporate specific business information about a project from the information relating to plans, design and processes that should be available to all project participants belonging to different organizations to facilitate effective collaboration. In the Filmstaden project, involved project participants logged on to the extranet to use it for adding

updates of design drawings and upload project plan documents and meeting protocols, and also to find contact information to other participants of the project. Skanska together with the partnering client were determining the use procedures for the project collaboration extranet, which included guidelines for creation, revision and handling of documents, assigned deadlines and individual responsibilities for producing different kinds of documentation, as well as specifically defined data formats of design drawings.

Tablet project in North Carolina

During the case study at Filmstaden, a highly interesting pilot project concerning mobile ICT for construction site management was going on at Skanska's USA based business unit, Skanska USA Building. This pilot project started in early 2005 and involved new mobile ICT tools for fieldwork management purposes at a construction site at Duke University in North Carolina USA. This innovative ICT venture became the initiation of similar mobile computing development efforts at different business units at Skanska, referred to in this thesis as the 'tablet projects'.

The Duke University construction project at Skanska USA Building in North Carolina was a so called 'design-bid-build' project. Design-bid-build is the traditional project setup in the construction industry worldwide, and is the regular business model for most building projects in the North Carolina region of Skanska USA Building. A design-bid-build project setup usually implies that the contractor is not involved in the design process of a building. The architect, often in collaboration with various technical consultants, is responsible for creating the drawings and specifications of the building according to the client's requirements. This design documentation is then coordinated by the architect and put out for bid to various competing contractors. When a contractor is selected and awarded the build phase of the project, its execution setup may vary. The contractor may for instance supply construction site activities with its own workforces, but common production site operations procedures for Skanska in North Carolina involved that most human and material project resources were supplied by subcontractors. In such project setups, as the one at Duke University, Skanska as contractor had a general construction management role of planning and overseeing the overall progress of the building production process, where the majority of actual site work activities mainly were carried out by subcontractors.



A design-bid-build construction project setup

The architect has generally a more influential role in design-bid-build projects like the one at Duke University compared to design-build projects such as at Filmstaden. While the architect's design work is delimited by the contractor's strict directives in a design-build project, the architect in a design-bid-build project often acts as the client's agent in the communication with the contractor, illustrated with the dashed line in the figure above. This client agent role of the architect commonly entails reviewing the progress of the work, changing orders and issuing necessary documentation to the construction process. A design issue that arises in the production setting in a design-build project normally results in that the contractor orders the architect what needs to be changed in plans and specifications to be able to continue production operations. A design issue that arises in the production site context of a design-bid-build project requires that the contractor carefully and accurately communicates the problem with the architect organization so that they can revise drawings and documentation according to the client's requests. The so called 'request for information' (RFI) issued from the contractor to the architect in assessing these often occurring situations was a central ongoing information and communication activity in the design-bid-build operations at the Duke University construction site. These RFI procedures were used in circumstances where it was necessary to confirm the interpretation of details, specifications and notes on construction drawings, and to clarify and verify different work directives from the architect and the client in order to continue site production operations. In general, an issued RFI from the contractor that is handled and answered by the architect and distributed to all stakeholders of the construction project, functions in practice as an

accepted change to the content and scope of work among the involved parties, unless further approval is required for the costs associated with the change.

The Duke University construction site management team evaluated their existing building processes in the search for new solutions of deficient administration of fieldwork activities. In their evaluation, the team found that the primary distribution of site work information was paper based, where printed documents were carried into the field by hand. Managing the physically overwhelming quantity of paper based drawings and documents that were distributed to the construction site often generated poor quality of information in the field. As a result, the site management staff was forced to deal with slow problem solving and construction rework. Members of the Duke University project team began to investigate new ways to improve site production information by expanding the use of ICT onto the construction site. Over all, the use of ICT resources by production site management teams at Skanska USA Building was not as widespread compared to ICT use in construction projects at Skanska Sweden. With less existing project specific ICT applications in use in the production fieldwork environment, the construction site management team at Duke University freely started exploring new possible ICT tools that could be helpful in the performance of their everyday work in the field.

During the review of existing site management work processes at Duke University it became clear that there were two primary types of documents that were critical to the completion of onsite work activities, namely drawing plans and specifications. Beyond these, there were also numerous secondary documents including coordination plans, subcontracts, project schedules, quality inspection forms, safety notices, punchlists, technical codes and references, and product databases which regularly also must be referenced to complete work activities. The size, weight, and volume of these documents made it difficult for fieldwork management to physically carry any significant portion of them at all. In many cases, supervisors established document 'outposts' on the construction site so that information, usually drawing plans, could be stored in the field. While these outposts were useful, much of their information was often out of date. The result of this situation was that issues in the field were sometimes resolved using inaccurate data, by memory, or that fieldwork management staff left the field to go to the site office to collect the relevant information and then return to the field with an answer. Retrieving an answer of a

site work issue also required frequent involvement of additional project participants such as architects and technical consultants to coordinate information to generate a proper solution. This collaborative process regularly required additional resolution time of construction problems ranging from days to several weeks. When an adequate response to an issue was provided, additional documentation was then added to the already burdensome library of fieldwork data. During the time frame between the generation of an issue and the release of updated construction information, site work personnel were required to continue moving forward, either by reorganize their work to avoid the questioned area or to begin work on the area and then rework or correct the area once an answer was provided. The opportunity of mobile ICT applications that could provide adequate and timely construction information to the field seemed therefore significant for the production management team at Duke University.

Additionally, some of the typical production startup procedures of construction projects at Skanska in North Carolina were also highlighted as central problems in the evaluation at Duke University. When the first complete set of drawing plans and specifications are originally issued, or when documentation are reissued, drawings pass through a series of plot error checks between the architect and a reprographer prior to being printed and sent to Skanska. These checks usually last two to three days provided that there are no errors that need to be corrected. After these checks are completed, the reprographer begins the process of printing the large volume of drawings ordered by the client, the contractor Skanska, and the subcontractors. On large projects like the one at Duke University, initial drawing plot and print orders take several days to fulfill. Once the documentation is printed and issued, additional time is often involved in distributing and posting the plans at their final locations. This initial process can take more than a week to complete before Skanska receives the information needed to begin the work in the field. While in full fieldwork production, a construction site management team regularly encounters numerous coordination conflicts and document deviations which require swift resolution. RFI procedures of fieldwork managers at Skanska USA Building were traditionally handled verbally using mobile phones or by returning to the site office to explain arisen issues to other members of the project team. This problem communication relies heavily on visual aid for clarity, and descriptions by phone are therefore often inaccurate and a waste of time. Moreover, when construction site managers are

forced back to the site office to handle fieldwork issues, their time spent in the field is limited. The required time for developing and issuing an RFI to the architect also varies greatly depending on the complexity of the problem, but typically ranges from one to several days.

In the search to improve the deficient information processes in the field just described, a pilot project at Duke University combined basic wireless ICT infrastructure with internally developed software to create new mobile ICT tools to distribute plans and specifications digitally to construction site management personnel. A digital document management system was implemented together with software to wirelessly synchronize the latest plans and specifications with 'tablet computers' used by management staff in the field. A tablet computer device looks like a flat laptop computer screen without a keyboard. It is thinner and lighter than a regular portable computer, and the user navigates the tablet computer by using an electronic pen writing directly on the screen, shown in the picture below.

Tablet computer with electronic pen

The tablet computer pilot project at Duke University focused on handling of drawings and specifications used onsite. The targeted users were site work supervisors and how their administration of field production activities could be improved by using the mobile tablet computer platform. When the correct information of an arisen production issue were not available to fieldwork management, they generated a complete digital RFI using the tablet computer and then send it via a wireless network to the site office staff without leaving the field. Issues were then consulted with the architect who responded with a proper solution. Once a document change or RFI response was completed and forwarded by the architect, it was received by a member of the site office staff at Duke University via the project management information system, who then became responsible for the initial review and distribution of documentation to the field. With the tablet computers, supervisors were able to include specifications, contracts, photographs, and plan snapshots in a RFI, which enabled a richer description of a production issue and possibly a more rapid and concise response from the architect.

Before the creation of this digital document administration process at Duke University, multiple paper copies of documents were normally delivered by hand or shipped to each production site management team member. Additional copies were also made and taped to the current set of drawing plans at different locations in the site office. These traditional paper based processes of change, distribution and posting of drawings, plans and specifications were usually carried out once per week, and were often limited by the time between the distribution of documents and when fieldwork supervisors reviewed an issue or when subcontractors received an issue by mail or fax. With the new ICT supported procedures, when a change was received from the architect, the process of posting changes via the digital document distribution system became more consolidated. Once a member of the site office project team received a change via the project management information system, they linked the issue immediately to the document that was modified on the digital document management system. Once this link was created, documentation updates were available to every member of the project instantaneously, and could be wirelessly accessed and downloaded on the tablet computers by fieldwork management staff on site. The distribution speed of the digital construction information was limited by the frequency that each team member synchronized their computer with the latest changes. Theoretically, the posting and distribution

process could be accomplished very rapidly. But, the production management team at Duke University had grown accustomed to posting changes weekly, so many changes were stored in the digital document management system waiting to be linked for a week or more. Therefore, the initial use of the tablet computer document distribution system at Duke University involved learning processes of establishing partly new procedures for the drawing update process as a whole.

As new systems and tools of the tablet computer expanded at Duke University, a 'user champion' was appointed to further direct and support the development. This user champion originally served as a project engineer at the Duke University construction project, and was the one who initiated the ideas of using tablet computers in the field as an opportunity to overcome the deficient information situation in site work management. In practice, this individual directed the overall development and use of the tablet computer digital document management system based on his original visions and ideas. The user champion's role at Duke University was loosely defined, but included training, support, and encouragement of other team members to use the technology. The champion started this process by replacing own work routines with new procedures using the tablet computer. To help carry new ideas to realization, the user champion together with the overall tablet project manager expanded the relationship with a software consultant who initially deployed project web tools for the Duke University building project management team at Skanska in North Carolina. The result was a growing ICT enabled toolset accessed through the tablet computer device that could replace existing administrative onsite work processes.

In the site management team's own evaluation of the test of the new ICT tools at Duke University in August 2005, they expressed experienced improvements of their own personal productivity when equipped with updated and portable project information through the use of tablet computers. With improved quality of information in the field, site work supervisors could better respond to raised issues, with less time spent walking between the site office and the site operations and more time spent in the field administrating work activities of subcontractors and responding to questions. The use of the digital document management system allowed distribution of plans, drawings and specification without the involvement of a reprographer. The digital format enabled faster distribution of documents. This

way of providing information on time to the Duke University production site management team was important for their ability to work proactively with fieldwork issues. Site management practitioners were able to in more detail respond to a larger amount of issues to prevent construction rework. Once an identified field issue was documented using the mobile computing system, the resolution of the problem through the communication between the construction management staff at Skanska and the architect avoided many of the traditional processes that delayed responses including reviewing, reprinting and delivery of drawings. With issues resolved quickly and returned to the field adequately, fieldwork management staff was able to continue to work unhindered. The tablet project evaluation at Duke University showed that fieldwork supervisors considered the most valuable part of using tablet computers in their work as having the ability to carry an entire set of plans, drawings and specifications for the project at all times, and to access it when needed on site.

Tablet computer use at Duke University

Tablet project in Stockholm

As a consequence of the positive results of the tablet computer tests at Duke University, Skanska initiated a corporate wide mobile computing effort in the fall of 2005. The initiator and user champion of the tablet project at Duke University was appointed a global coordinator role to encourage applications of the tablet computer technology to be developed, implemented, used and evaluated in various construction projects at Skanska worldwide.

At Skanska Sweden a tablet computer pilot project was initiated in October 2005 at the construction site Forum Nacka in the Stockholm house building region. Forum Nacka was a design-build project with a similar setup as the Filmstaden project. In the case of Forum Nacka, Skanska were in charge of the total project delivery, including design and production, of a complex reconstruction and extension of an existing shopping mall in Stockholm on behalf of a commercial facility developer. The tablet computer pilot project at Forum Nacka was set up in a similar fashion as the tests at Duke University, focusing on site management use of the tablet computer device in the fieldwork production environment. The tablet project at Forum Nacka was a collaborative effort between the Stockholm region construction business unit and the ICT unit at Skanska Sweden. The objective was to find out if the tablet computer concept was useful for the Swedish site management context, and if so, to identify how a mobile computing platform based on the tablet computer device should be designed and used in order to improve current ways of working with existing ICT resources in production site operations.

Early on in the Stockholm tablet project it was noticed that there were national differences of business processes between Skanska USA Building and Skanska Sweden in for example construction contract forms, project setups and ICT use, which in turn resulted in divergence of work practice in production site operations between the two business units. This generated to some extent different expectations of application areas of the tablet computer for construction site management purposes at Forum Nacka compared to Duke University. In a typical Swedish design-build project such as Filmstaden or Forum Nacka, drawing update processes were very different compared to design-bid-build project setups such as Duke University. Somewhat simplified, the RFI handling of plans and specifications

present at Duke University could be described as a process where only a part of the drawing was updated with added attachments of changes to the existing set of documentation. The complete drawing is not updated. With or without the digital document procedures using tablet computers, all sets of plans and specifications were manually updated with the needed modifications by copying and pasting part of the drawing next to them with the marked changes. If this procedure was forgotten on some set of paper drawings out on site or in a digital document system, these documents were not up to date. These RFI procedures seemed to be the main reason why Skanska USA Building considered the tablet computer to be such a useful tool for speeding up the update process. In contrast, when design issues arise that require changes of existing plans and specifications at a design-build project such as Forum Nacka, Skanska as contractor is in control of the review and revision process and communicates with the architect and technical consultants what needs to be changed in order to continue the production process. New sets of drawings are then ordered, produced and distributed to the production site that is modified according to Skanska's command. For this reason, the production site management team at Forum Nacka did not see any useful application of tablet computers in the field for drawing update purposes.

Another fundamental difference between the design-bid-build project setup at Duke University compared to the design-build project at Forum Nacka was Skanska's level of responsibility as contractor in the production phase, which affected the scope of administrative procedures and routines surrounding it. Skanska's design-build responsibility at Forum Nacka included managing the whole supply chain of building material, tools, machines and human resources for the construction site. This implied spending a lot of time on activities such as detailed planning of construction work preparation and procurement of building material. At Duke University, much of the procurement, material logistics and detailed work planning were handed over to the subcontractors, while Skanska principally managed the overall coordination processes of preventing all kinds of collisions between production activities. Superintendents and site work supervisors at Duke University could therefore be more often out in the field coordinating work, rather than spending a lot of time at the computer in the site office. Almost the opposite work situation were experienced by the production management team at Forum Nacka.

Parallel with the use of existing project management ICT tools, the tablet project at Duke University in North Carolina created more or less 'from scratch' the new tablet computer digital document management system along with appropriate use procedures. Historically, ICT resources have certainly been used in managing construction projects at Skanska USA building, but regularly not extended to the fieldwork management teams. This neglected site based ICT support was specifically addressed by the tablet project at Duke University. The tablet computer device enabled new simple tools specifically targeting identified information and communication deficiencies in the field. The tablet computer was a welcomed opportunity to complex problems that the site management practitioners themselves had been experiencing in their professional work for a long time. The tablet project at Duke University also implied that the use of tablet computers for some of the superintendents and site work supervisors was the first time they used ICT as a part of their professional practice. At Skanska Sweden, ICT resources for production management purposes had been systematically developed and used for decades. The standardized business ICT platform and the intranet knowledgebase for project management were widely used in essentially all building site operations at Skanska Sweden. Comparing the two production sites Filmstaden and Forum Nacka also show that both construction site management teams used Skanska Sweden's ICT resources basically in the same way and to the same level of extent. Consequently, the technical and social legacy of ICT use in construction site management was a more complex issue in Forum Nacka compared to Duke University. Introduction of new ICT capabilities in the work organization at Skanska Sweden had to be carefully integrated with the existing ICT resources and its procedural framework of use, as the company's business processes were already heavily dependent on these technical abilities. Making the existing ICT platform more 'mobile' therefore entailed a complex development process that required significant 'technical legacy' considerations of intricate design problems of adapting its current interdependent ICT systems structure. Additionally, as there were more individuals with profound prior experience of ICT use in their professional work at Forum Nacka compared to Duke University, there was also a higher degree of 'social legacy' of ICT use in the Swedish case. Even though site management practitioners at Forum Nacka often did not appreciate, or even disliked, using Skanska Sweden's ICT platform they still were accustomed to and were dependent on of using these information and communication resources in the performance of their everyday work. From the very

beginning of the Stockholm tablet project, the Forum Nacka site management practitioners primarily expected that the tablet computer device possibly could improve the ability of wirelessly being 'online' and using existing ICT resources in the field.

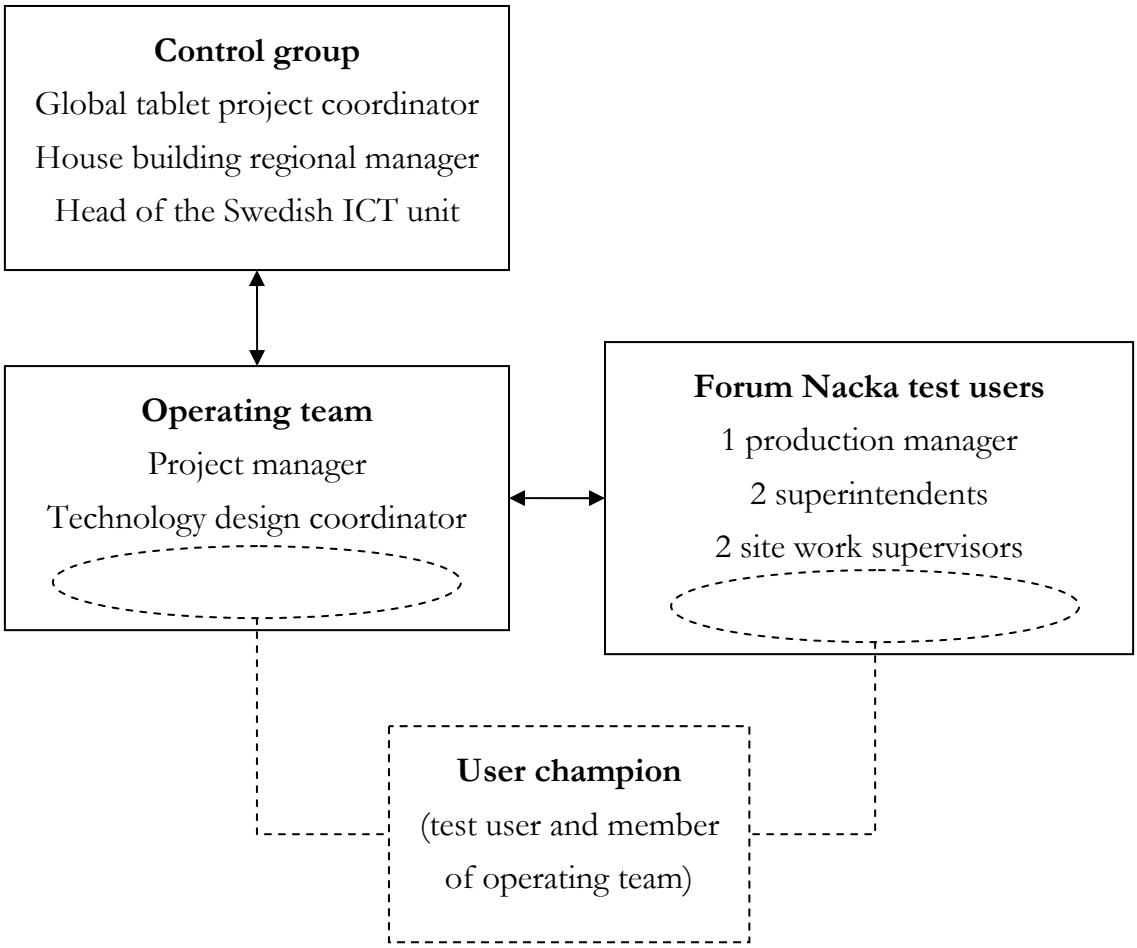
With these differences concerning construction project setups, fieldwork management practice and ICT use of the Stockholm tablet project compared to the pilot tests in North Carolina, it became clear that the tablet project at Forum Nacka had to focus on other application areas of the technology in order to create usefulness for production site management purposes. With no specific initially identified purpose for the tablet computer in practice, the tablet project in Stockholm employed a more cautious approach compared to the one in North Carolina. The Swedish approach was more in the form of a feasibility study, placing the tablet computer devices into the hands of construction site management practitioners at Forum Nacka and together with ICT development staff at Skanska Sweden figuring out whether the technology in different ways possibly could improve everyday fieldwork practice. The participants of the Stockholm tablet project did not want to 'go live' with any mobile computing platform on site before its usefulness and possible obstacles for adoption and use were sufficiently evaluated.

The tablet project organization in Stockholm included a control group, an operating team and a group of test users at the Forum Nacka construction site. The control group consisted of the global coordinator of the tablet projects at Skanska worldwide (who was also the initiator and former user champion of the tablet project at Duke University), the manager of the northern Stockholm house building region at Skanska Sweden, and the head of the ICT unit at Skanska Sweden. This control group was put together to serve different goals of the Forum Nacka tablet project. The global coordinator's role was to advocate that the mobile computing technology was implemented, tested and evaluated in different building projects and countries of the Skanska corporation. The role of the Stockholm house building regional manager in the control group was to make sure that the tablet project at Forum Nacka served the needs and demands of the site production environment. The head of the ICT unit monitored the new concepts and opportunities that came out of the Stockholm tablet project, and whether these ideas could possibly be

aligned and incorporated within the existing ICT systems infrastructure at Skanska Sweden.

The Stockholm tablet project 'operating team' consisted of a 'project manager' from the Swedish ICT unit, a 'user champion' who was a project engineer working at Forum Nacka, and a 'technology design coordinator' who worked as a project ICT coordinator at the northern Stockholm house building region at Skanska Sweden. The purpose of having a person from the Swedish ICT unit as the operating project manager of the tablet project was mainly to facilitate quicker development of new applications and/or configuration of existing ICT systems from new concepts that were expected to arise from the tablet computer trials. Selecting a project engineer, firmly rooted in the site production setting at Skanska Sweden, as the user champion of Stockholm tablet project allowed for better understanding of using mobile ICT in its situated fieldwork practice. To have a regional project ICT coordinator at Skanska Sweden participating as the technology design coordinator in the tablet project at Forum Nacka further assisted in understanding facilitators and barriers for development, introduction and use of mobile computing in the construction site environment.

The user champion of the Stockholm tablet project was also one of six test users of the tablet computer device at Forum Nacka. The rest of the tablet computer test user group consisted of one production manager, two superintendents and two site work supervisors. The organization of the Stockholm tablet project is illustrated in the next figure.



The Stockholm tablet project organization

The Stockholm tablet project was studied from its start in the fall of 2005 to its finish in the beginning of 2007. The case study was primarily focused on following the operating team and the group of six test users in their experiences with the tablet computer devices. Since the user champion was a part of both the operating team and the group of six test users, this individual was particularly important to follow for the purpose of this study. The user champion took part in the direct use of the technology in the situated work practice at Forum Nacka, where this individual also exchanged expected and experienced use of the tablet computer with the other five fellow production management colleagues that were test users in the tablet project. In addition, as a member of the tablet project operating team the user champion was a direct link between the test users at Forum Nacka and the tablet project manager and the technology design coordinator of the operating team, to communicate and discuss the practical use of the tablet computer device and possible adaptations of the technology towards better fit for production site management work purposes.

Other tablet tests were also initiated at Skanska in for example Norway and the UK. However, the rest of this thesis will further describe and analyze the two tablet projects carried out at Skanska USA Building in North Carolina and at Skanska Sweden in Stockholm. However, and this is an important emphasis, the purpose of this study is not to evaluate Skanska's mobile ICT project or to map out individual person's or project group's efforts relating to the outcome of the respective projects. The two selected tablet projects at Skanska was studied because they serve as excellent real life examples of the complex processes of evolving usefulness issues in the development of mobile ICT resources for dynamic fieldwork environments, which this thesis tries to shed new light on, analyze and discuss. The main focus is on the Stockholm tablet project because it was studied in more detail from start to finish, while the tablet project in North Carolina serves as a reference case of mobile ICT development within a similar, however not identical, fieldwork context within the same company.

Method and me

My educational and professional background is in ICT management. I do not consider it to be an overstatement to say that I am fairly 'acquainted' with issues of design, use, maintenance and development of ICT systems for different purposes in organizational contexts. However, at the beginning of this research project I was unfamiliar with the construction industry and the specific organization, logic and work processes of construction projects. Therefore, the observations of ICT use at Filmstaden and tablet computer use at Forum Nacka were important initial information for my own sensemaking of practical ICT usefulness in this unfamiliar fieldwork context. However, it was in conversations, meetings and social interactions with the involved practitioners that these observations was further interpreted and understood. My data collection and interpretation processes were therefore heavily interdependent on each other – first observing and documenting ICT use in practice, and then listening and taking notes on practitioners' conversations about their expectations and actual experiences of the technology, and vice versa. My interest was to see how the 'expressions' of expected and experienced use changed over time in the studied case. These changes, in terms of both use and conversation, were to me the essential manifestations of the sensemaking and negotiating processes of usefulness by the involved actors during the course of the study.

The rest of this chapter describes my approach for outlining, conducting and evaluating the research efforts presented in this thesis. As will be shown, the research can be depicted as a continuous process of my own sensemaking of the case at Skanska that was progressively analyzed in relation to emerging theoretical standpoints and multiple interpretations of the study findings.

Inspiration

My research approach has not tried to capture how people really 'think' of the meaning of mobile computing. The research can only reveal indications of user-practitioners' opinions and views of the technology when they are using it, and their expressions of expectations and actual experiences of it. In this sense, my study is inspired by a basic pragmatic approach where the understanding of meaning is made through observation of its occurrence and practical consequences in reality. This can

be related to the research streams of studying for example real life developments of 'learning by doing' through individuals' adaptation, problem solving and action (see for example Dewey, 1922), as well as studies of reflective and social interplay between humans and the material surroundings (see for example Mead, 1934). From these perspectives, human action and social interaction are affected by a range of facilitators and constraints of the environment in which they take place. However, these contextual preconditions do not constitute a fixed objectively given reality. Human circumstances exist in a social reality that is continuously and open-endedly under interpretation and development by the people who are acting in it. Put into the context of this thesis, my initial understanding of ICT usefulness is that users' perception of meaningful use of mobile computing in situated work practice is derived from both individual and social factors. To serve this perspective, studying everyday ongoing events in practice may better grasp the complexity of individual and social aspects of sensemaking and negotiation of meaning as it takes place and are expressed in real life (Lave, 1988; Wenger, 1998). I strongly identify with Wenger's (1998) attempt to balance the seemingly conflicting view on individual versus social meaning. My standpoint is that a resulting experience of meaningfulness in real world practice is grounded in a complex intertwining of individually shaped as well as socially negotiated processes of meaning.

Garfinkel's (1967) ethnomethodological approach was an initial source of inspiration for the methods used in my research. Ethnomethodology can be roughly defined as a research discipline within social science that examines the ways in which people make sense of their situated real life context, display and express this understanding to others, and produce mutually shared social structures in which people act. In this sense, meaning and social norm are not objectively given or taken for granted, but rather a result of social interaction where people continuously define, redefine and adapt their actions according to changing goals, practice and context. Garfinkel (1967) argues that to understand practical human reality, the study of everyday events and social interaction within its situated context is central. Heath and Luff (2000) argue that ethnomethodology does not directly deal with 'meaning'. That may be true, but in order to capture expectations and experiences of meaningful use of mobile technology in an ongoing work context, a basic ethnomethodologically inspired approach that achieves closeness to the everyday events in the social real life context was fruitful for achieving improved

understanding the study at Skanska. However, I would never claim that my study at Skanska was an ethnomethodological study.

Weilenmann (2001) highlights the importance of initial use of technology when mobile computing is introduced in real life practice. Building further on the works of Feldman (1984) and Orlikowski and Gash (1994), Weilenmann argues that expectations of using the technology are often set by the first behavior that emerges in a user group. Therefore, the very first days of use are important to study in order to understand the sensemaking and negotiation of meaning of mobile computing (Weilenmann, 2001). It is possible that initial use behavior was influential for the rest of the developments of the studied tablet projects at Skanska, but that puts too much focus on spectacular and extraordinary phenomena of technology introduction in creating meaningful use. To balance this perspective, everyday 'mundane' events of using mobile computing in the site management fieldwork setting and the conversations surrounding these events were studied at Forum Nacka over a longer time frame in order to capture the gradual changes of individually and socially shaped meaning of technology use in the work context. As a result, my research at Skanska has not sampled stereotypical extreme patterns of problems, deviations, great events and flamboyant individuals that are common in social science studies (Brekhus, 1998, 2000). The focus of the study of the tablet projects is not to highlight the extraordinary individual use details of mobile computing, but rather to describe the use experience of the technology and its general developments in the situated practice over the studied time period. So the perspective is the 'individual in general', highlighting once again that individual sensemaking and socially negotiated meaning of mobile computing use in situated work practice can not be easily separated, and must therefore be studied in its naturally emergent complexity in reality. In line with the arguments of Brekhus (1998, 2000), studying the mundane everyday events may also give new fundamental explanations of sensemaking and negotiation of meaning of mobile computing use as well as the cause and course of development of technology usefulness in practice, beyond the many mainstream descriptions of 'best practice' and the extraordinary.

Further, Weilenmann (2003) advocates four principal models for studying mobility and mobile ICT use in real life contexts; 'follow the actors', 'follow the technology', 'study a place' and 'study the virtual communication space'. All these approaches

were applied to different extent and in different periods of the study at Skanska. At Filmstaden, my purpose of the study was to understand the dynamic work context of the production site management practitioners relating to their use of ICT. Here I followed the actors and studied a place. The study of the tablet projects, especially the one in Stockholm, had elements of all four research approaches. I studied the individuals of the operating tablet project team and the test users directly involved in the sensemaking and negotiation of meaning of the mobile computing technology (actors). I observed the use of the tablet computer in situated work practice at Forum Nacka (technology) as well as the use conditions of the construction site management work setting (place). My study also included how applications and tools were in fact used on the mobile computing device (virtual communication space).

The case study at Skanska can be related to a 'process oriented approach'. Process research studies ongoing organizational processes of development and change, where data is collected in the real life context of events and actions within organizations (Poole et al., 2000). But the purpose of this is not to reproduce a detailed account of actions and events as in the ethnomethodological approach, but rather to depict and explain an overall process of development over time. Process research is regularly used for generalizing findings of multiple case studies (Poole et al., 2000). Nevertheless, the conceptual framework of process research have been inspirational for my research at Skanska because it can be applied to a single micro level case study analysis in explaining general patterns of change and development of particular circumstances within an organizational context over time.

Some case study researchers argue that there is a strict formal way of conducting case study research (see for example Yin, 2003). My standpoint is that a case study is not a methodological choice, but a choice of a study object that can be examined in many ways (see Stake, chapter four in Denzin and Lincoln, 1998). My overall case study approach is inspired by Stake's (1995) pragmatic and flexible case study design, which emphasizes understanding and learning from the specific case at hand, rather than generalizing beyond. If generalization on a theoretical level cannot be realized, improved understanding of the research topic will be achieved anyhow through the findings of the studied case. My case study approach has a narrative perspective and is driven by a broad problematic issue and with various questions

and concepts that surround it. The complex of problems and the research questions develops and becomes more determined as the case study evolves. This process of continuously refining the research scope of a case is often called 'progressive focusing' (Stake, 1995). The case study approach of Eisenhardt (1989) is similar, which suggests that after an initial broad definition of the research questions, an early specification of concepts and constructs can help further focus the study. As the study progresses, research questions and the scope of the study may naturally need revisions as the examined topic and the case at hand are gradually better understood in due course of time.

In brief, the initial outline of my research methods can be summarized as a process oriented and flexible case study approach with 'ethno' inspired data collection methods.

Practice

At Filmstaden, the main case study method can be characterized as 'participant observation'. The method is often associated with profound cultural and social studies of ethnography. The main standpoint of the participant observation method is that there is not enough to have general understanding about a certain matter, the researcher also have to get to know it through experience. The method highlights the importance of first person observations of developments, processes and situations. Participant observation is a very suitable collective method for the described approach of my research. The term participant observation says more about the researcher's way of working rather than focusing on the conceptual positioning of what a case study or field research may or may not include. Participant observation as a method is simply about balancing the complex role of being among people and participating in their interaction, at the same time as the very same people and processes are being studied and observed (Fangen, 2005). The scope of participant observation implies that the researcher is moving on a scale ranging from pure observation to just participation. There are problems associated with both extreme points of this scale. As a pure observer there is a risk of that the researcher will become a passive bystander that does not fully grasp the processes occurring or does not understand the communication between people. A pure participating role, on the other hand, involves the risk of 'going native' with the study environment or that the researcher is actively influencing and changing the

studied phenomena (Fangen, 2005). This intervening approach usually belongs to action oriented research approaches, and is normally not a part of participant observation methods as used in this study. To strengthen the research quality of studies based on participant observation and to get a nuanced picture and additional perspectives of study findings, the method is often combined with informally structured conversations and interviews with the studied individuals and groups of participants (Fangen, 2005).

My participant observation study at Filmstaden was carried out during August to December 2005. Through daily observations of the work of production site management practitioners at Filmstaden, a broad picture of issues concerning ICT use in this characteristic fieldwork environment was established. The observations consisted of following the production site management team of eight individuals in their everyday work, being in the field following the developments of construction activities with communication and collaboration onsite, as well as taking part in production meetings listening to discussions of construction issues and project planning. Observations were written down as they occurred, and at the end of each day these observations were summarized and reflected upon in daily research journal notes. My first person observations at Filmstaden were accompanied by collecting written documents such as production plans and official production meeting transcripts that were produced by the studied actors, as well as conducting interviews with each member of the studied production site management team at Filmstaden, eight interviews in total. These interviews were loosely thematically structured, with the purpose of getting the interviewed individuals to talk freely about their work situation relating to the use of ICT. I further supplemented this case study material by interviewing ICT management staff at Skanska Sweden in order to get technical and possibly contrasting perspectives of the observed issues of practical ICT use at Filmstaden.

The tablet project case study at Skanska was not as intense as the one conducted at Filmstaden. The tablet projects were studied over a longer period of time and consisted of recurrent periods of data collection. I studied the Stockholm tablet project at close range from its start in October 2005 until its conclusion in January 2007. Over the same time period, I continuously monitored the developments of the tablet project in North Carolina, which served as a reference case to highlight

similarities and differences of the developments between the two projects respectively. In the Stockholm tablet project study I participated in a range of project feedback meetings with different representatives from the control group, operating team and test users. During these meetings I listened and took notes on the discussions that related the ongoing development and use of tablet computer devices in the site work environment. These research activities were complemented with five half day observations of tablet computer use in the fieldwork setting at Forum Nacka, accompanied by observations from five group meetings among the test users of the Stockholm tablet project. This user oriented case study material at Forum Nacka was collected during a period of seven months, all collected in structured journal notes. Additionally, I conducted various follow up interviews with members of the tablet project operating team in Stockholm, as well as engaged in numerous ordinary conversations and observed use sessions of ICT applications with the user champion at Forum Nacka. These observations, interviews and conversations enabled me to obtain a broad picture of different perspectives and viewpoints of the progression of usefulness aspects and meaningful use of the mobile computing technology from the individuals directly involved in the development of Stockholm tablet project.

The tablet project in North Carolina was studied at distance at first. After the initial round of mobile computing trials at Duke University the tablet project team in North Carolina conducted an ambitious evaluation of the project and produced a thorough case study report and additional documentation in August 2005. I analyzed this material and continuously compared it with the case study findings of the Stockholm tablet project. In September 2005, I interviewed the initiator/user champion/development coordinator of the tablet project at Duke University in order to obtain this person's opinions of the project outcome, next steps for Skanska in North Carolina in further developing the tablet computer platform, as well as the champion's new role as the global coordinator for the tablet projects at Skanska in other countries. I also became more acquainted in person with this global tablet project coordinator during three different workshop meeting sessions between the Stockholm and North Carolina tablet projects during September 2005 and November 2006. During these occasions I was also able to observe how the global tablet project coordinator's views and opinions of the using the tablet computer device in site production gradually changed over time.

In November 2006, I made a study visit to Skanska USA Building in North Carolina together with the user champion and the project manager of the tablet project in Stockholm. This visit consisted of an observational study at two different construction sites in the North Carolina building region where tablet computers were used as standard ICT equipment by production site management staff. During these two site visits I participated in meetings and conversations with two superintendents and three site work supervisors who used tablet computers in the field on a daily basis. Then followed a two day conference of the Skanska tablet projects, where representatives of the tablet projects at Skanska USA Building, Skanska Sweden and Skanska UK were participating, as well as people from different mobile ICT developers and software vendors. The purpose of the conference was to share experiences within Skanska of the tablet computer tests between the different countries and exchange new ideas for further development of the respective tablet projects. I documented in detail both the site visits and the conference proceedings in North Carolina in journal notes as they occurred. During all events of the North Carolina study visit, I closely tracked the user champion and the project manager of the Stockholm tablet project. The purpose of this was to interpret my observations of events also through the actions, conversations and comments made by these individuals while the events were taking place. Observed events in my journal notes were therefore highlighted with additional comments of expressed views and opinions by the Stockholm tablet project manager and the Forum Nacka user champion of the same experiences. At the end of each day of the North Carolina visit I made informal follow up interviews with the user champion and the project manager of the Stockholm tablet project. Through these conversations I took notes of their reflections of the experienced events during the day and possible new ideas that had emerged during these experiences that related to the tablet computer tests back home in Stockholm. In this way, I documented expressions and interpretations of their individual sensemaking of the events observed during the study visit in North Carolina and their perceived connections of meaning relating to the Forum Nacka tablet project.

My research, both empirically and theoretically, can be summarized as an 'interpretive' approach. Interpretive methodology has emerged as a valid and important practice of studying ICT in organizational contexts (see for example

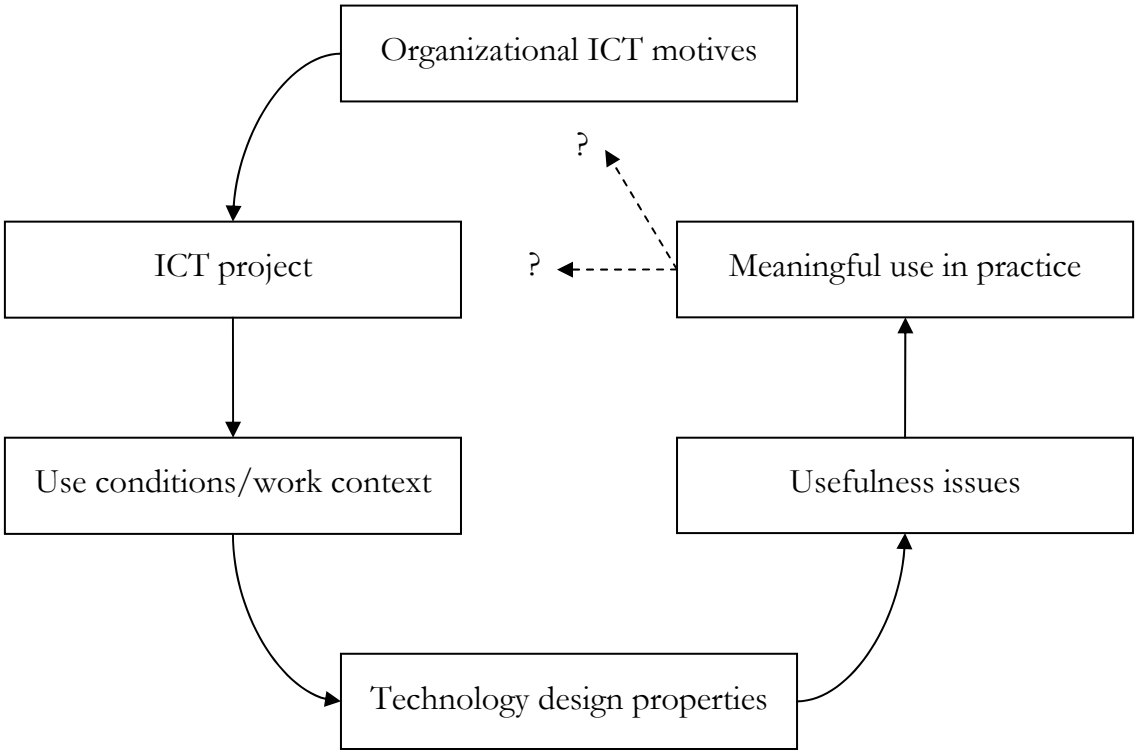
Walsham, 1993; Klein and Myers, 1999). Research can be classified as interpretive if it is focused on gaining understanding of 'reality' through social constructions such as language, consciousness, shared meaning, documents, tools and other artifacts (Klein and Myers, 1999). This usually involves studying real life complexities of for example human sensemaking and change processes in social contexts. Relating to Walsham (1993), interpretive research methods of ICT issues in organizations can be described as aiming at producing an understanding of the context of technology, and the processes of which the technology influences and is influenced by the context. Klein and Myers (1999) particularly describe one type of interpretive research which I specifically comply and adhere to, namely the 'interpretive field study'. Klein and Myers's definition of a field study is helpful in further positioning my research, as it may include both general case studies of ICT in organizations (such as Walsham, 1993) as well as more specific 'ethno' oriented approaches (such as Suchman, 1987). Klein and Myers (1999) have developed a manageable and practical set of seven principles for conducting and evaluating interpretive field studies of ICT. I will now show how these seven principles of 'the hermeneutic circle', 'contextualization', 'interaction between the researcher and the subjects', 'abstraction and generalization', 'dialogical reasoning', 'multiple interpretations' and 'suspicion' have been employed to improve the quality of my research efforts and results.

The hermeneutic circle

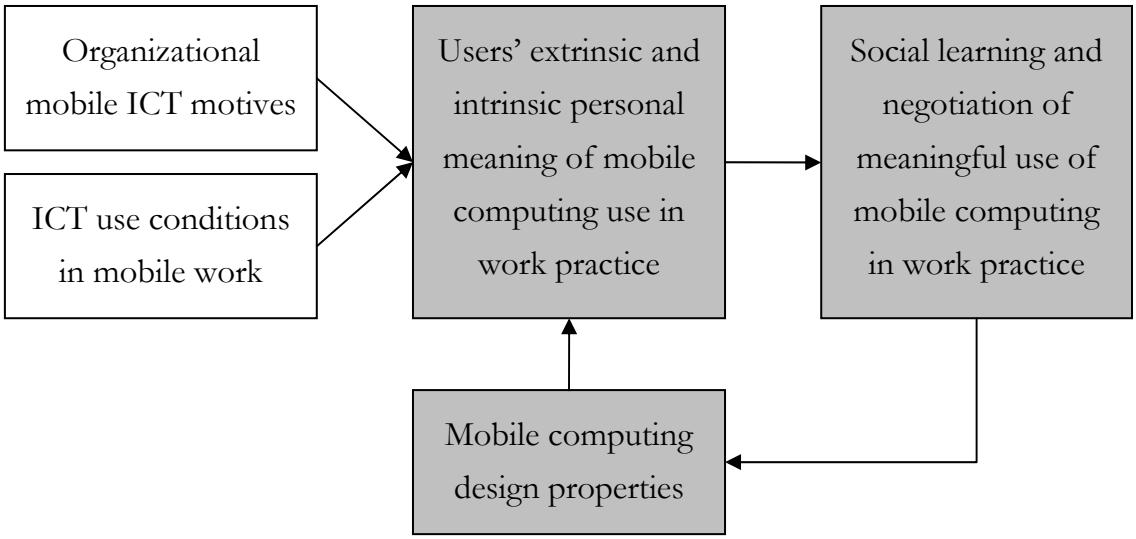
The principle of the hermeneutic circle is an overall guiding principle of the interpretive field study approach on which all of the following six principles expand. The idea of the hermeneutic circle is essentially about understanding a complex 'whole' from preconceptions about its 'parts' and their interrelationships. 'Understanding' as iterative cyclic interpretation is central. The progress of understanding is constantly moving from the whole to the separate parts and back to the whole. Depending on the study, the whole and the parts can of course imply a variety of 'meaning'. The parts can be factors of a historical tale, and the whole then represents the described perspective of the historical context. In other cases such as this study, the parts are the interpretive researcher's and the studied actors' pre-understandings of certain conditions and phenomena, and the whole consists of the complex shared meanings that emerge from the interactions between them. During repeated cycles of the hermeneutic circle, all of the other principles can be

applied iteratively, forming a complex web of interpretations of the parts, the whole, and the understanding of them. Klein and Myers (1999) suggest that the researcher could use the hermeneutic circle principle to move back and forth between different interpretations of the field study material using the other six principles with the goal of filling in gaps of the researcher's own interpreted data.

There are two fundamental hermeneutic circles of my research, namely the overall scope and journey of the thesis and its analytical framework, both described in previous chapters and illustrated once again in the two following figures.



The scope and the journey of the thesis as 'hermeneutic circle' 1



The analytical framework of the study as 'hermeneutic circle' 2

These two hermeneutic circles are of course related to each other. The first hermeneutic circle, the overall scope and journey of the thesis, illustrate the whole of the study as a search for interconnected usefulness perspectives ultimately starting and ending with organizational ICT motives and ICT projects. This search is based on the defined parts of evolving theoretical preconceptions and the specific organizational study context at Skanska. The second hermeneutic circle is a restructuring of the first that reformulates the overall goal of the thesis into an analytical framework of the study that is approachable and researchable in practice. This central hermeneutic circle of my research consists of the evolving micro level understanding of the development process of mobile computing usefulness in the studied case at Skanska as a whole, and in which sensemaking, negotiation of meaning and adaptation of technology design properties are parts. In the discussion of the case study in chapter 5, I specifically return to the separate parts of the analytical framework, highlighted in gray in the figure above. In the epilogue in chapter 6, I relate the results of the research back to the first hermeneutic circle of the overall scope and journey of the thesis.

Contextualization

Contextualization of the case study, together with initial abstraction and generalization of theoretical standpoints, is what I mainly have done in this thesis so far. The contextualization principle is about describing the subject matter and set it in its social and historical study context so that the intended audience can see how the current situation under investigation emerged (Klein and Myers, 1999). When a researcher conducts interpretive field research, the results of the study are influenced by the social and historical context of the organization and the research itself becomes a part of the organization's future history. In line with the recommendation of Klein and Myers (1999), I have therefore persistently tried to observe and depict the studied context and its participants as 'producers' instead of just 'products' of the social environment and its history. The emergent theme of the study context and its actors has been a fundamental standpoint throughout my research, which is openly illustrated in the representation of it in this thesis.

Interaction between the researcher and the subjects

In interpretive research of social contexts, data are not just waiting to be gathered. The researcher, the studied subjects and their interconnected interpretations of the social context are all part of the process of the construction of understanding of the study (Klein and Myers, 1999). The data collected for this thesis is nothing but 'interpreted data' based on my preconceptions of the study and my interactions with the research context and its participants that continuously shaped the reproduced interpretations of my observations in this thesis. It is therefore important to recognize that the studied subjects, maybe as much as me as a researcher, play an important role in forming the resulting portrayal of the case and the analysis of it. For example, the studied actors at Filmstaden were affected by my presence in the work environment, even though I did not directly took part or interfered in their work. The construction site management practitioners at Filmstaden knew that my purpose of being there was to study the use of ICT in course of their everyday work. Consequently, I became the 'trigger' for them to start reflecting about their ICT use situation. It is quite reasonable to suggest that they normally would not reason about this matter, at least not to the level of extent that my presence made them do. Also, during my interviews at Filmstaden, the practitioners were talking about concepts and issues relating to ICT use that they maybe in fact had no

opinion about. As a result, they may have given me answers to my questions that they thought that I wanted to hear, rather than saying 'I don't know' or 'I haven't thought about that really'. A large part of the research task at Filmstaden was therefore to continuously build a sense of trust between me as a researcher and the site management practitioners as study subjects, in order for them to talk to me and talk to others with me present more freely without restrictions. Through being invited to and attending several social events during my study period at Filmstaden, such as a crayfish party and various after work gatherings, I experienced that the site management practitioners gradually regarded me with less 'suspicion' and talked more freely directly with me, as well as with each other and with other participants in my presence. The latter was important for me to become an accepted background element in the practitioners' work at Filmstaden, so that I almost could act as a 'fly on the wall' that they did not pay too much attention to, or did not make them feel uncomfortable.

In the Forum Nacka tablet project case study, it was easier for me to blend in as if I was a real member of the pilot project team, even though I in fact was an external participant observer. I also think my educational and professional background in ICT and my research experiences at Filmstaden may have made the tablet project participants feel that I was a somewhat 'trustworthy' individual that understood the fundamental and often conflicting perspectives of ICT use in production site management. I felt that the tablet project participants at Forum Nacka did not perceive me as an intimidating element, but rather as an external reviewer of the project who could document and analyze the venture from a broader perspective that was not biased by for example a one-sided political agenda within Skanska. I actually experienced that all studied participants of the Forum Nacka tablet project felt a certain trust in me and spoke openly and frankly in conversations about the use and usefulness of the tablet computer. Additionally, the tablet projects already contained the necessary trigger for the participants to continuously reflect upon and express their expectations and experiences of the technology, namely the tablet computer itself. With this conversational trigger in the form of an artifact, I became a passively observing participant during use sessions and feedback meetings of the tablet project, and I could conduct informal dialogues with the studied participants in relation these observed events. Instead of me asking participants about for example expectations and experiences of the tablet computer, the technology itself

in the hands of the studied actors were essentially triggering the conversations about its issues of use during my social interactions with them. The consequence of this was that I never formally had to setup interview sessions with the Forum Nacka tablet project participants that might have been perceived by them as awkward and strained 'interrogations'. Instead, these interview situations were carried out as a sporadic, thrifty and continuous flow of questions and an ongoing informal conversation with participants before, during and after observed use sessions and feedback meetings, with the purpose of trying to make the participants feel that my dialogue with them occurred as a natural part of the 'real' tablet project in the course of their everyday work.

The study of the tablet project in North Carolina did not imply the same direct interaction between me as a researcher and the subjects, as this case mainly was studied at distance. The study visit and the tablet project conference in North Carolina also required modest participation by me, as I mainly observed the events occurring and interaction between the participants as a background figure. Additionally, because I am living and working in Stockholm, the physical distance to the tablet computer case in North Carolina reduced my ability to directly participate and observe its day-to-day developments. This is also the main reason why I have chosen only to use that project as a comparative reference case to the Forum Nacka tablet project study in this thesis.

Abstraction and generalization

The principle of abstraction and generalization emphasizes the importance of relating the unique and specific context of study to general ideas and concepts. This does not necessarily imply testing of theory in a real life context. However, theoretical abstractions and generalizations should carefully be related to the field study data as they were experienced and collected by the researcher, in order for readers to follow how the researcher arrived at certain theoretical insights (Klein and Myers, 1999). I agree with both Walsham (1993) and Klein and Myers (1999) that validity of a case does not depend on the representation of the study in a statistical and neutral sense, but on the plausibility and cogency of the logical reasoning used in describing the case and the results of this process. In my case, it is important to acknowledge that the studied concepts such as 'usefulness', 'user acceptance' and 'meaningful use' are all matters of interpretations. Depending on

what theoretical perspectives are chosen, the description of the case and the analysis of it may look fundamentally different. In chapter 2, I tried to carefully describe my theoretical preconceptions of the studied matters, and generate the overall analytic framework of the research to help the reader understand from what conceptual viewpoints I have studied the case at Skanska. Also, in the portrayal of the case study material in chapter 4, I gradually introduce my interpretive perspectives by relating the case study description to relevant theoretical concepts in the literature. In that way, the reader can trace how many of the analytical standpoints of the field study evolved.

Dialogical reasoning

Pre-understanding of a case, in terms of for example contextualization and abstraction and generalization, is generally a necessary starting point for interpretive field studies. The dialogical reasoning principle then requires the researcher to confront these preconceptions that guided the original outline and theoretical perspectives of the research with the case study material that emerge through the research process (Klein and Myers, 1999). The empirical research findings may for example not fully support the initial preconceptions of the study, which require that the theoretical standpoints have to be extended, modified or even abandoned. The fundamental point of dialogical reasoning is to present the historical and intellectual basis of the research and its developments during the study proceedings as transparent as possible to the reader. In chapter 5, I explicitly discuss, extend and revise the initial analytical framework of the research in relation to the case study findings.

Multiple interpretations

The principle of multiple interpretations requires the researcher to examine the influences that the social context has upon the study by seeking and documenting multiple viewpoints of the studied actors and the reasons for them (Klein and Myers, 1999). Analysis of multiple interpretations may include conflicts related to for example power, economics and social values within the studied context. While the principle of dialogical reasoning is bout confronting the researcher's preconceptions with the case study material, the idea of the multiple interpretations principle is to confront possible conflicting interpretations of occurring issues and events among the studied participants in the field. In either case, revisions of the

researcher's preconceptions may be the outcome (Klein and Myers, 1999). As I declared in the introduction of this thesis, this study has not an explicit ambition of problematizing the political agendas and organizational motives for introducing and using certain ICT systems in organizations. These factors are merely taken as given preconditions for the studied case. In other words, the use of ICT at Filmstaden represents the 'default mode' of ICT use in production site management practice, and the decision of testing the tablet computer in this professional environment is already made within Skanska, whatever different corporate agendas for this decision may include. The focus of the research is therefore on the evolvement of technology usefulness issues in practice within the micro level of actors directly involved in the development of the Skanska case. Throughout the portrayal of the case in chapter 4, multiple interpretations and different perspectives of using mobile computing and ICT in construction site management from the involved participants is depicted and interwoven. The starting point of these multiple interpretations is the perceptions and opinions of the technology expressed by the site management practitioner users. These interpretations are then complemented and contrasted with the viewpoints of the involved ICT developers. However, it is important to acknowledge that it is not mandatory that conflicting interpretations between studied participants are present (Klein and Myers, 1999). There may be for example discussions of subject matters that are 'unknown' for some of the participants, and which they cannot relate to, or do not have an opinion about. Construction site management practitioners may not have familiarity of certain design properties of ICT systems, and ICT development professionals may not have detailed understanding of onsite work practice in order to relate this to useful ICT system design. In the portrayal of the case study findings at Skanska, I try to describe several of these interpretive aspects in the social sensemaking and negotiation of meaning of technology usefulness between the studied user-practitioners and ICT developers.

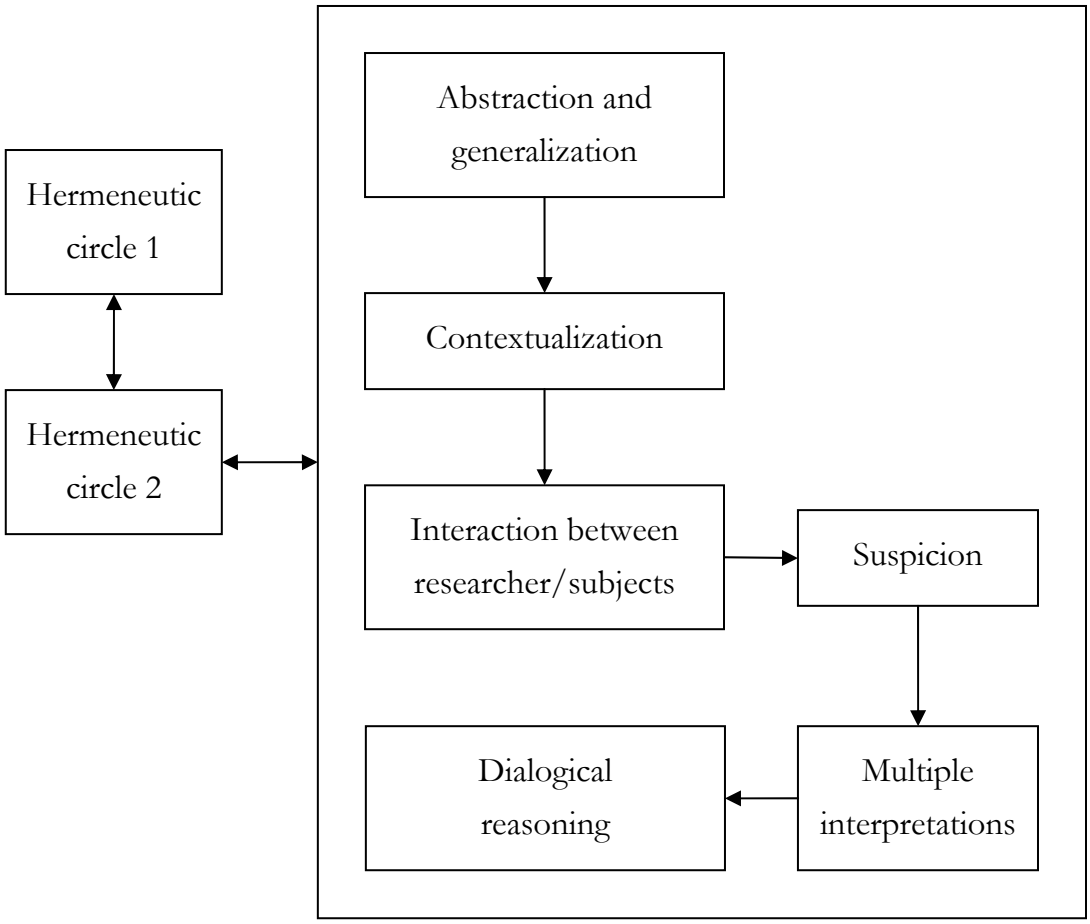
Suspicion

The principle of suspicion implies that the researcher should try to discover false preconceptions and 'consciousness' among the participants in the studied social context (Klein and Myers, 1999). This may for example imply analyzing details in the figures of speech to reveal distortions and fallacies in studied conversations between participants that show signs of deception of opinions and facts as well as underlying power struggles and differing interests in the organizational context. Due to the complexity of describing suspicion and considerable disagreement of what the principle should and should not include, Klein and Myers (1999) leave open that some interpretive researchers may choose not to follow this principle in their work. This principle has not been a guiding principle in my research. However, I can still relate my research efforts to some basic level of 'suspicion' in the sense that I have not taken for granted that all participants in the Skanska case study were at all times expressing their honest opinions and viewpoints about matters. This should not be interpreted as that I have suspected that the studied actors deliberately were not 'telling the truth'. However, the studied actors may at times have been contradictory in their use of ICT and their opinions about it, or that they may have expressed opinions about matters that showed signs of varying standpoints in different points of time. Therefore, I continuously tried to contrast opinions of individual participants with each other, which resulted in multiple interpretations of the case study findings. Also, I found it important to complement one-sided perspectives of discussed matters with interviews with other actors that were related to the specific issue, but sometimes from a fundamentally different viewpoint due to another professional role within Skanska. This was for example made during the study at Filmstaden, where I interviewed staff at the ICT unit at Skanska Sweden to obtain other perspectives of the issues experienced with ICT use in site management practice. Similarly, during the Forum Nacka tablet project case study, differing perspectives and opinions between the project manager, user champion and the technology design coordinator of the operating team during their project meetings and in conversations with me were continuously documented and compared. This was made as a consequence of my underlying suspicion of not getting a 'balanced view' of the developments of the case. As a result of this, I obtained multiple interpretations of discussed issues from three fundamental viewpoints – ICT governance/ICT project management (the project manager), practical ICT use in

construction site management (user champion as a representative of the test users), technical ICT adaptation and support (technology design coordinator). Additionally, I obtained opinions about the use of the tablet computer directly from the test users in their feedback meetings with the tablet project operating team. In the case of the tablet project in North Carolina, the information I obtained of the project was based on official case study documentation of the Duke University tests and the interviews and conversations with its initiator and user champion. This material was compared with my own observations during the study visit at Skanska USA building in North Carolina, and was related to the interpretations of the same events made by the project manager and user champion of the Stockholm tablet project. As a result, throughout the research at Skanska the suspicion principle indirectly guided me not to immediately take studied participants' views and opinions at 'face value', which resulted in a emergent form of method 'triangulation' of informants in a continuous and determined search for multiple interpretations of the studied social context and its proceedings.

Interdependence of the principles

Klein and Myers (1999) point out that the seven principles of interpretive research are not like bureaucratic rules of conduct that can be applied equally to every form of study. The researcher carefully has to consider how the principles relate to the background, context and purpose of each unique study, and also reflect upon how the principles are interconnected in the research process. All principles are usually not equally applied to all types of field studies because some of them are more central than others depending on the circumstances of the research. However, the researcher should not just select some of the principles and explain those as governing for the study, while simply ignoring the rest of them. The researcher should instead explain how the principles relate to each other in the specific study, as well as what principles have been more guiding and what principles have not been as prioritized during the course of research (Klein and Myers, 1999).



Interdependence of the principles for the study

The figure above illustrates how the seven principles just described are interconnected to each other in relation to my interpretive field study at Skanska. It shows the two hermeneutic circles as the evolving understanding of the 'whole' of the research on which the six other principles expand. Hermeneutic circle 1 describes the overall scope and journey of the thesis, starting and ending with formation of organizational ICT motives and ICT projects. Hermeneutic circle 2 describes the reformulation of this overall understanding into an analytical framework for the research. From the second hermeneutic circle the study then became concretized via initial abstraction and generalization of analytical concepts and contextualization of the case study setting at Skanska. Through the described approach for the interaction between me as a researcher with the studied subjects, an underlying suspicion of obtaining too little information and an unbalanced view of the case continuously induced me to seek multiple interpretations of observed proceedings from different sources within the social research context. The principle of dialogical reasoning then enabled me to discuss the interpreted case study data in

relation to the evolvement of initial theoretical concepts, and to link the research back and forth between the second hermeneutic circle and its underlying principle parts. Conclusions of the research were generated through expanding the broadened interpretations of the case study findings and the analytical framework of the second hermeneutic circle, and discussing them in the context of the overall scope and journey of the thesis of the first hermeneutic circle.

The seven principles of interpretive research can also be related other evaluation frameworks for conducting and evaluating qualitative research in real life environments. One such common framework is the requirements of 'trustworthiness' suggested in Lincoln and Guba (1985). Three of the four trustworthiness criteria – credibility, dependability and confirmability – are indirectly covered by the scope of the seven principles discussed. The forth criterion for trustworthiness, 'transferability', is not explicitly discussed as a trait of interpretive research in Klein and Myers (1999). Transferability is essentially about providing enough information of the studied case to allow for comparison with other contexts. However, the way I interpret and use the principles of Klein and Myers (1999) is that transferability of an interpretive field study can be made through dialogical reasoning between the analytical standpoints and the case study material in order to revise initial preconceptions of abstraction and generalization of the research. In the last two chapters of this thesis I relate the theoretical-empirical discussion of the study back to the overall hermeneutic circles of the research, and thereby generate open-ended 'moderate generalizations' (Payne and Williams, 2005) of my improved understanding of them. These generalized perspectives can then be confirmed or rejected by for example researchers and practitioners acting in similar organizational and technological contexts.

Representation

During this research project, I gradually have felt that I wanted to move away from the details of particular situations and events observed in the Skanska case study written down in lengthy collections of interpreted data, to instead focus on the 'big picture' of developments of the studied case. Therefore, I have actively tried to reduce my relentless notes from ICT use situations, conversations, interviews, meetings, and everyday events to a coherent story of ICT usefulness development in a real life setting. This is not a 'full story', it is simply an interpreted representation

of the case based on my observations, perspectives and evolving understanding. The story is inevitably influenced by my educational and professional background in ICT management, as well as my particular interest in the ICT usefulness issues of the Skanska case. Therefore, there are certain perspectives I actively have chosen to acknowledge, as well as put aside, in order to focus and delimit the central purpose of the study. So, the research has been a persistently ongoing interpretative process, from the first observation and journal note at Filmstaden to the last sentence of this thesis, based on the seven principles described in the previous sections. I will finish this method chapter by explaining how I have chosen to represent the extensive collection of journal notes and transcripts from the Skanska study in the portrayal of the case that follows in the next chapters.

The representation of the study at Skanska is not going into details of analyzing specific conversations between the involved actors, or between participants and me. As I have pointed out, the level of analysis is on the ongoing results of these conversations and the developments of usefulness issues of the case over time. Similarly, even though details of using ICT applications among the fieldwork practitioners were studied, this is not represented in the case description. I mainly studied ICT use activities of site management practitioners to be able to illustrate how they used the technology in their everyday work on a general level. In other words, ICT use sessions were studied to serve my own initial understanding of user-practitioners' sensemaking of the technology, which was valuable input in interpreting these individual perspectives in conversations between participants, and between participants and me. What is conveyed in the description of the Skanska case study is an integrated story of developing technology usefulness over time, simultaneously involving individual and social perspectives.

It is very popular in interpretive field study reports to reproduce 'scenes' or 'vignettes' of observed situations and events, combined with excerpts from interview records and journal notes. The purpose of this is usually to provide a more vivid and dramatic 'feel' for the case study context as well as particular circumstances and actions of participants. I acknowledge the value of this method of representation, but in my case I see a problem of creating a balanced representation of the study where some events are highly detailed and dramatically portrayed, while most others are just briefly described as processes over time.

Therefore, I have tried to depict the 1,5 years of case study material at Skanska at the same level of detail, namely illustrating a range of interpretations of the overall evolvement of the case over the studied time period.

The representation of my study is partly inspired by the reduced 'narrative explanation' often employed in process research (Poole et al., 2000). This process oriented narrative approach is commonly documenting the contributions, actions and events of different actors in the studied social context, but then configures and summarizes these parts into a whole episode illustrating the 'big picture'. Further, I have chosen to depict the story of the Skanska case in a condensed form that can be related to a 'realist tale' (Van Maanen, 1988). This form of representation implies that I am not 'visible' in the representation of the study. For example, instead of formulations such as 'I saw the practitioner use the tablet computer during production meetings', I describe them in forms as 'the practitioner used the tablet computer during production meetings'. The realist tale representation has been criticized for trying to reproduce the researcher's subjective observations as if they were 'objective facts'. However, I have at this point clearly explained that the research of this thesis is an interpretive study where the fundamental perspective is that all data representation is based on socially constructed interpretations of case study findings based on the researcher's preconceptions and emerging understanding of the research. The discussion of concepts such as 'objectivity', 'fact' and 'truth' is therefore not applicable to this kind of hermeneutically grounded research. Consequently, all descriptions, reasoning and discussions of the case itself and in relation to theoretical standpoints in this thesis is nothing but my 'voice' reproducing the interpretations of the research based on my evolving understanding of the study before, during and after it was carried out.

Collected material

The interpretive representation and analysis of the research presented in this thesis is based on the following case study material collected at Skanska during August 2004 to January 2007.

Filmstaden, Stockholm:

- Journal notes of an uninterrupted daily participant observation study of the production management team, eight individuals in total, during the period of 2005-08-18 to 2005-12-20.
- Official transcripts from daily production meetings during the period of 2005-08-18 to 2005-12-20.
- Journal notes from production team feedback meeting, 2005-10-19.
- Interview with production manager 1, 2005-09-22.
- Interview with production manager 2, 2005-10-20.
- Interview with superintendent 1, 2005-11-18.
- Interview with superintendent 2, 2005-11-18.
- Interview with site work supervisor 1, 2005-10-19.
- Interview with site work supervisor 2, 2005-10-19.
- Interview with site work supervisor 3, 2005-11-18.
- Interview with site work supervisor 4, 2005-11-18.

Complementary interviews:

- Head of ICT security, corporate staff ICT, Skanska AB, 2005-08-26.
- District manager, Stockholm region, Skanska Sweden, 2005-08-18.
- Procurement coordinator, Stockholm region, Skanska Sweden, 2005-08-26.
- Head of ICT, ICT unit, Skanska Sweden, 2005-08-31.
- Project ICT coordinator 1, Stockholm region, Skanska Sweden, 2005-09-14.
- Project ICT coordinator 2, Stockholm region, Skanska Sweden, 2005-09-27.
- Data communications manager, ICT unit, Skanska Sweden, 2005-09-23.
- Regional ICT coordination manager, ICT unit, Skanska Sweden, 2005-09-27.
- User terminal and support manager, ICT unit, Skanska Sweden, 2005-10-07.
- Development and maintenance manager, ICT unit, Skanska Sweden, 2005-10-18.
- Administrator of the intranet knowledgebase, Skanska Sweden, 2005-11-16.

Tablet project, North Carolina:

- Case study report of the first tablet pilot project at Duke University, North Carolina, Skanska USA Building, August 2005.
- Telephone interview with initiator/user champion/development coordinator of the tablet project at Duke University (later the global coordinator of the tablet projects within Skanska), North Carolina, Skanska USA Building, 2005-09-21.
- Journal notes from construction site visit at Raleigh Convention Center in North Carolina, including meetings with 2 superintendents using tablet computers, Skanska USA Building, 2006-11-01.
- Journal notes from construction site visit at the Biotechnology Education Center in North Carolina, including meetings with 3 site work supervisors using tablet computers, Skanska USA Building, 2006-11-01.
- Journal notes and project presentations from 2 day conference of the Skanska tablet projects (Skanska USA Building, Skanska Sweden and Skanska UK), Durham, North Carolina, 2006-11-02 and 2006-11-03.

Tablet project, Stockholm:

- Journal notes from whole day start-up meeting of the Stockholm tablet project, control group and operating team, Skanska headquarters, Stockholm, 2005-10-03.
- Journal notes from whole day tablet computer workshop, control group and operating team, construction site Sjöstadsskolan, Stockholm, 2005-10-04.
- Journal notes from tablet project operating team meeting, Skanska headquarters, Stockholm, 2005-10-10.
- Journal notes from 5 half day participant observations of tablet computer use in construction management practice (6 test users), Forum Nacka, Stockholm, during the period 2005-10-28 to 2006-06-07.
- Journal notes from 5 feedback meetings (tablet project operating team and test users), during the period 2005-10-28 to 2006-06-07.
- Telephone interview with tablet project user champion, Forum Nacka, Stockholm, 2005-10-18.
- E-mail conversation with tablet project manager, 2005-10-18.

- Journal notes from use session of Skanska's ICT based project management tools with user champion, Forum Nacka, Stockholm, 2005-10-19.
- E-mail conversation between user champion and tablet project manager, 2005-10-27.
- Interview with tablet project user champion, Forum Nacka, Stockholm, 2005-10-28.
- Interview with tablet project technology design coordinator, Skanska headquarters, Stockholm, 2005-11-15.
- Journal notes from meeting between tablet project operating team and a handheld computer device manufacturer, Skanska headquarters, Stockholm, 2005-12-15.
- Interview with tablet project user champion, Forum Nacka, Stockholm, 2005-12-20.
- Interview with tablet project manager, Skanska headquarters, Stockholm, 2006-05-11.
- Journal notes from consultant meeting between tablet project operating team and a wireless ICT analyst, Skanska headquarters, Stockholm, 2006-05-30.
- Journal notes from whole day workshop, global tablet project coordinator and the Stockholm tablet project operating team, Skanska headquarters and Forum Nacka, Stockholm, 2006-06-07.
- Telephone interview with the tablet project user champion, 2006-12-01.

4 SITE SEEING

Reflective practice and ICT use

Before going deeper into the study of the tablet projects, this section will further describe the ICT use situation in construction site management practice at Filmstaden. The findings of the initial case study at Filmstaden is elaborated to illustrate some of the common issues relating to ICT use in construction site management practice at Skanska that the tablet projects partly intended to address.

A notable element about everyday work of the construction site management team at Filmstaden was the highly informal nature of their communication, social interaction, problem solving and decision making. In the field, production site management practitioners were engaged in face-to-face interactions with other fieldwork participants to direct and coordinate personnel and work activities. This often included last minute changes of planned work, as well as adaptation and improvisation of work activities in order to continuously direct the construction process forward. The whole production site workforce relied heavily on the use of mobile phones for communicating with people who were not physically present, for example communication between construction workers in the field and production site management personnel in the site office, or between site management professionals and project actors situated at locations offsite.

Most production related decision making processes were outlined in a large amount of meetings. Some of these meetings concerned the overall planning and execution of the project as a whole, where representatives of the client and the project manager, building design coordinators and production managers participated. These meetings often resulted in indirect guiding decisions for the physical production process, typically concerning changed time schedules for production activities. Beyond these meetings, a large amount of different production meetings were held at Filmstaden on a daily basis. Some of them only included the core production site management team of production managers, superintendents and site work supervisors, while other meetings involved representatives of the construction site workforce as well as subcontractors. These frequent production meetings resulted in

daily decisions and changes of production activities on site. Problems occurring on site were continuously discussed during the production meetings at Filmstaden. These issues typically involved errors in delivery of building material to wrong site locations, deficient advance planning of production processes as well as conflicting and unsatisfactory completion of work activities. Much of these production problems were caused by deficient information exchange and communication between managing and executing personnel on site (meeting minutes and journal notes, Filmstaden, 2005-09-01). The proceedings of the meetings were written down in official meeting minutes and distributed to the involved parties. These meetings and their resulting transcripts were important in order to continuous monitor and document the progress of the Filmstaden production operations as a whole. For the meetings that related directly to the physical construction site work process, their resulting documentation was both official records of production planning events, as well as binding documents for decisions of specific site work activities and whose responsibility it was to carry them out. The production managers at Filmstaden were responsible for authoring and distributing all production related meeting minutes, which resulted in a lot of time spent at their computers in the site office after these meetings.

When divergences between planned and actual work in the production process at Filmstaden were detected on site, deviation reports were produced by the production site management personnel, normally conducted by superintendents and site work supervisors. Deviation reports included detected errors in drawing plans and specifications, as well as issues of planned, ongoing and completed site work activities. When such errors and faulty events were discovered, deviation reports had to be produced, even if the detected incidents did not result in any rescheduling of the production process or additional costs for the project. When deviations involved work carried out by external subcontractors and consultants, it was important to quickly inform the involved parties in order for them to correct the issues a soon as possible. Producing deviation reports was a central ongoing element of everyday work for the production site management team at Filmstaden, as it was vital for the continuous progress and follow up of daily site work activities and documentation of unexpected conflicts and changes of the construction process as a whole. A discovered deviation was normally first written down in the field. The issue was then discussed among other members of the production management team and

transcribed into an official report on the computer. Thereafter, the concerned participants were contacted in order to start solving the problem. The superintendents at Filmstaden expressed that these current deviation reporting procedures were not very effective as they demanded too many steps and were taking too much time in the course of everyday work (journal notes, Filmstaden, 2005-08-26).

There were frequent problems at Filmstaden associated with local planning and coordination of site work activities that caused a good deal of delays in production process. One production manager at Filmstaden expressed that the assignment and coordination of responsibilities of site work activities often were vague and that there was generally very limited time for advance planning of delegated tasks between site work teams (interview, production manager, Filmstaden, 2005-09-22). The construction site management team often had to be at two places at the same time – at the site office doing administrative work at their computer as well as being out on the site coordinating work. Improved routines and tools to achieve better control and planning of building activities was perceived as critical for improved performance of everyday production operations (interview, production manager, Filmstaden, 2005-09-22). A large number of delivery delays and design deviations resulted in increased efforts of production management personnel in handling swift drawing modifications and acute on site construction adjustments (production meeting minutes, journal notes, Filmstaden, 2005-09-02, 2005-09-28). One production manager at Filmstaden had become increasingly frustrated that time plans and specifications of critical onsite construction activities were not properly distributed to all involved parties of the production process (journal notes, Filmstaden, 2005-09-29). Without adequate information of field work activities, site work activities could not be fully coordinated and sequenced, resulting in improvised execution and delays of the building process. Although much of the improvisational production work at Filmstaden caused frustration among the production management staff, they frequently pointed out that all events onsite could not be foreseen or planned. One site work supervisor expressed that a large part of the coordinating work was to solve problems as they occurred. Most of these situations in the field implied using mobile phones to get in touch with the right people, finding additional information about an issue in plans and

specifications, and collaboratively finding alternative solutions to problems (journal notes, Filmstaden, 2005-10-19).

In the continuous proactive routines to increase and secure fieldwork safety at Filmstaden, numerous environment and safety inspection rounds were conducted on site. During these inspection rounds, the responsible production manager together with a few other individuals from the core production site management team reviewed the overall onsite environment of tools and machinery, as well as specific critical construction work locations, and safety clothing and equipment of individual personnel. They checked the status of the work setting and took notes with pen and paper of onsite issues that needed swift corrections in order to meet the high demands of fieldwork safety that is required within the standards of Skanska. Similar to the administrative procedures of deviation reports, the production managers at Filmstaden then used a computer document template obtained from Skanska Sweden's intranet knowledgebase to transcribe the notes into official reports of the environment and safety rounds, which then were stored on a shared project document server. The corrective measures resulting from these weekly safety inspections were initiated and controlled by the responsible production manager, and detected issues from one inspection were normally rectified before the next environment and safety round (journal notes, Filmstaden, 2005-09-28).

Quality inspections of completed construction work were another important area of documentation for the production site management team at Filmstaden. The quality inspections included audits of critical building checkpoints such as damp, insulation, ventilation and sanitation, but also the general methods of completion of construction work. Skanska Sweden as the design-build contractor created the overall quality control program in the beginning of the Filmstaden project, and an external client representative was responsible for controlling the total quality of the constructed buildings. The quality of completed individual construction work activities was inspected by the persons who performed them, so called self audits. These self audits were in practice carried out by the superintendents and site work supervisors, as many of the construction workers and subcontractors in the field did not carry the necessary documentation equipment with them in the field. The quality inspections therefore resulted in increased administrative documentation

burden for members of the production site management team, both in the field and then when these audits were transcribed in report templates on the computer (journal notes, Filmstaden, 2005-10-20). The external total construction quality inspector reviewed the completed self audit reports produced during production and complemented these with own inspection rounds of the buildings to make sure that the construction was carried out according to regulation of municipal authorities and the demands of the client.

As the above description tries to illustrate, there were extensive requirements and obligations of documentation activities of the production site management team at Filmstaden involving both internal and external quality standards that regulated the continuous audits of construction quality, as well as the procedures for transcribing and storing historical project proceedings and data. Every meeting transcript, drawing, safety round record, deviation report and other continuous documentation of the project were stored centrally in digital format. Even though these demands were appropriate from a quality assurance point of view, they were frequently causing double amount of administrative work for the production site management team at Filmstaden. Documentation of construction work activities, production meetings and various inspections had to be carried out twice; once when they were actually occurring and then again using computer document templates which were then uploaded on a central document server and e-mailed to all involved project participants.

Creation, updates and revisions of digital drawings and specifications often lead to confusion among the construction site management team at Filmstaden. A web based project collaboration extranet was intended to be used by all involved project participants for shared document management purposes, most importantly for revisions of digital drawing files and notifications of made changes in building documentation. But this communication and distribution of project documents was often conducted via e-mail instead. Involved parties regularly used e-mail distribution lists to send and receive changes made in drawing files and production documents. Swelling mailboxes with distributed documents as well as problems of identifying the correct files that contained the properly updated project information contributed to general confusion. At Filmstaden, this resulted in that involved participants of the project from time to time were using different versions of a

specific set of plans and specifications in their work (journal notes, Filmstaden, 2005-10-18).

During a large project feedback meeting at Filmstaden the whole production staff including site management and site workers shared and discussed experiences of the ongoing production operations (journal notes, Filmstaden, 2005-10-19). The main topic of discussion during this meeting was the frustration of that there were numerous external factors of the production environment that were beyond managers' and workers' control, which had a direct affect on the everyday work of the construction site operations. These factors were foremost how the work procedures of supporting staff functions and supplying business units within Skanska Sweden as well as suppliers and subcontractors from other organizations frequently were interrupting the production at Filmstaden. The discussion pointed out that these issues often related to differences in information procedures between project participant organizations and deficiencies of communicating the expected and required work of involved parties from a production viewpoint. Corporate support units and ICT functions at Skanska, subcontractors and suppliers focused on their partial delivery of the construction project business chain, and organized and conducted their businesses very differently compared to the site production setting. Many external parties did not seem to fully understand the delivery requirements of their work contributions in order to make these correspond to the needs of the production environment (journal notes, Filmstaden, 2005-10-19). The feedback meeting also clearly showed a shared pragmatic production focused view on the execution of construction projects among the staff at Filmstaden. One example was their consensual negative critique of the architect who in certain parts of the building design had prioritized artistic ideas ahead of the practical and functional construction solutions, which had resulted in a range of tangible challenges regarding the completion of the building in practice. Another example was their complaints of the prefabricated building element supplier who they considered was more concerned about the outline of the manufacturing process, while the physical assembly process of the elements on site appeared to be neglected with many improvised adjustments and production delays in the field as a result. These examples indicated that the general shared opinion during this meeting was that whole construction project should be more centered around and concerned about the physical production process of the building. All design and planning

activities should therefore be more focused on how to better serve and improve a practical and efficient realization of the site based production (journal notes, Filmstaden, 2005-10-19).

The pragmatic production focused view on construction was also strongly reflected in the site management team's opinions of ICT use at Filmstaden. Their views were clear – in the same way as design, planning and prefabrication activities of a construction project should serve the actual site production process, ICT had to be better adapted to construction fieldwork management purposes in order to be meaningful to use in practice. The use of ICT at Filmstaden was perceived by the production site management practitioners as a partly obstructive element for effective performance of everyday work, as too much time was spent at the computer instead of being out on site managing and coordinating fieldwork activities. Still, they were highly dependent on Skanska Sweden's ICT systems platform in their professional work, which left them with no alternative to the existing ICT use situation. One production manager at Filmstaden was clearly annoyed that the ICT unit at Skanska Sweden did not seem to fully understand the situated reality of ICT use in the production work context. Some ICT systems had more or less been pushed out into the work organization without considering their suitability for the production context (journal notes, Filmstaden, 2005-09-14, 2005-09-22). One such example that was repeatedly mentioned by site management practitioners at Filmstaden was when the Skanska Sweden introduced a centralized procurement system with the ambition that all purchasing activities of every business unit and construction project were to be made through the system. This idea was sensible from a conceptual standpoint because central purchases could streamline and reduce costs of procurement activities across all construction projects of the firm. But the problem was that the design of the ICT based procurement system and its intended use procedures did not correspond to the habitual processes and accustomed behavior of procurement and purchasing activities in the production work environment. The clash between the new modern way of working with ICT based centralized procurement and the established decentralized local purchasing routines was immense, and the company was forced to revise their approach of outlining and gradually introducing the procurement system along with new use procedures that was more accepted by operating production site management personnel.

Skanska Sweden's intranet knowledgebase for construction project management was a central part of everyday ICT use at Filmstaden. The intranet knowledgebase was intended to be used as a standardized helping tool for planning, executing and documenting construction project activities. It seemed however that this ICT resource was not very well adjusted to the fieldwork production management environment. Both ICT staff at Skanska Sweden and the production site management team at Filmstaden expressed that one of the main problems of the intranet knowledgebase was that the frameworks and routines for administrative work and documentation in the construction site environment were well described and explained, but there was essentially no integration of these guiding resources with other existing project ICT resources (journal notes, Filmstaden, 2005-11-03; interview, regional ICT coordination manager, Skanska Sweden, 2005-09-27). As the intranet knowledgebase was constructed as a catalogue of documentation templates and explaining texts, it did not add any active supportive tools to actual performance of everyday work in the fieldwork setting. If the same procedural construction project management framework could be integrated with existing ICT systems and create appropriate production management applications for administrating site activities, it could be used more effectively and possibly reducing some of the present double documentation work procedures in the field (interview, regional ICT coordination manager, Skanska Sweden, 2005-09-27; interview, development and maintenance manager, Skanska Sweden, 2005-10-18; interview, administrator of the intranet knowledgebase, Skanska Sweden, 2005-11-16).

Over the years, there have been several bottom-up ICT projects at Skanska Sweden that explicitly targeted production fieldwork information and communication issues. These ICT ventures have often been isolated one off initiatives of single construction project organizations. Local technology keen construction project managers have regularly started these ICT ventures, more or less for the fun of it (interview, head of ICT, Skanska Sweden, 2005-08-31). But with no clear ICT management processes, these projects typically have been uncoordinated, poorly documented and essentially lead to nothing (interview, project ICT coordinator, Skanska Sweden, 2005-09-14). This recurring pattern of spontaneous local ICT projects have resulted in that accumulated financial, technological and organizational resources have been spent on testing new ICT systems and use processes, but with

no overall coordination of their gained outcomes that could have been distributed to the rest of the company for further learning and development (interview, user terminal and support manager, Skanska Sweden, 2005-10-07). Part of the learning process of incrementally separating effective technical ICT concepts from inadequate ones in the continuous development of fitting ICT applications for the production management work context have therefore been lost (interview, regional ICT coordination manager, Skanska Sweden, 2005-09-27).

The Filmstaden production site management professionals themselves were reflecting on their information and communication environment and the use of ICT in their work. They often expressed a clear view of what the benefits and problems were with existing ICT tools (journal notes, Filmstaden, 2005-11-03). Many of them understood the organizational ICT motives why Skanska Sweden over the years had developed the ICT systems platform that they now were required to use. The production site management practitioners at Filmstaden realized the potential benefits of using standardized ICT and established use procedures for all construction projects at Skanska Sweden and the consistency and control of the business processes and units this were intended to produce. Additionally, using the same ICT tools in project after project was also considered as favorable from the individual user-practitioner perspective, as such use behavior could contribute to a socially agreed, established and shared set of ICT use routines among participating actors which needed no renegotiation between one project to another (journal notes, Filmstaden, 2005-11-03). Still, all members of the production site management team at Filmstaden agreed that the existing ICT systems platform at Skanska Sweden was not adequately adapted to their everyday work in the field. The general opinion among the production site management professionals at Filmstaden seemed to be that the structure of existing ICT resources was too comprehensive and the procedures of using these systems in practice were not very well informed or explained. Fieldwork management practitioners were overwhelmed with all sorts of information and communication systems, but they did not always know how they were supposed to use them, or to what purposes. The unfocused use of ICT resulted in that the production team at Filmstaden perceived that they were spending too much time at the computer doing the wrong things (journal notes, Filmstaden, 2005-11-03). One production manager expressed that when checking the computer for new e-mail had almost become more important than practicing

onsite construction leadership, there was something unhealthy about the priorities of professional fieldwork management practice (journal notes, Filmstaden, 2005-11-03). This opinion was also shared by ICT staff at Skanska Sweden who regarded some routines and behaviors of ICT use in the production environment as ineffective because these were conducted on the expense of the performance of actual production activities in the field (interview, regional ICT coordination manager, Skanska Sweden, 2005-09-27). The issues of ICT use in production operations were also a product of that site management practitioners were so encumbered with administrative work activities that there was generally no time left for learning and developing new routines and effective use procedures of ICT on a day to day basis (interviews with project ICT coordinators, Skanska Sweden, 2005-09-14, 2005-09-27). Additionally, the onsite presence and engagement of the production management team at Filmstaden was frequently disrupted by too much computer work inside the site office. Improving the deficient management situation in the field was considered as imperative by the Filmstaden team.

Moreover, the construction site management practitioners at Filmstaden expressed ideas of how to change the use of ICT in order to improve their work situation. Improved portability of ICT resources to perform documentation and process information while taking part in fieldwork activities were generally considered as a main area of ICT development by the production management team at Filmstaden, an opinion also shared by coordinating ICT staff at Skanska Sweden (interview, project ICT coordinator, Skanska Sweden, 2005-09-14; interview, data communications manager, Skanska Sweden, 2005-09-23). Mobile access to e-mail and calendar with daily overview of planned activities and reminder functions were for example mentioned in these conversations (interviews with superintendents and site work supervisors, Filmstaden, 2005-10-19, 2005-11-18). The two superintendents explicitly and repeatedly expressed that enhanced mobility of ICT tools would allow them to perform better in the field. With wirelessly connected handheld computing devices they could quickly access the information and communication resources at the moment when they needed it, instead of running back and forth to the site office to obtain it. Especially fieldwork documentation, reporting and online purchase of building material, tools and machinery was considered to become more efficient if this could be done directly on a handheld computer onsite, instead of taking notes on a piece of paper and then transcribing

notes and placing orders once again when being at the desk in the site office (journal notes, Filmstaden, 2005-09-28, 2005-11-11). Due to the dependency of ICT use in supporting decisions in fieldwork administration and finding the time for performing them, commonly at Filmstaden was that site management activities were piling up before they actually were attended to and executed (interviews with production managers and superintendents, Filmstaden, 2005-09-22, 2005-10-20, 2005-11-18).

The superintendents at Filmstaden also highlighted an important link that should be created between deviation reporting procedures and the procurement purchase ICT system (interview with superintendents, Filmstaden, 2005-11-18). Detected construction work deviations often generate orders of additional building material to be able to finish job activities. If this is not dealt with immediately it could be left unattended for weeks. New daily management routines where a mobile computing device could be used in the field to document production deviations with complementing tentative orders placed in the procurement system could possibly enable improvements of this situation (interview with superintendents, Filmstaden, 2005-11-18). At the end of the day, deviation reports could then quickly be edited and finalized from the notes in the field, and purchase orders completed and sent, which in turn would generate more structured and integrated procedures for handling these administrative tasks during the course of everyday work. The Filmstaden team generally expressed that onsite use of mobile ICT could possibly enable increased presence and engagement of production management personnel in the field (journal notes, Filmstaden, 2005-11-03). The frequent and lengthy ICT use sessions inside the site office made site management practitioners at Filmstaden feel increasingly distanced and isolated from the construction site work teams. At the same time as site management practitioners were frustrated that they sometimes felt disconnected from the actions in the field, the site work teams often wondered what their managers were doing at their computers that was so important instead of supervising and coordinating the actual production activities. Having mobile ICT capabilities in the field could assist in breaking this negative trend of site management practice and improve leadership, teambuilding and collaborative understanding among participating professionals on site (interview with superintendent, Filmstaden, 2005-11-18).

Interestingly, some members of the production site management team at Filmstaden also reflected over some of the shortcomings that could arise from using mobile ICT in the field (journal notes, Filmstaden, 2005-09-28; interviews with superintendents, Filmstaden, 2005-11-18). Site management practitioners described scenarios out on the field when critical problems occur that may cause temperamental and indignant gushes of emotions. In some of these cases, instant mobile access of ICT resources could lead to rash conclusions resulting in incorrect decisions which may cause unnecessary conflicts with other project participants, or even lead to further construction costs or delays. For these frequently occurring scenarios in the field, it may be better not to have direct access to project data or to immediately get in touch with certain people (journal notes, Filmstaden, 2005-09-28; interviews with superintendents, Filmstaden, 2005-11-18). Instead, site managing staff could cool down, think things over and establish a nuanced picture of what actually occurred. A well considered decision could then be made at a later occasion that involves the accurate set of project participants and resources. Other issues of mobile computing that were reflected by production site management practitioners were the danger of information overload and the stress of always being online and reachable (journal notes, Filmstaden, 2005-11-03).

The study at Filmstaden showed the changing character of work situations of production site management practitioners, which reflects the adaptability requirements in handling complexity and uncertainty in professional practice in general (Schön, 1983). Work situations at Filmstaden often contained a mismatch between traditional patterns of practice and emergent features of situated everyday events. The Filmstaden site management practitioners had to find ways to make sense of complexity of everyday events and their use of ICT in trying to reduce uncertainty of arisen situations. They displayed a creative artistry of persistently adapting to situated events in their fieldwork practice which can be described as an ongoing 'conversation' with unique and uncertain situations, often referred to as 'reflection in action' (Schön, 1983). In the continuously ongoing adaptation of situated work practice, the issue is often not to identify how to solve a certain problem, but to identify what problem to solve, framing the relevant things, activities and context that have be dealt with. This reflective artistry of professional practice is therefore a often a matter of relentless 'problem setting' rather than just 'problem solving' (Schön, 1983). At Filmstaden, this was regularly done through

face-to-face meetings and conversations with other project participants as well as finding the right information and communicating with remote parties via the use of ICT. In this process, construction site management practitioners regularly had to handle the often occurring gaps between established professional competences and the dynamic demands of fieldwork practice in reality.

Relating the study at Filmstaden to project management practice in general, the production site management work at Filmstaden did not only imply a mere execution of a plan, but rather included constant handling of unexpected events (see for example Söderholm, 2008). In the complex and emergent context of project based work environments (see for example Engwall, 2003), it is not possible to assess and proactively manage all possible internal and external impacts that may occur during the completion of a project. Nevertheless, plans still have to be made. In the construction site environment at Filmstaden, plans assisted in shaping the expectations of the fieldwork production setting that were desirable, necessary and likely if actions were carried out without unexpected disturbances. Plans were the resources on which site management practitioners built the daily agenda of fieldwork activities, which then assisted them in directing their attention and guiding them in determining what to look for to confirm that their expectations were correct or incorrect. Nevertheless, the production operations at Filmstaden were to some extent ambiguous and filled with unexpected events because conditions continuously changed over time and things did not unfold as planned. In these often occurring situations, management personnel regularly engaged in reactive actions in order to manage the unexpected events parallel to executing the plan (Söderholm, 2008). Analogous to the analysis of project based adaptation in Lindkvist (2008), the construction site management practice observed at Filmstaden can be characterized as goal oriented according to project plans, but open-endedly adapted to how the goal should be reached and how emerging contingencies to plans should be handled.

Access to ICT based information and communication resources was critical in fieldwork management practitioners' reactive handling of and constant adaptation to everyday complexity and deviations from plan at Filmstaden. However, the use of ICT resources was a conflicting and ambiguous part of professional practice. At the same time as the construction site management team was dependent on using

Skanska Sweden's ICT systems platform in their daily work, these systems were not designed according to their needs and use patterns, forcing practitioners into unnatural and ineffective ICT use behavior on the expense of the performance of productive work. One such conflicting obstacle was the frequent need for rapid access to digital information in the field versus the fixed actual use of ICT located inside the site office. The deficient and inflexible ICT situation experienced on a daily basis by the production site management practitioners at Filmstaden triggered them to reflect upon how to improve these conditions, and they often expressed tangible ideas how existing ICT resources could be better adapted to their fieldwork setting. These expressed ideas can be related to Suchman's (1987) ideas of using computing systems as resources for 'situated actions' in real life contexts. Similar to the previous discussion of adaptive reflective practice and handling of unexpected events, Suchman (1987) argues that purposeful actions are inevitably situated actions. Situated actions imply actions taken in the context of particular concrete circumstances. The circumstances of actions are never fully anticipated and are continuously changing in the context in which they occur. Plans, on the other hand, are dependent on the circumstances in which they are invoked. Plans do not determine human conduct, but rather provide a resource through which individuals organize their own actions and interpret the actions of others. A statement of 'intent' to accomplish some 'goal' generally says very little about the detailed action that follows. Useful plans are inherently vague because they state intention without having to describe the actual course of action, and must therefore include and assist the unforeseeable contingencies of particular situations in everyday events (Suchman, 1987). Plans are located in the larger context of some ongoing practical activity and are often only formulations of previous conditions and consequences of actions that account for actions in probable ways.

Analogously, computing systems are regularly designed on a plan based model of human action, which confuse plans with situated actions (Suchman, 1987). The model treats a plan as something located in the user's head which directs this person's system use behavior. But, a planned system design does not determine the actual use in the course of real life actions or adequately reconstructs them. Instead, individuals use a planned computer system as a general resource for the conduct of particular situations. At the same time, an individual's purpose of using a system is constrained by its planned functionality and the actions of use are limited by the

system design. Suchman (1987) argues that there is an elementary difference between the physical design and planned use of computing systems and the socially interpreted use of computer applications in the situated real world, which constitutes a fundamental challenge when designing ICT systems for particular contexts of use. At Skanska Sweden, a comprehensive ICT platform had been built and modified for decades within the company for rational and planned purposes, including ICT tools for procurement, resource planning, budgeting and documentation. But the case study at Filmstaden indicated that the practitioners who were supposed to use these ICT resources in their situated fieldwork context, did not judge the usefulness of the systems only based on their physical design and procedures of use, but rather based on the practical meaning of using the technology in the unexpected and changing course of everyday work.

Further, Suchman (1987) argues that fully planned models of computing system design lead to problems with interfaces between users and applications that generally reflect the system designer's intentions regarding its use purposes, which may be very different from how users are perceiving technology use in practice. An adequate user interface is not just the physical interface itself by which an individual is purposefully interacting with an application on a computer terminal. It must also consider social and contextual aspects of using the technology in the practical work situation. This means that a computing system user interface in reality can either support or prevent its situated use in practice. In the case of Filmstaden, the data content itself of the ICT systems used by the production management team was not the direct issue of the problematic ICT work situation. Rather, it was the fixed desktop use conditions and the overwhelming extent of use that primarily made site management practitioners feel 'detached' from their colleagues and work activities in the field. Consequently, part of the problem of the ICT platform used at Filmstaden was not primarily about its purposeful design for planned use, but that the content of the ICT systems was delivered through an user interface that did not generate a meaningful use experience to the construction site management practitioners in supporting information and communication processes of the emergent and dynamic fieldwork environment.

Improved mobility of ICT resources was considered by the Filmstaden site management team as a required area of future ICT development. Construction site

management practitioners at Filmstaden expressed anticipation that mobile computing technology could assist in supporting the unexpected and changing site management practice by extending the access of information and communication resources to the real life actions and hands-on circumstances in the field. These viewpoints reflect purposeful intentions of using ICT in the fieldwork environment, rather than strictly planned actions of using the technology as such. The expressed ideas of using mobile computing at Filmstaden could be interpreted as what site management practitioners perceived was missing in their current use of ICT, and their opinions of how to make ICT a 'usefully vague' and adaptable resource for their emergent and dynamic fieldwork requirements. However, Suchman (1987) points out that extending access of computing resources into the context of users' situated actions may not be adequate to overcome deficient computer use. Another part of the problem is to make the user understand the limitations of the access to computing resources and their delimited set of functions. Wirelessly extending the ICT platform and using mobile computing devices in the field at Filmstaden will not change how the ICT systems themselves are planned and designed. Even though the access to ICT resources are extended into the hands of the user-practitioners on site, the shortcomings of the ICT systems and applications per se will be the same as previously. Therefore, using mobile computing technology for accessing existing ICT resources in construction site management practice will most likely cause new deficiencies of ICT use that will call for further design changes of the underlying systems infrastructure in order to adapt it to the complex use context in the field.

Expectations and experiences of mobile computing in practice

The general opinion expressed by production management practitioners at Filmstaden that they were spending too much time at their computers inside the site office was shared by the user champion of the Stockholm tablet project (journal notes, start-up meeting, Stockholm tablet project, 2005-10-03). The Stockholm tablet project user champion was working as a project engineer at the construction site Forum Nacka, the fieldwork environment that was the test site for the tablet computer trials at Skanska Sweden. The Forum Nacka user champion expressed initial positive expectations of the mobile computing technology in bringing the necessary ICT resources to the work activities in the field and improving the overall presence and leadership of production management staff on site. Better technical support for administration and documentation of production meetings was also of interest, as some production site management practitioners frequently were spending almost whole days on writing transcripts of previous meetings. If structured notes could be made directly with the electronic pen on the tablet computer during meetings, and then e-mailed to all parties immediately after the meeting, it could enable more effective meeting routines according to the user champion at Forum Nacka (journal notes, start-up meeting, Stockholm tablet project, 2005-10-03).

As indicated earlier, identified divergences in construction project setups, contractor responsibilities and production management work between Skanska in North Carolina and Stockholm resulted in different expectations of using the mobile devices in the respective tablet projects. The global tablet project coordinator encouraged the operating team of the Stockholm tablet project to use the technology for drawing update purposes, because of the positive experiences of this at Duke University (journal notes, start-up meeting, Stockholm tablet project, 2005-10-03). But the Stockholm tablet project operating team, and especially the user champion at Forum Nacka, considered that the handling procedures of drawings in Swedish construction projects were quite satisfying as they were. Instead, the user champion at Forum Nacka hoped that the tablet computer could enable working wirelessly with the existing ICT resources while being out on the construction site (journal notes, Stockholm tablet project, 2005-12-14). The global tablet project coordinator at Skanska, and former initiator and user champion of the tablet project

at Duke University, pointed out that it was vital to understand how field management professionals really work on site to be able to support it with fitting ICT tools. Experiences from Duke University showed that if the technology was not easy to understand and operate, it simply was not used (journal notes, start-up meeting, Stockholm tablet project, 2005-10-03).

Stockholm tablet project start-up workshop, October 2005

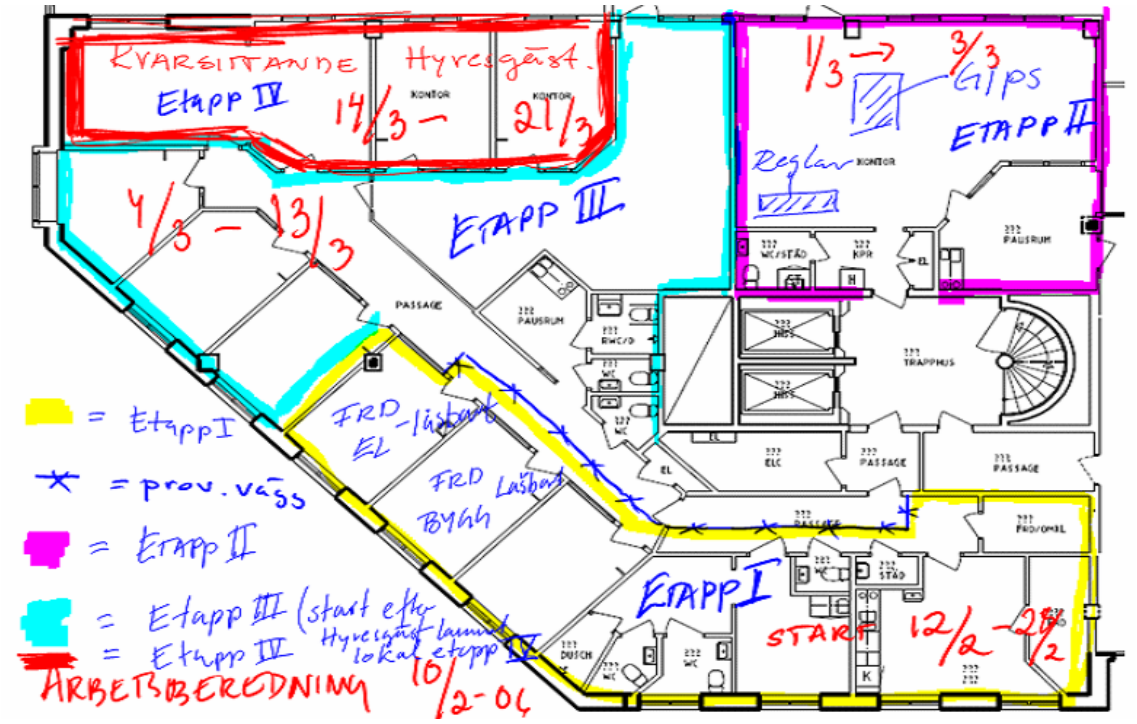
All six test users at Forum Nacka initially considered the tablet computer device as an enabler for wirelessly bringing ICT resources into the field to work more integrated with necessary information and communication tools while engaged in onsite construction management work activities. Also, having a wirelessly connected tablet computer as an active ICT resource during production meetings for accessing and viewing documents, taking notes and making sketches was anticipated by the site management practitioners at Forum Nacka to be a useful application area of the technology in everyday work (e-mail conversation between user champion and tablet project manager, Stockholm tablet project, 2005-10-27). Early on in the tablet project at Forum Nacka, the user champion expected positive effects of using the tablet computer together with Skanska Sweden's activity based project management

system. This system was used to set up and organize whole construction projects with detailed activity plans of assigned work events, resources and costs. Such a planned activity structure was then continuously followed up during the delivery of a project by allocating the degree of realization and actual costs to accumulated work activities. The activity based project management system was integrated with Skanska Sweden's overall business ICT systems platform which enabled the ability to periodically report on the execution status of a construction project. As the system automatically generated notifications of deviating ongoing and completed work activities in relation the preplanned processes, the activity based project management system enabled a simple tool for continuous handling of project deviations. The user champion expected that the use of the activity based project management system on the tablet computer in the field could improve procedures of documenting deviations and work activity changes directly in the production site environment (ICT use session and interview with user champion, Stockholm tablet project, 2005-10-19, 2005-12-20). The operating team of the Stockholm tablet project also wanted to consider more closely the possibilities of improving fieldwork documentation routines using document templates from Skanska Sweden's intranet knowledgebase together with the tablet computer. Especially onsite documentation of deviation reports, environment and safety rounds and self audits were considered to be interesting application areas of fieldwork management use of tablet computers (journal notes, start-up meeting, Stockholm tablet project, 2005-10-03). The test users at Forum Nacka also expected that working with digital fieldwork forms would be a good application area for the tablet computer device. They expressed that being able to perform inspections and documentation directly on the tablet computer on site would be a significant improvement compared to existing fieldwork administration routines. Instead of having to run back to the site office to access documents and data needed about an issue in the field and to write reports, the production site management team could then perform all documentation in the field with the tablet computer and send resulting reports and documents in digital format directly to involved parties. Such improved administrative routines together with wireless access to ICT resources on site could potentially save a lot of time for construction site management practitioners (journal notes, feedback meeting between operating team and test users, Stockholm tablet project, 2006-03-15).

Both tablet projects in North Carolina and in Stockholm showed that site management practitioners appreciated the combination of using digital cameras and markup sketching functions with the tablet computer pen to create more illustrative descriptions of documented issues in the field. They considered this combined use of technology to improve the frequent informal communication processes of problem solving between involved parties in the site production environment. One interesting feature of the tablet computer was a 'snipping tool', which was a pen based application for cutting and copying parts of documents and pictures and pasting them into other documents. The test users at Forum Nacka quickly saw the potential of the snipping tool to cut out parts of drawings and photos and use them in for example deviation reports (journal notes, feedback meeting between operating team and test user, Stockholm tablet project, 2006-03-15). The tool enabled site management practitioners to add new illustrative information of documented fieldwork issues, which could then be communicated in the problem solving processes between involved parties to enhance mechanisms of shared understanding of production activities (journal notes, feedback meeting between operating team and test users, Stockholm tablet project, 2006-05-04). Having the ability to take digital photos of construction site issues with a mobile phone camera, transferring these to the tablet computer where the pictures were edited, sketched and commented with the electronic pen was explicitly valued by the superintendent test users at Forum Nacka (journal notes, feedback meeting between operating team and test users, Stockholm tablet project, 2006-03-15).

The site management tablet computer test users at Forum Nacka frequently stressed that they often communicated construction work problems with other involved participants via photos and illustrations. The user champion pointed out that all information that was produced with the tablet computer did not need to be stored as text or structured data. The formalization of ICT use to produce text documents and structured data seemed to the user champion as something that was almost an 'end in itself', and that such narrow perspectives on ICT implied risks of destroying the social, collaborative and communicative aspects of ICT use (interview, user champion, Stockholm tablet project, 2005-12-20). The potential value of using the tablet computer device for informal use purposes was highlighted during the trials at Forum Nacka, such as making less structured but more illustrative fieldwork notes along with sketches, figures, additional digital photos and parts of documents.

Handwritten meeting minutes were made directly on the tablet computer device which resulted in more expressive forms of meeting documentation which could be better communicated to involved participants (ICT use session and interview with user champion, Stockholm tablet project, 2005-10-19). One example, shown in the figure below, was work preparation sketches made collaboratively and discussed during production meetings, which then could be e-mailed to all participants directly after the meeting,.



Work preparation sketch made on a tablet computer at Forum Nacka

The user champion considered that the problem with different file versions of drawings, plans and specifications during project meetings could possibly be improved by interactively working with the latest file versions directly on the tablet computer during meetings. With a tablet computer connected to a projector, the concerned information of a collaborative construction issue could be shown directly on a wall screen. Meeting participants could then discuss and make sketches and change suggestions with the electronic pen on the tablet computer device. When solution agreements of problems were fully negotiated among the involved parties, work copies of the concerned files could then be saved and distributed to involved parties for further assessment (user champion interview, Stockholm tablet project, 2005-10-18). Additionally, the user champion at Forum Nacka expressed that the

tablet computer could be useful as an audio recording tool during negotiating business meetings with subcontractors and consultants. During these meetings, conversations could be recorded with the tablet computer and a microphone. This information could then be retrieved and referred to in the events of conflicting views of contracts and responsibilities of production operations (user champion interview, Stockholm tablet project, 2005-10-18).

After a short period of using the tablet computers at Forum Nacka, the site management test users expressed that without a permanent wireless connection to ICT resources much of the benefit of using the device in the field was lost (journal notes, feedback meeting between operating team and test users, Stockholm tablet project, 2005-12-05). There seemed to be varying needs of availability and mobility of ICT resources among the practitioners at Forum Nacka. Some test users at Forum Nacka perceived the tablet computer as a fitting user terminal for their wide ranging dependence on both fixed desktop ICT use and mobile computing in their everyday work. Others had more limited ICT needs of working with mobile data in the field which required a lighter, more basic and less versatile handheld computing device. Matching diversified professional ICT mobility and connectivity needs in the production site environment with a range of different user terminals appeared to be important for the test users at Forum Nacka. This standpoint was also shared by the project manager and the technology design coordinator of the Stockholm tablet project (journal notes, feedback meeting between operating team and test users, Stockholm tablet project, 2005-12-05).

The test users at Forum Nacka highlighted several practical problems of using the tablet computer in the field. Now and then production management practitioners needed to deal with onsite work activities that required both hands. At these occasions the tablet computer device temporarily had to be put away in order to attend to these hands-on activities. The site management practitioners at Forum Nacka therefore wanted safe storage locations in the field, where tablet computers occasionally could be placed and kept protected to avoid that the devices were broken or lost (journal notes, feedback meeting between operating team and test users, Stockholm tablet project, 2005-12-05). Additionally, locations on site where tablet computer batteries could be recharged and changed were also requested by the test users at Forum Nacka, as the batteries of the used devices did not last a

whole working day (journal notes, feedback meeting between operating team and test users, Stockholm tablet project, 2005-12-05). At Duke University, the site management professionals carried the tablet computers as a shoulder bag on their backs in the field. The tablet project in Stockholm considered a similar carrying solution. However, the Forum Nacka test users found it critical to cut down the weight of the tablet computer device as much as possible, and to only carry around the equipment that was absolutely necessary. The technology would otherwise not be used, because it would be too cumbersome and impractical to handle in the field. If a slim device could be carried and used by practitioners on site to make schematic notes of fieldwork activities, the additional work to complete documentation processes could then be fulfilled at a later occasion, using the tablet computer with a docking station as an ordinary desktop terminal in the site office (journal notes, feedback meeting between operating team and test users, Stockholm tablet project, 2006-03-15). This way of working with the tablet computer both as a mobile computing device in the field, as well as a docked desktop workstation was widely used during the tablet project at Duke University.

A docked tablet computer for desktop office use

When the Forum Nacka site management practitioners started using the tablet computer instead of their ordinary desktop computers, they soon felt that they were downgraded in computing performance and network connectivity speed. Site work supervisors at Forum Nacka regarded the tablet computer as too slow and that the device had to be rebooted too often (journal notes, feedback meeting between operating team and test user, Stockholm tablet project, 2006-06-07). Even though the pen based snipping tool for cutting, copying and pasting parts of documents into other documents was appreciated by all test users, it seemed that the application often made the tablet computer crash (journal notes, feedback meeting between operating team and test user, Stockholm tablet project, 2006-03-15). It became increasingly obvious for the participants of the Stockholm tablet project that a mobile ICT platform needed to be better adjusted to the intended users and use conditions of everyday fieldwork practice. The Stockholm tablet project operating team began to question and reconsider the actual purposes of using mobile ICT in site management practice, and if the tablet computer really was a proper user device for the fieldwork environment.

Additionally, it became increasingly apparent for the Stockholm tablet project manager that the differences in construction site management practice between Skanska USA Building and Skanska Sweden had lead to separate views regarding potential application areas for the tablet computer in the field (interview, tablet project manager, Stockholm tablet project, 2006-05-11). To possibly get new ideas in moving forward in the trials at Forum Nacka, the Stockholm tablet project operating team considered it important to get some complementary input from the apparently successful tablet computer trials at Skanska in North Carolina. Consequently, in November 2006 the project manager and the user champion of the Stockholm tablet project operating team traveled to Skanska USA Building in North Carolina to conduct study visits at construction sites where management personnel were using tablet computers in their everyday work. During this trip the Stockholm tablet project manager and user champion also took part in a two day conference involving the ongoing tablet projects at Skanska companywide.

During one study visit at a construction site of a convention center in North Carolina, the user champion and project manager of the Stockholm tablet project met and talked with a superintendent who revealed that in the beginning of the

production operations there had been high expectations on the use of tablet computers among site management practitioners, due to the positive results of the trials at Duke University. All seven superintendents of the convention center construction site were using a tablet computer in their daily management fieldwork. Some superintendents had not previously used computers in their work, so the tablet computer was their first systematic use of ICT for professional purposes. Several of them were also involved in teaching other site management teams at Skanska USA Building how to use the device in the field (journal notes, construction site visit at Raleigh convention center, North Carolina, 2006-11-01).

The Stockholm tablet project manager asked all superintendent users met with in North Carolina about the learning process of using the devices. Their answers pointed to that there had been shortcomings regarding the technology itself as well as difficulties of learning new use routines and changing accustomed management fieldwork procedures. However, when the Stockholm project manager asked the superintendents if they would like to be without their tablet computers in their next construction project, their unanimous answer was 'no'. And when they were asked whether the tablet computer was a useful tool in their work, their mutual answer was 'absolutely' (journal notes, construction site visit at Raleigh convention center, North Carolina, 2006-11-01). This shared positive attitude towards the use of tablet computers among site management practitioners was confirmed at another site visit in North Carolina where five site work supervisors were using the devices on a daily basis. Some of these site work supervisors were using the tablet computer actively in the field to perform RFI procedures, documentation and reporting of performed work activities, while others appreciated using the device merely as a portable computer for office use (journal notes, construction site visit at biotechnology education center, North Carolina, 2006-11-01).

Construction site visit in North Carolina, November 2006

During the North Carolina site visits, the Stockholm user champion got the impression that part of the positive attitude towards using the tablet computer among fieldwork management staff at Skanska USA Building had to do with their prior inexperience of ICT in professional work (journal notes, Raleigh Convention Center, North Carolina, 2006-11-01). At Skanska Sweden, where site management personnel were using ICT since the mid 1990's, the introduction of tablet computers was not perceived as an extraordinary event. Relating this back to the 'technology acceptance model' described earlier, factors such as 'perceived ease of use' and 'perceived usefulness' may have different relative influences on acceptance depending on the user's previous experiences of ICT. Those without prior experience of using ICT may initially focus on ease of use and might be appealed by merely using the technology as such. With increased experience, users presumably overcome concerns about ease of use and may focus their attention on the actual usefulness of the technology for purposes in practice. This suggests that the path from ease of use to actual use will be stronger for inexperienced users, while experienced users are more focused on the path from perceived usefulness to actual

use (Taylor and Todd, 1995). An implication of this for the Skanska tablet projects could be that site management practitioners in North Carolina paid more attention to the ease of use aspects of the tablet computer since they were inexperienced users. They got a sense of satisfaction by simply using the technology. The more experienced ICT user-practitioners at Forum Nacka were probably more focused on the usefulness aspects of the tablet computer relating to work performance and did not get attracted by the technology itself to the same extent as their colleagues in North Carolina.

After the construction site visits in North Carolina, the user champion and tablet project manager of the Stockholm tablet project participated in an experience sharing conference of the tablet computer trials at Skanska, with company representatives from the USA, Sweden and the UK. Also present were representatives from different mobile ICT and software vendors who were taking part in Skanska's tablet computer venture to various extents. During this conference a number of technical issues of the tablet computer use were acknowledged and discussed among the participants. Some of these issues related to the device itself such as computing performance, battery runtime, handwriting recognition tools, pen based interfaces and applications, while other discussed problems were associated with overall infrastructure components to enable for example integration and mobility of ICT systems, wireless connectivity and synchronization of data. Some of the technical problems experienced in Skanska's tablet projects and discussed during the conference were caused by conceptually interesting, but not fully developed, mobile computing applications that were still offered by technology suppliers to the user market. This deficiency was also confirmed by some of the participating vendors (journal notes, presentations by mobile ICT vendors, Skanska tablet project conference, Durham, 2006-11-02, 2006-11-03).

Social and organizational barriers of using mobile computing applications for production site management purposes at Skanska were also addressed during Skanska's tablet computer conference in North Carolina. Negative attitude towards change both in the operative production environment and at other organizational levels within Skanska were identified as a main barrier for mobile computing development within the company. The tablet project conference participants considered this barrier partly as a result of earlier ICT project failures at Skanska

that have made employees skeptical towards introduction of new technology in general. Other related issues included age and generation factors of ICT adoption, as well as cultural differences and deficient communicative processes between ICT developers and user-practitioners when new systems are developed and deployed. Developing a supportive culture of change at all organizational levels within Skanska was considered by the tablet computer conference participants to be critical in overcoming these barriers. Incentives for using mobile computing should be created in the operative production site environment, and the tangible benefits of using the technology in the everyday course of work have to be clearly demonstrated and continuously advocated. Change processes should also be firmly supported and encouraged by management teams at all levels of the organization. Especially, the authorization and promotion of intended change efforts by top management representatives within Skanska was considered by the tablet computer conference participants to be crucial to succeed in any comprehensive ICT development project in the construction site work environment (journal notes, Skanska tablet project conference, Durham, 2006-11-03).

Tablet project conference in North Carolina, November 2006

Tablet project conference in North Carolina, November 2006

The positive attitude towards the use of tablet computers at the visited construction sites at North Carolina also appeared to be a result of the energetic progress focused approach of key persons in the tablet project development team at Skanska USA Building. The initiator and user champion of the tablet project at Duke University, who later became the acting global coordinator of the tablet computer trials at Skanska companywide, frequently spoke about ICT as a key enabler of innovation for the construction process in general, and the specific opportunity of the tablet computer for site management purposes (journal notes, workshop between global tablet project coordinator and Stockholm tablet project operating team, Skanska headquarters and Forum Nacka, 2006-06-07). This technology focused development approach was also displayed during the tablet project conference in North Carolina. A presentation made by an ICT director at Skanska USA Building made it clear: 'Technology is NEVER a barrier to success or profitability, but an enabler to achieve success' (journal notes, presentation slideshow by ICT director at Skanska USA Building, Skanska tablet project conference, Durham, 2006-11-02).

Relating the approach of the tablet project in North Carolina to the Stockholm tablet project, the user champion at Forum Nacka was also a technology keen individual, or expressed with that person's own words: 'I'm a technology nerd' (interview, user champion, Stockholm tablet project, 2005-12-20). The user

champion's enthusiastic attitude towards new ICT gadgets and tools was also shown during the tablet computer tests at Forum Nacka. Early on in the trials, the user champion took a personal initiative and explored the mobile computing device and found innovative opportunities and ideas of using the technology for various production site management purposes. Most of these explorative activities were driven by the user champion's amusement of playing with the tablet computer such as using the electronic pen to sketch pictures and highlight things on the screen with different colors (interview, user champion, Stockholm tablet project, 2005-12-20). Nevertheless, when it came down to supportive use of ICT in the context of 'actual' work, ICT was far from glorified or embellished by the user champion at Forum Nacka. On the contrary, if the tablet computer, or any other ICT application for that matter, did not improve the performance of everyday work in the production site environment, there was simply no justification for using it. Or as the Stockholm tablet project user champion put it: 'Show me the money!' (journal notes, feedback meeting between operating team and test users, Stockholm tablet project, 2006-05-04; interview, user champion, Stockholm tablet project, 2006-12-01).

The pragmatic 'no-nonsense' view on ICT use in construction site management practice was also acknowledged by ICT staff at Skanska Sweden. Construction site management practitioners in general could not be convinced to use new ICT systems by showing them fancy technology concepts. In order to catch the sharp attention of this professional group, new ICT tools and applications had to address direct improvements of their existing work practice. Advanced and sophisticated ICT systems were only used effectively by production site personnel if the technology appealed to their seemingly inherent competitiveness and showed immediate and tangible benefits in their everyday professional work (interview, regional ICT coordination manager, Skanska Sweden, 2005-09-27). A general opinion among site management practitioners at Skanska Sweden was that the use new ICT capabilities should be adjusted to the operative fieldwork context and not the other way around. With this in mind, the Stockholm tablet project manager chose a cautious ICT development approach for the tablet computer trials at Forum Nacka. From the beginning of the Stockholm tablet computer project, the project manager stressed that the production management team at Forum Nacka were supposed to continue working according to their regular professional practice. The aim of the tablet project was then to find out whether the proposed technology

could enable better support and improvement of the established work routines (journal notes, feedback meeting between operating team and test users, Stockholm tablet project, 2006-03-15). This approach was very different from the one demonstrated in the tablet project at Skanska in North Carolina.

Most likely however, during the tablet project at Duke University the test users also experienced some of the technical shortcomings of the tablet computer device that were encountered at Forum Nacka. The global tablet project coordinator even acknowledged that there had been conflicts between involved parties of the tablet project in North Carolina about the practical use of the technology in the field (journal notes, workshop between global tablet project coordinator and Stockholm tablet project operating team, Skanska headquarters and Forum Nacka, 2006-06-07). Production site management personnel had on occasion wondered what the benefit of using tablet computers in the field really consisted of, and some of the members of the site management team at Duke University had even regarded the use of tablet computers as a waste of time at first (journal notes, workshop between global tablet project coordinator and Stockholm tablet project operating team, Skanska headquarters and Forum Nacka, 2006-06-07). Still, it seemed that the user-practitioners in North Carolina were not overly annoyed and discouraged by the shortcomings of the tablet computer, as was displayed during the trials at Forum Nacka.

The positive and progression focused spirit that seemed to permeate the tablet project in North Carolina may be regarded as a necessary development component in order to cope with, accept and overcome deficiencies and obstacles of using mobile computing in practice. Reaching the desired operative goals of the tablet project in North Carolina required changes of both technology and site management practice. Solely modifying technology would only contribute to half of the addressed problem. With clear and communicated objectives of the project and how it potentially could improve the future work situation in the field, targeted site management users were willing to struggle with the technology and gradually change their existing work routines according to new use procedures of the tablet computer. In the Stockholm tablet project, on the other hand, the approach was instead to adapt the technology to present site management practice and did not involve the ambition of directly changing current ways of working in conjunction

with the use of the new ICT capabilities. The user-practitioners at Forum Nacka were not willing to change their existing behavior in order to adopt mobile computing technology and integrate it with their everyday work practice. In this way, existing and functioning systems, procedures and routines at Forum Nacka may have effectively hindered the uptake of the tablet computer. With accustomed legacy work routines and ICT use procedures in operation, there probably were small incentives and large resistance for the practitioners at Forum Nacka to take on new technology (see also Smith et al., 2002).

Emergence of useful technology and meaningful use

From the very beginning of the tablet project at Forum Nacka, the user champion pointed out that the tested technology must be able to deliver multipurpose mobile online use of existing ICT resources in the field. If this could not be accomplished, the tablet computer would probably not become an all-embracing mobile ICT solution for production site management purposes, only a partial replacement of the desktop computer. With only limited use of the tablet computer device, its contribution would then most likely be questioned among production management professionals as they still would experience the many of the existing obstructive fixed elements of ICT use (journal notes, start-up meeting, Stockholm tablet project, 2005-10-03; interview, technology design coordinator, Stockholm tablet project, 2005-11-15).

The global tablet project coordinator at Skanska expressed however that the term 'online' was a problematic concept in mobile computing. Even though the ambition could be to offer seamless wireless connectivity on site, the global tablet project coordinator regarded the improvement of ICT support for construction work activities as the main guiding principles for the tablet projects (journal notes, start-up meeting, Stockholm tablet project, 2005-10-03). With this line of thinking, 'online' was not a relevant concept, as the real issue was to develop a robust tablet computer based mobile computing platform that was accepted and used by the production site management practitioners in their everyday work. Also, it proved to be somewhat problematic to cover a whole construction site with wireless local area network access due to different floor levels of a building and constant changes in the production setup as a whole. At a consultant meeting with a wireless ICT analyst, the Stockholm tablet project operating team got the advice to work offline with data on mobile computing devices in the field and then synchronize local copies of documents and data at wireless 'hotspot' connections located at strategic positions in the field (journal notes, consultant meeting between operating team and wireless ICT analyst, Stockholm tablet project, 2006-05-30). This alternating 'online/offline' user approach was employed in the tablet project at Duke University. An alternative to deploying wireless local area networks on site was to utilize mobile broadband services from a mobile telephony operator which could enable more persistent wireless data network connection capabilities in the field

(journal notes, consultant meeting between operating team and wireless ICT analyst, Stockholm tablet project, 2006-05-30).

The tablet project at Forum Nacka aimed at bringing ICT resources to the fieldwork environment bit by bit, starting with defining a limited number of site management activities to support with fitting tablet computer applications which then could be gradually expanded (journal notes, start-up meeting, Stockholm tablet project, 2005-10-03). This approach started with initial user requirements identification of a general mobile ICT platform on which specific applications and functions could be built. Input from the targeted test users at Forum Nacka was considered to be vital for adapting the tablet computer device and existing ICT systems to their management activities in the field. The dilemma of the Stockholm tablet project was however that on one hand it strived towards enabling wireless extension of existing ICT resources into construction site operations in general, on the other hand the project wanted to address specific onsite ICT needs and administrative deficiencies for fieldwork management professionals. In other words, the tablet project at Forum Nacka included both a general and a specific target area at the same time, but with no distinct intention for any of them. With these vague objectives, open-ended sensemaking and negotiation of meaning of using the tablet computers in its practical work context became the essential way forward towards adapting technology design and its usefulness in practice. In contrast, the tablet project at Duke University was very specific and designed from the very beginning. It did not consider any general wireless connectivity approach to serve overall availability of ICT systems for production management practitioners on site. On the contrary, the tablet project at Duke University intentionally tried to identify a limited number of specific onsite management activities that called for improved information and communication support. New ICT tools and use procedures were then developed that specifically addressed and supported the considered work activities on site (journal notes, start-up meeting, Stockholm tablet project, 2005-10-03).

The participants of the tablet project at Forum Nacka wanted to avoid the project to become another ICT venture where an immature ICT application was introduced into the site production environment without special consideration of its consequences for fieldwork practice. This had apparently been done several times before at Skanska Sweden according to the project manager and the user champion

of the Stockholm tablet project (journal notes, start-up meeting, Stockholm tablet project, 2005-10-03). The Forum Nacka user champion especially stressed that the tablet computer should not be forced into the production work environment, and that the development efforts should not be hurried, as the novelty of technology and its meaningful use routines in practice must be able to evolve slowly (interview, user champion, Stockholm tablet project, 2005-12-20). The user champion considered that the only true way to find out whether the tablet computer could be an appropriate onsite ICT tool was to test different concepts and configurations of the technology and its practical use in production fieldwork in an open-minded way without any unrealistic promises of grand results (interview, user champion, Stockholm tablet project, 2005-12-20). If the technology did not correspond to the ICT use requirements of the production site setting, but nevertheless fully implemented, it would most likely generate confusion, frustration and a lot of time consuming efforts among user-practitioners in order to make the technology work. In such a case, the mobile computing technology may merely function, but would most likely not work sufficiently in the fieldwork setting and would not be an effective and beneficial ICT system from a business viewpoint. The operating team of the Stockholm tablet project shared a mutual standpoint that being too quick in introducing an ICT application and to be overly focused on the delivery of its benefits may result in that the realization of an ICT project goes against its own business enhancing objectives, especially if the practical use context of the technology is not fully understood (journal notes, start-up meeting, Stockholm tablet project, 2005-10-03).

The test users at Forum Nacka expressed that the use of the tablet computer had to enable robust and seamless switching between using the device in the field and using it as a stationary desktop computer with an external keyboard and computer screen in the site office. If data connections repeatedly were lost and the devices behaved irrationally, the tablet computers would most likely not be used by the site management practitioners at all. The Forum Nacka user champion was convinced from the very beginning of the tablet project that only a versatile set of tablet computer applications which directly targeted the wide-ranging ICT needs of production site management would be well received by the user-practitioners (journal notes, Forum Nacka, 2005-10-28).

Device discussions

Mobile fieldwork of construction site management practitioners at Skanska generally entailed direct involvement and supervision of various hands-on tasks which required full attention in the field. Due to fieldwork practitioners' often limited attention to secondary tasks such as using mobile computing devices, the tablet computer had to support brief and concise use of ICT tools while simultaneously involved in various work situations (similar to the discussion in Pascoe et al., 2000). Production site management practitioners at Skanska needed to spend as much time, attention and effort as possible in the physical fieldwork environment with the tasks and people at hand, and to minimize the time devoted to interacting with the computing device. In addition, the physical size and appearance of the mobile computing equipment should not encumber users and contribute to obstructing their attention to fieldwork events. Both at Duke University and Forum Nacka, site management practitioners often spent long time periods in the field performing work tasks. The tablet computer test users at Skanska therefore requested a mobile device that could be used during a whole day without requiring replacement of batteries. Both the test users and the operating team of the Stockholm tablet project were also questioning whether the tablet computer was sufficiently robust to handle the rough fieldwork environment of the construction site with its changing conditions of light, temperature, water, damp and dust, (journal notes, feedback meeting between operating team and test users, Stockholm tablet project, 2006-03-15). Such limiting factors relating to deficient ergonomics and usability of the technology as well as lack of practical applications may hinder the broad appeal of the mobile computing devices among user-practitioners (see for example York and Pendharkar, 2004; Nah et al., 2005).

However, many of the constraints of mobile computing devices are actually a result of the fact that they are intentionally and specifically designed for mobile use purposes. Devices are regularly small enough to be portable and have lower processing power compared to desktop computers (Buyukkokten et al., 2002). Mobile computing devices are however rapidly becoming more powerful and almost equivalent to the performance of desktop computers, except for one particular feature – the screen size. Therefore, one of the main challenges in designing mobile computing terminals, applications and interfaces is often to compensate for the

limited visual display of the devices (Lee and Benbasat, 2003). Mobility of ICT resources is not simply about having the instant capability to obtain the appropriate data, for example a document. It also includes how the information is used and whether it is in the appropriate form for viewing and interaction. For certain tasks, such as reading and understanding documents in the field, a tablet computer may be a suitable user terminal, while a handheld device with a small display may be an inappropriate medium. A handheld device may enable effective exchange of information that is adjusted for presentation on a small screen, but may be inappropriate technology for other data that require additional viewing support such as a large display or a printer (Perry et al., 2001). The tablet computer technology of the mobile computing pilot projects at Skanska were chosen mainly because it was considered to be a suitable compromise between a small and convenient mobile device with primitive performance and small screen size, and a powerful desktop computer with low level mobility. The Skanska tablet project participants anticipated that the tablet computer could enable an adequate configuration of portability and use performance of ICT resources for fieldwork management purposes.

The Duke University tablet project tested a wide range of tablet computers from different vendors before a specific model was selected. The chosen device was somewhat physically robust and had good performance in relation to its price. It had a polarized screen for outdoor use and approximately four hours of runtime on battery. The battery on each tablet computer therefore had to be replaced once a day with a newly charged one to make the device last a whole working day in the field (journal notes, start-up meeting, Stockholm tablet project, 2005-10-03). The tablet computers were not used at Duke University for mobile online access to ICT systems. Only local wireless hotspots were deployed on site to be able to synchronize modified data in the field at specific locations. Several tablet computer models were also evaluated in the Stockholm tablet project. Among them, a rugged model that was durable towards dust and water was demonstrated to the Stockholm tablet project operating team by the computer manufacturer (journal notes, operating team meeting with device manufacturer, Stockholm tablet project, 2005-12-15). This tablet computer model also had a touch sensitive screen which enabled users to navigate the device directly which one hand on the screen. The touch screen function was appreciated by the user champion at Forum Nacka, but

considered the device as too heavy and bulky for the requirements of production site management use (journal notes, operating team meeting with device manufacturer, Stockholm tablet project, 2005-12-15). The Stockholm tablet project operating team decided to use lighter and less rugged tablet computer models for the trial at Forum Nacka, as they did not know whether the tablet computer device was a proper response to construction site management practitioners' mobile ICT requirements in the field. As the tablet project progressed, the test users including the user champion at Forum Nacka were showing increasing signs that smaller handheld devices might be more suitable for the information and communication needs in their everyday work, mainly due to the heavy physical size of the device (journal notes, Stockholm tablet project, 2005-12-14). The user champion at Forum Nacka early on recognized that a handheld 'personal digital assistant' would be a more appropriate device in many field use situations, because it was smaller, lighter and more convenient to carry and operate (journal notes, workshop between control group and operating team, Stockholm tablet project, 2005-10-04; interview, user champion, Stockholm tablet project, 2005-12-20). The test users at Forum Nacka in general appreciated the large display of a tablet computer, while the compactness of a personal digital assistant was more interesting from a portability viewpoint. Both the test users and the operating team of the Stockholm tablet project started to see diversified information and communication needs for different professional groups in the production setting that probably should be addressed with different ICT user terminals.

The Stockholm tablet project participants gradually identified the tablet computer as best suited for 'semi-mobile' professionals involved in both field and office based work, where replacement of paper based administration and documentation activities could create benefits of the technology. A meeting with an external ICT consultant also strengthened the growing standpoint that Skanska would not be able to find one single mobile computing device for all professional needs in the production environment (journal notes, consultant meeting between operating team and wireless ICT analyst, Stockholm tablet project, 2006-05-30). For other fieldwork professional categories, such as construction workers, smaller handheld personal digital assistant devices were considered to be more appropriate for their often limited and specific information needs on site (journal notes, Forum Nacka, 2005-10-28). The tablet computer was not considered by any of the parties involved in

the tablet project in Stockholm as an ultimate solution for the ICT requirements in the construction site work setting. The tablet computer was considered by the participants as one of many steps for Skanska towards identifying potentially useful applications of mobile computing for site production purposes. The idea was that the findings of the tablet computer tests by production site management practitioners could lead to additional concepts of how to improve the mobility and quality of ICT tools in the fieldwork environment. The need for improved mobility of ICT in construction site management at Skanska was 'genuine' in the sense that it was clearly indicated through the site management practitioners themselves. The tablet computer pilot project was in fact initiated by construction site management personnel at Duke University, which later caught the interest of production personnel at Forum Nacka. With expected and indicated opportunity of the technology, site management practitioners were willing to test and explore the tablet computer.

Early on in the tablet project at Forum Nacka, it seemed that one of the features of the tablet computer device that directly appealed to the test users was the ability to navigate and interact with the device using the electronic pen. In field based work settings, a pen based mobile computing user interface may provide an ergonomic solution that can be held in one hand when viewing data in varying use situations. It can also enable a natural substitute for paper based documentation activities in the field, as a pen based user device often is similar in size and operation as a regular notepad (see for example Pascoe et al., 2000). The site management practitioners at Forum Nacka were accustomed to using pen and paper for administration and documentation in the field. Using the tablet computer for the same work activities was therefore an intuitive development of practice, with the anticipation that the technology could make this more effective by reducing the current double amount of administrative work associated with many ICT use procedures in the site production setting (journal notes, Stockholm tablet project, 2005-11-01). Consequently, the 'mental leap' for site management practitioners of using the tablet computer device in the field was not vast, as the onsite administrative routines the technology was addressing were basically left unchanged. However, equipped with the new mobile computing device, the Forum Nacka test users anticipated that these activities could be completed directly in the field when events actually occurred (journal notes, Stockholm tablet project, 2005-11-01). Partly boosted by

the results from Duke University, the initial expectations on the tablet computer among all participants of the Stockholm tablet project were high. Expectations that consequently were not so easily met by the actual use experience in practice.

At Forum Nacka, Skanska Sweden's intranet knowledgebase was frequently used to download different document templates for administrative activities in the field. These activities were then carried out twice; taking notes on site and then transcribing these later when working at the computer. An initial approach of the tablet project in Stockholm was therefore to try to transform these ineffective work routines into a supportive system of digital forms for fieldwork documentation to use with the tablet computer on site (journal notes, operating team meeting, Stockholm tablet project, 2005-10-10). The idea was to convert document templates from the intranet into specific tablet computer formatted forms. These forms could then be integrated with existing ICT resources such as the activity based project management system, so that when for example deviations of project activities were detected in the system, production management practitioners could click on an associated digital deviation report form and document the events directly in the field using the electronic pen on the tablet computer screen. These reports could then be stored in the central database of Skanska Sweden's ICT business system and linked to specific business activities of the concerned building project (journal notes, operating team meeting, Stockholm tablet project, 2005-10-10). Interviews with corporate staff personnel at Skanska Sweden who were involved in various business-ICT alignment development efforts also revealed that improved integration between intranet document templates and existing ICT systems to enable better technical support and workflow of documentation activities of construction projects was a prioritized development area of ICT use within the company (interview, administrator of the intranet knowledgebase, Skanska Sweden, 2005-11-16; interview, regional ICT coordination manager, Skanska Sweden, 2005-09-27).

However, shortly after the beginning of the Stockholm tablet project, the participants discovered that the handwriting recognition feature of the tablet computer platform was not available for the Swedish language. The usefulness of the technology for pen based documentation purposes was therefore decreased considerably because the tablet computer was not able to recognize Swedish words written with the electronic pen on the screen and translate them to data text. The

Stockholm tablet project manager regarded this fact as a major backlash, as the one of the initial anticipations of the project was to use the tablet computer in improving onsite inspection and documentation procedures by working directly with digital tablet computer forms in the field (e-mail conversation, tablet project manager, Stockholm tablet project, 2005-10-18). Interestingly, some of the ideas from the Stockholm tablet project regarding digital forms for field based documentation and reporting caught the attention of the tablet project in North Carolina. Based on these ideas, Skanska USA Building started developing a set of tablet computer based forms to use for onsite administration purposes, where fieldwork report data inputted on the tablet computer were then intended to be directly linked to and stored in the existing project management ICT system (journal notes, workshop between global tablet project coordinator and Stockholm tablet project operating team, Skanska headquarters and Forum Nacka, 2006-06-07).

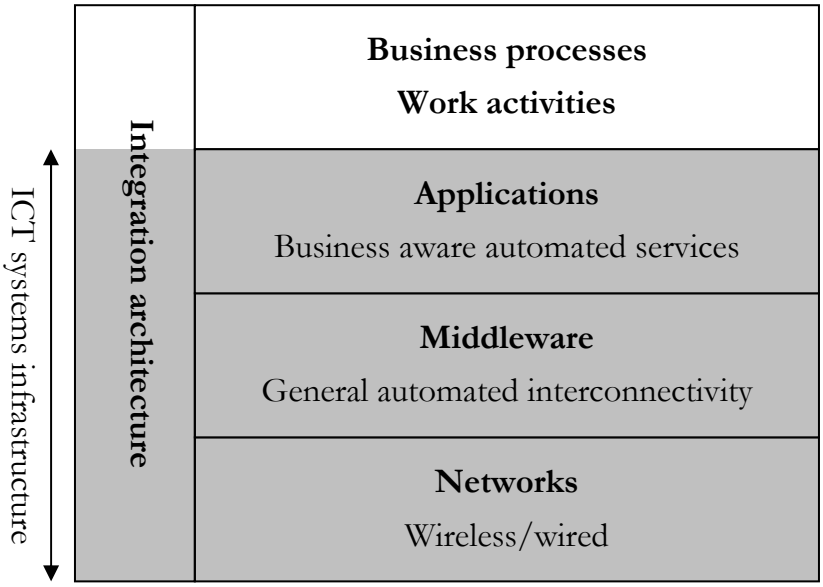
As the Stockholm tablet project moved forward, both the operating team and the test users showed growing doubts of the tablet computer technology. Slow processing performance and poor wireless network connectivity of the tablet computers hindered the continued development and use of the device in the field at Forum Nacka. The test users repeatedly pointed out that the tablet computer had poor battery runtime and that it was too heavy to carry all the time, which caused practical obstacles for its use. Both the test users and the operating team of the Stockholm tablet project were therefore increasingly loosing interest for the technology and for the venture as a whole (journal notes, feedback meeting between operating team and test users, Stockholm tablet project, 2006-03-15; interview, project manager, Stockholm tablet project, 2006-05-11). The involved participants of the Stockholm tablet project simply did not want to spend more time, effort and resources than necessary on a task that appeared to lead to a dead end. The user champion at Forum Nacka gradually regarded the tablet computer only as a portable complement to the regular desktop computer, rather than a fully mobile ICT platform. The Stockholm tablet project participants started to consider their endeavor as one of many future steps towards eventually narrowing in on fitting ICT use for the construction fieldwork environment that is more in line with the actual information and communication requirements of production site management practice (journal notes, feedback meeting between operating team and test users, Stockholm tablet project, 2006-05-04).

Platform perspectives

Among the greatest difficulties of supporting mobile work with ICT is to integrate proper mobility and adaptability features into applications and infrastructure in order to adjust the technology to the specific context of use, and to personalize mobile devices and user interfaces to often varying user needs (Brodie, 2003). Creating appropriate mobility and adaptability of ICT resources for any mobile work setting is certainly not only about the end user mobile computing devices, as it might seem at first. A vast technological challenge lies in designing and developing the underlying mobility enabling ICT systems infrastructure. This includes integration of existing ICT resources, adequate range of wireless network connectivity and end user presentation layer of ICT systems with personal adaptation of data based on individual needs. With this holistic thinking, the user terminal through which information and communication is handled becomes a secondary issue. Different work roles and professional groups have diverse requirements of ICT use. Many of them require a high level of communication mobility and instant information accessibility, while others do not have these requirements at all. Therefore, taking the mobile step in ICT use is to enable 'generic access' of data to mobile workforces. This means that data should be able to be accessed, presented and computed through a 'personalized interface', using any type of user terminal regardless if it is a mobile device, a portable laptop or a fixed desktop computer. An interesting aspect of mobility enabling ICT is that it generally does not exclusively consist of using new emerging mobile and wireless systems and infrastructures, but comprise the situated use of both old and new technology (see for example Kakihara and Sørensen, 2002, 2004). A large part of developing mobile computing for mobile work purposes therefore involves making better use of existing information systems and communication resources by combining and integrating them in new ways, enabling generic access and adaptable use of ICT tools.

At Skanska Sweden, the business ICT platform was gradually built, integrated and extended inspired by an so called 'service oriented architecture' approach (interview, head of ICT, Skanska Sweden, 2005-08-31; interview, development and maintenance manager, Skanska Sweden, 2005-10-18). One of the key principles of the service oriented architecture approach is that it tries to enable a higher level of

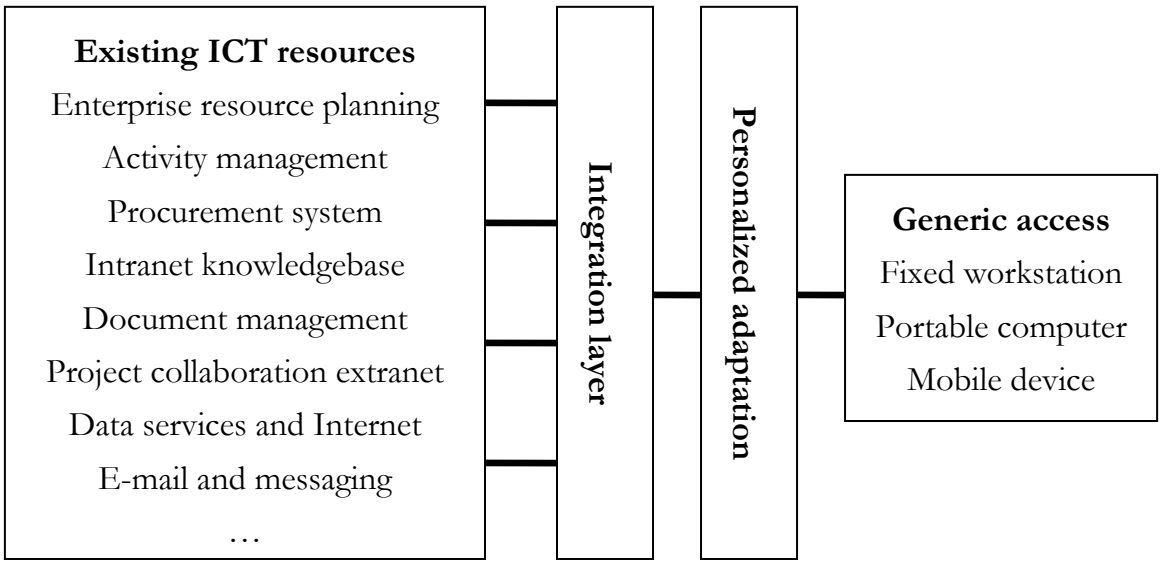
integration and interoperability of new and older systems and networks, and that new applications and communication services can be provided to users through combining and repackaging data obtained from existing ICT resources (see for example Umar, 2005). This architectural approach may therefore enable a better alignment between designed ICT systems and actual business processes, adaptability between real life work activities and computing applications, as well as increased independency of the physical location of both users and ICT resources. It tries to make user access to remote applications and automated communication between distributed systems independent of the underlying network architectures, and create independency between physical locations of individual users and ICT resources (Umar, 2005). This may enable a flexible ICT platform where all kinds of system applications and services are integrated into one single framework to support varying information and communication needs of users, to be accessed globally by geographically distributed mobile workforces.



The service oriented architecture approach

The central idea of the service oriented development approach of Skanska Sweden's ICT platform was to enable an adaptable systems infrastructure to support varying ICT requirements of different parts of the organization (interview, development and maintenance manager, Skanska Sweden, 2005-10-18). Mobility of information and communication resources was even considered by some ICT staff at Skanska Sweden as a 'non issue' as most ICT system developers and vendors increasingly were integrating mobility components into their platforms. Instead, an issue that

was emphasized from an ICT perspective was the importance of developing a fitting systems infrastructure within integrated with a personalized user portal so that Skanska employees working in different operating environments of construction projects could adapt their ICT resources according to their information and communication needs (interview, development and maintenance manager, Skanska Sweden, 2005-10-18). Each individual could then log on to the user portal and access any data through any preferred user terminal, illustrated in the figure below.



Mobility enabling ICT systems infrastructure for mobile work

The service oriented architecture approach of ICT platform design was also embraced by Skanska USA Building. Similar to Skanska Sweden the focus was on integrating existing ICT resources and offering generic and personalized access of data (journal notes, presentation by ICT director at Skanska USA Building, Skanska tablet project conference, Durham, 2006-11-02). A central part of this ICT systems structure was a web based user portal to interconnect underlying ICT components and generate interfaces and applications to users according to their diversified needs and demands. Creating the appropriate level of interoperability between ICT systems and personalized generic ICT access from any preferred user terminal was considered by ICT staff at Skanska USA Building to be a matter of 'peeling the onion' of the web based user portal so that it only contained a specific set of applications and functions that users actually needed (journal notes, workshop between global tablet project coordinator and Stockholm tablet project operating team, Skanska headquarters and Forum Nacka, 2006-06-07). Comparable to Skanska

Sweden, Skanska USA Building was increasingly enhancing the mobility of the ICT platform by adapting the underlying systems infrastructure.

The general opinion of ICT unit staff at Skanska Sweden was that a mobile computing platform from a technical viewpoint should support the diverse requirements of the company as a whole and not be built around a certain user device such as the tablet computer, as different professional groups within a construction project organization may use ICT very differently. Therefore, a long term mobility enabling ICT platform could only be built on a broad, versatile and adaptable systems structure where individuals use different user terminals for different ICT needs and purposes in their varying situations of work (interview, regional ICT coordination manager, Skanska Sweden, 2005-09-27). ICT staff at Skanska Sweden considered it to be a more suitable and sustainable solution to configure a mobile computing platform based on data communication through mobile telephony networks, rather than using self deployed wireless local area networks. Utilizing handheld devices with wireless high speed broadband connections via a mobile telephony service provider could enable a standardized and robust mobile communication service because of better range and coverage compared with wireless local area networks (interview, head of ICT, Skanska Sweden, 2005-08-31; interview, data communications manager, Skanska Sweden, 2005-09-23). Additionally, self deployed wireless networks at production sites required that they had to be installed and maintained by Skanska. Using mobile telephony broadband connections instead required no wireless network infrastructure investment and implementation because the service was purchased from an operator with certain quality and security guarantees of the offered service (interview, head of ICT, Skanska Sweden, 2005-08-31; interview, data communications manager, Skanska Sweden, 2005-09-23).

The ICT unit at Skanska Sweden had previously reviewed the tablet computer device as an interesting ICT concept for documentation and administration of production site activities and to integrate these applications with existing ICT systems (interview, user terminal and support manager, Skanska Sweden, 2005-10-07). Combined with a web based user portal with a personalized interface that could be accessed virtually anywhere through mobile broadband connections, could enable more flexible use of ICT tools in construction projects (interview, head of

ICT, Skanska Sweden, 2005-08-31). The tablet project in Stockholm was welcomed by ICT staff at Skanska Sweden because it could give new input to the requirements of information and communication support in the production site environment. Even though the tablet computer may not be a part of a future development path for Skanska Sweden, the tablet project could result in improved understanding of what the construction site teams were requesting regarding the ICT support in their everyday work, especially their need for mobility of ICT resources and ICT use in the field (interview, data communications manager, Skanska Sweden, 2005-09-23; interview, development and maintenance manager, Skanska Sweden, 2005-10-18). However, ICT staff at Skanska Sweden was also questioning the usefulness of the tablet computer device for production site management purposes as it was considered to be too large and bulky for field personnel to carry with them at all times. A mobile computing platform based on smaller handheld user devices was considered to be more versatile and portable for field based construction management (interview, regional ICT coordination manager, Skanska Sweden, 2005-09-27). Tests with handheld personal digital assistant devices in the production environment had been conducted at Skanska Sweden some years earlier, but at that time the technology was not fully matured and there were several issues regarding the reliability and mobility of data as well as ease of use aspects which resulted in no further development of these trials (interview, regional ICT coordination manager, Skanska Sweden, 2005-09-27).

An interesting usefulness aspect of the long term ICT development approach shown at Skanska is that it focused on fundamental infrastructure components to facilitate improved mobility and flexibility of ICT use that were requested by the users in the production site environment. On which user terminal ICT tools then are accessed and used is then up to the actual users, because they are basically the ones who can decide what terminal is best suited for the ICT needs and use behavior in their everyday work. The study at Filmstaden and the mobile computing trials at Forum Nacka showed that site management professionals often had quite clear ideas of how they wanted to change their ICT use to make it better adapted to their varying work situation in the field. The mobile computing trials at Forum Nacka showed that users explored the features of the tablet computer device in trying to make sense and find meaningful use of the technology in their professional work. In this learning process the test users considered the whole practical ICT use

chain from user terminals, applications and interfaces to the underlying structure, function and logic of ICT systems. They were thinking in terms of the practical value of using different ICT resources in different work situations, and the potential improvements of existing ICT systems if they could be combined, presented and accessed in new ways, complemented with technology that enabled mobility. The test users at Forum Nacka displayed and described a variety of work situations that were dependent on ICT use in different ways and presented ideas relating to both technology and use procedures to better support these situations, involving both the tested tablet computer and other technical concepts and use configurations. These user expressions form the fundamental input to change system configurations and features of the ICT platform in order to improve the practical usefulness of the ICT resources in the real life production site work context.

An underlying ICT systems infrastructure that facilitates generic access and personalization of data may assist users in adapting their individual ICT support to the purposes of their work context. However, a mobility enabling ICT platform can not be designed to specifically address all types of eventualities and activities in the operative work context. Instead, a holistic and flexible ICT systems design that effectively frames and presents tools and applications that address general information and communication needs of changing events in production site management practice is a more possible approach, and a more probable one in order to generate usefulness in the mobile fieldwork setting. As the mobile computing tests at Forum Nacka showed, users often do not behave and use ICT applications and functions as intended and expected by its designers and developers. Instead they adjust the features of the technology and find new, and often informal, ways of use its functions through rearranging planned work flows of applications to better match their actual work context. One interesting idea is therefore to design ICT to be simple and highly flexible rather than specified purpose systems in order to support unexpected circumstances of the work setting (see for example Robinson; 1993; Perry et al., 2001; Pekkola, 2003). When the Forum Nacka test users talked about specific ICT applications or systems for particular work activities, it often concerned the access and availability of these ICT resources and not the detailed use procedures of the systems. Also, their needs and actual use of ICT were constantly shifting in relation to the adaptive and improvisational nature of work situations in the field (compare with for example Weick, 1998).

5 IN SITE

In the beginning of 2007, when the case study at Skanska ended, the use of tablet computers had spread to other projects and business units of Skanska USA Building, and the technology was gradually becoming standard ICT equipment for production managers in the field. The tablet project at Skanska USA Building had brought new meaningful and practical mobile computing tools into the site production environment. After the study visit in North Carolina, the user champion at Forum Nacka and the regional manager in the control group of the Stockholm tablet project discussed the progress of the trials and decided that without any clear benefits of using the tablet computer, the use of the device in the field was only going to be voluntary in the future (interview with user champion, Stockholm tablet project, 2006-12-01). In January 2007, the Stockholm tablet project was ended, or at least put on hold while finding a new approach for further development. The tablet computer tests at Forum Nacka had drawn attention to the frustrating ICT use conditions in the daily work of production site management practitioners, and had triggered new ideas towards overcoming these issues.

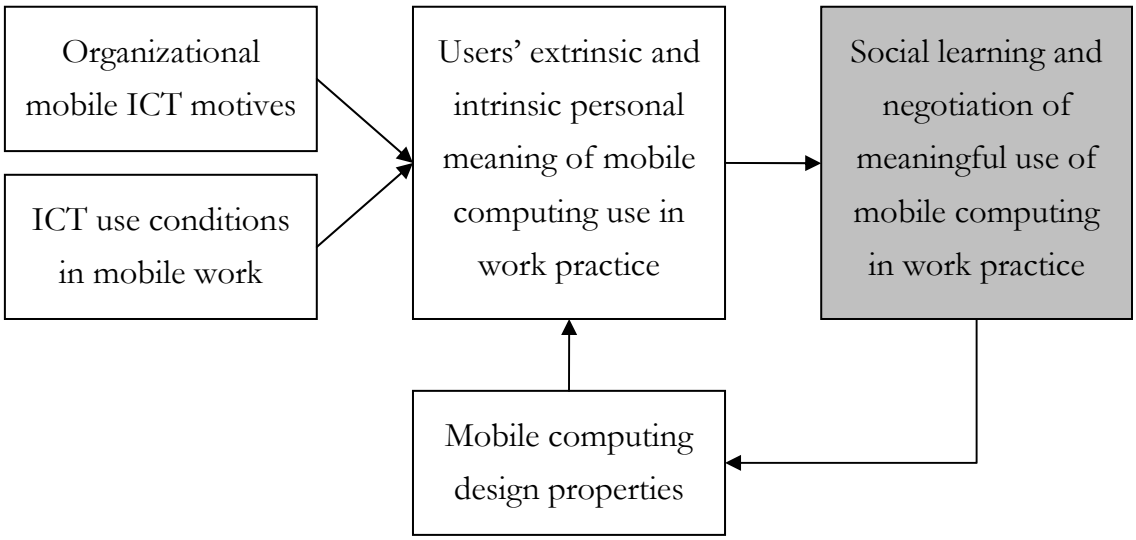
The mere construction and configuration of sophisticated systems architectures and applications will never be enough in successful ICT development in business organizations. Understanding the operative work context and situated professional practice in which the technology is supposed to be used is fundamental to create ICT business value. There are essentially no shortcuts in creating practical usefulness of ICT systems and it can only be captured through the opinions of the actual users. This implies finding out how users perceive the meaning of using ICT systems and applications in the performance of their everyday professional work. However, the results of sensemaking processes and negotiation of meaning of ICT use can not be planned or forecasted. The Stockholm tablet project did not result in any tangible mobile computing applications or improved ICT use procedures for construction site management practice. Yet, this does not mean that the technology was meaningless. Instead, the results of the tablet computer tests at Forum Nacka founded a new basis of understanding ICT use in the situated fieldwork practice, and established possible development directions of adapting the existing ICT platform to site production management needs and purposes.

The study at Skanska can be compared with Sarker and Wells' (2003) investigation of how mobile computing users individually and socially assess and evaluate their experiences of meaningful use relating to functional, psychosocial and relational dimensions, which directly influence the manner in which mobile devices are accepted and utilized in a longer timeframe. The first phase of users' learning process can be characterized as exploration and experimentation of interfaces and applications of the mobile device. This initial use process includes learning to improvise in order to bypass limitations of mobile computing technology that arise during the exploration and experimentation phase. The second phase of the use process of mobile technology comprises assessment of experiences of the initial exploration and experimentation with the device. According to Sarker and Wells (2003), positive experiences in the learning and assessment of use in terms of functional, psychosocial, and relational outcomes can beneficially influence adoption decisions and behavior of the users. The effect of a positive use process may result in increased commitment and continuity of using mobile computing technology over time, leading to an increased adoption overall. Similarly to the findings in Sarker and Wells (2003), the tablet projects at Skanska showed innovative user approaches in learning how to use the tablet computer and how to handle its shortcomings. Another related study by Kim et al. (2007) shows that adoption intension mechanisms of mobile computing applications among individual users are often determined by users' perceived value of the technology based on the beliefs of its benefits and the sacrifices needed to acquire and use it. Kim et al. (2007) indicate that sacrificing and obstructive components of using the technology have greater negative effect on the perceived value of mobile computing, than the positive effects benefit components have on increased value perception (Kim et al., 2007). Correspondingly, the tablet project test users at Forum Nacka perceived the sacrifice components of using the tablet computer as too dominating compared to it benefits.

A common concluding section of the kind of case study presented in this thesis, where two separate pilot projects within the same organization have been investigated, would be to take on a contrasting perspective of comparing their respective outcomes. This would for example lead to conclusions such as that the tablet project in the USA was a 'success' and the one in Sweden was a 'failure',

followed by an evaluation of key factors leading to these results. This kind of conclusions will not be made in this chapter. In line with the discussion made in Lindahl and Rehn (2007), studying project 'failure' in a 'moralizing' rather than an 'analytic' way will not improve the understanding of underlying circumstances leading to the deficient outcome – avoiding reality instead of engaging in it. The purpose of the study is not to evaluate Skanska's efforts in the development process of the tablet computer platform. This chapter will instead go back to and discuss the fundamental topic of this thesis, namely the processes of learning in the development towards a useful mobile computing system design and its meaningful use in the dynamic fieldwork setting of construction site management practice.

Usefulness as emergence of meaning



Positioning 'usefulness as emergence of meaning' in the analytical framework

Four basic models for describing and analyzing organizational change - life cycle, evolution, dialectic and teleology (Van de Ven and Poole, 1995; Poole et al., 2000) - were employed in Löfgren (2006) to depict the development dynamics of the then ongoing tablet projects at Skanska. The analysis was focusing on the overall user oriented management of introducing the mobile computing technology within the construction site work setting, and found that it was necessary to use characteristics of the four basic models of change to be able to describe different aspects and viewpoints of the development process (Löfgren, 2006). This can be compared with for example Baskerville and Pries-Heje (2001, 2003) who argue that separate but complementary stories of ICT development and diffusion cases can create multiple analytic models that help in further illustrating and understanding different perspectives of the studied processes. The following section builds further on the analysis in Löfgren (2006, 2007), but takes a closer look at the explorative search for mobile computing usefulness in tablet projects at Skanska in general, and the one in Stockholm in particular.

In for example Stacey et al. (2000), Stacey (2001), and especially Fonseca (2002), development processes within organizations are described as emergent and continuous transformation patterns of human interaction, understood as ongoing and ordinary complex responsive processes between people in local situations in the

living present. It is in such 'messy' everyday relational participative processes that sensemaking and negotiation of meaning occur, and reifications in different forms emerge and may become tools for situated work practice. Meaning evolves in a process of individual and collective learning where aspects of tacit and explicit, conscious and unconscious, order and disorder, understanding and misunderstanding are intertwined requirements of the same process. Meaning stated as goals and outcomes are continually defined, produced and modified in naturally undesigned communicative interaction between people situated in real life practice. With this perspective there is no resolution or 'end state' of a development process, as the realization of a chosen goal is changing because it is interlinked with the ongoing and emergent evolvement of everyday work (Fonseca, 2002).

The development of usefulness issues in the Stockholm tablet project can be characterized as everyday participative processes of technology use and human interaction between the participants, significantly displayed as ordinary unstructured conversations. In line with Ford and Ford (1995), it was through continuous mundane conversations between participants that the scope and intentions of the tablet project at Forum Nacka were gradually shaped from a rather vague initial outset. Conversations are vital for the creation of meaning because they enable the communication between people of redundant and diverse viewpoints, experienced as misunderstanding and disorder, which are the fundamental sources to the emergence of new order, shared understanding and meaning (Fonseca, 2002). Still, there is no guarantee that such a socially shaped development process will result in a useful and acceptable outcome for the involved parties (Fonseca, 2002). Sensemaking and negotiation of meaning towards 'meaninglessness', an overall development towards 'nothing', may actually be a vital outcome component of the learning process. The Stockholm tablet project essentially did not lead to any explicit reification, design or use of the tablet computer per se. But this apparent 'failure' resulted in taking new steps in developing another kind of 'know how' within the whole pilot project group towards what actually were the requirements, opportunities and obstacles of ICT use and mobile computing in the construction site management work environment. This can be regarded as emergence of unexpected insights partly due to the absence of a detailed and purposeful plan of the tablet project at Forum Nacka (Fonseca, 2002). Analogous to Wenger (1998), negotiation of meaning can not be designed or foreseen, but is shaped in the

ongoing context of real life practice. It can even be argued that failing to make sense of using the tablet computers at Forum Nacka resulted in learning something else instead that might be even more important for further understanding the usefulness of ICT and mobile computing in construction site management practice in the future development of the ICT platform at Skanska Sweden.

The search for usefulness in the tablet computer trials at Forum Nacka can be described as a paradoxical pattern of sensemaking and negotiation of meaning that was stable and unstable, enabling and constraining, organized and chaotic at the same time. The development process was not purposefully designed in advance, and there was essentially no one in control of it. Mechanisms of intention and control of the process were therefore inherently socially shaped and self-organized in the ongoing interactions between the tablet project participants and the explorations of the tablet computer technology (compare with Weick, 1995; Fonseca, 2002). A favorable outcome of this kind open-ended and conversationally shaped development process of usefulness will at best result in a short term stable pattern or a temporary state of shared meaning, because the technology can always be improved and become more useful. However, people are not primarily and intentionally seeking novelty and development of new 'solutions' does not emerge by itself or for its own sake. Existing organizational legacy of practice and certainty of habitual behavioral patterns of work generally create organizational resistance towards change processes and acceptance of new technology (Fonseca, 2002). Relating this to the Skanska case, production site management practitioners acknowledged their deficient ICT use routines and understood that measures had to be taken to improve the situation. But understanding the background problem and potential technology opportunities to overcome the issues were not merely enough to create willingness to change. In order for a proposed technology option along with new use procedures to be accepted by the user-practitioners, it had to deliver a feeling of meaningful to use in terms of tangible improvement of their everyday work. Existing accustomed habits, behaviors and routines were not going to be abandoned in favor of something that felt uncertain and insecure just because it was 'new'.

The Duke University tablet project participants early on seemed to find a meaningful initial configuration of tablet computer applications and their use in

practice that could be developed further, while the tablet project participants at Forum Nacka were struggling with this throughout the trials. The tablet projects at Skanska generally showed a common usefulness problem of trying to transfer one accepted ICT application from one practical use context to a seemingly similar one. The developed tablet computer concept at Duke University was intended to be meaningfully reproduced when it was transferred to Forum Nacka. An ICT application that is accepted and used in one particular practical work setting does not automatically imply that the technology is complete and ready to the introduced in any other comparable context of use (Fonseca, 2002). The Stockholm tablet project participants simply had to start from the beginning in trying to understand what the tablet computer and its intended usefulness in practice was all about through exploring, expressing, communicating and negotiating expectations and experiences of the technology. User-practitioners' conceptualizations and expressions of ICT needs at Forum Nacka seemed to actually emerge along with their explorations of the tablet computers, rather than being clearly identified beforehand. By using and playing with the tablet computer device, it became a tool of concrete action through which site management professionals related their use experiences of the technology to their expectations and viewpoints of appropriate ICT use in their fieldwork practice. With the tablet computer as a conversational 'trigger', the user-practitioners at Forum Nacka were able to express more clearly tangible concepts, issues and requirements of ICT usefulness in the site production setting to other participants of the tablet project team.

The ordinary conversational nature of collaborating and communicating within the Stockholm tablet project group enabled mutual understanding between construction site management practitioners and the ICT staff of the tablet project. ICT developers enhanced their comprehension of the complexity of introducing mobile technology in the fieldwork setting, and realized that their conceptions of information and communication issues in the production environment, as well as the ICT requirements of site management personnel were somewhat simplified or even incorrect. The site management practitioners on the other hand obtained improved understanding of the possibilities of the new technology in their work setting. The user-practitioners also enhanced their understanding of the structure and content of the existing ICT platform, why it was constructed and integrated the way it was, and how and why this underlying systems structure to a large part

determined the opportunities and limitations for further development of new ICT tools. This kind of technological 'path-dependency' that both facilitates and restricts the evolution of existing capabilities is common in any development process within an organizational context (see for example chapter 5 in Tidd et al., 2005). However, the continuation of an existing ICT development path can not be taken for granted, because there are regularly contradictory tensions between conceptualization and design of ICT and its resulting implementation and use which persistently change over time within a work organization (Williams and Edge, 1996). Early development of technology is often held together by shared visions of particular objectives for its use and by the requirements of specific users. But as technology becomes more widespread, these conditions are likely to become more diverse. Factors giving rise to new development directions or continuation of a current ICT development process within an organization should therefore be sought in locally shared objectives and expectations of ICT use (Williams and Edge, 1996). That is why local technology development efforts such as the tablet projects at Skanska generally result in important input to future expansion and adaptation of ICT resources for use purposes in the operative work context, even though the individual efforts themselves may not materialize into any tangible technology applications in practice. Through the direct experiences with the tablet computers in practice, as well as the continuous conversations and feedback meetings between the test users and the operating team, the Stockholm tablet project participants increasingly realized that their perceptions of adequate ICT requirements for site management purposes dealt with more fundamental technological design issues of Skanska Sweden's ICT platform than they initially grasped. The test users at Forum Nacka gradually realized that meaningful use of ICT in their situated fieldwork practice had very little to do with the tablet computer or any other user device. The critical issue was whether the existing ICT systems infrastructure could provide the necessary flexibility, mobility, generic access and personalization of information and communication resources that construction site management practitioners were requesting. The ongoing conversations within the Stockholm tablet project group made the involved participants increasingly understand that without a proper underlying ICT systems architecture in place, no mobile computing device would ever be able to deliver the kind of ICT usefulness for the fieldwork setting that they were envisioning.

The evolvements of the tablet projects at Skanska can be partly illustrated as a 'mangle of practice' (Pickering, 1995), where human and material 'agency' can be used to denote the continuing process of doing things in real life. Material agency comes from outside the human realm and much of everyday human agency involves coping with these surrounding physical factors and artifacts. Human and material agencies are inherently intertwined, making them difficult to separate and therefore they have to be studied and considered both at once (Pickering, 1995). Human and material agencies can not be represented in distinct categories, instead they continually affect and relate to each other, and material agency persistently travels between being real entities and social constructs and back again. This 'mangle' can related to the studied tablet project in Stockholm in the sense that when the test users and the operating team were talking about usefulness of the tablet computers it sometimes meant the design of the technology itself and sometimes it denoted the practical use of the devices in the situated work context in the field. Additionally, the shaping of useful technology in the trials at Forum Nacka was not separated in distinct design and use phases. Instead a variety of areas and concepts of use were continuously discussed and tested as they arose during the course of the tablet project. This pattern can also be compared with the fundamental mechanisms of negotiation of meaning where aspects of participation and reification can not be clearly separated from each other (Wenger, 1998). Participation is not always denoted as merely taking part in human action such as technology use, and reification processes do not only comprise the organization and structure of meaning of for example technology design. Both processes are intertwined, simultaneously reinforcing and conflicting each other, and are needed in an always ongoing social shaping of meaning.

Further, Pickering (1995) emphasizes that material agency in terms of surrounding environment and artifacts never are decisively known in advance because these factors are emergent in real life practice over time. No one in advance may possess the ability of 'knowing' the shape and function of a particular technology for a specific context of use. Therefore, development of new technology necessarily involves exploration of contextual aspects and conditions of its situated environment of use through continuously identifying, modeling, solving, and tuning issues of design and use as they arise in real time practice. However, through real time participation in the often struggling development process, a logical and

persuasive retrospective story of ideas, intentions, choices, obstacles and breakthroughs leading to a resulting technology design can be reproduced, as if it was planned beforehand. In this sense, Pickering (1995) agrees with Suchman (1987) that human intentionality in terms of specific plans and goals are intertwined with both situated human action and material agency. These plans and goals continually evolve according to the everyday encounters with emergent situational and material conditions in the course of real life practice. Plans and goals are commonly shaped in an ongoing open-ended process with no determinate destination. Looking at the tablet computer tests at Forum Nacka, the intentions of the tablet project evolved gradually from the given requirements, conditions and needs in the fieldwork context and from the design, function and opportunity of use of a particular technology. The plans and goals of the Stockholm tablet project thereby emerged in the course of practice through exploring technology and expressing and discussing issues of expectations and experiences of usefulness among the group of participants. The intentions of the project never became fixed once and for all. Instead, plans and goals of the Stockholm tablet project were shaped in the real time context of practice, they did not control practice from without. The case study at Skanska illustrates some of the contradictory issues of developing useful ICT for a specific social work context. This development process can be described as an ongoing exploration of the tangible set of configurational design properties and functions of ICT system resources on the one hand, and the impure, diverse, emergent and dynamic work setting on the other. The course towards a useful technology design and meaningful use in practice is therefore a conflicting struggle of trying to make the perspectives fit together.

In Löfgren (2006, 2007), the importance of the user champion roles of the tablet projects at Skanska in Stockholm and in North Carolina was highlighted. The user champions as the link between ICT developers and users were vital in bringing together, discussing and negotiating the often diverse perspectives of intended technology design and its use in the varying fieldwork context. The role of champions is frequently highlighted in ICT management literature as important actors for bringing success in ICT project implementation in business organizations (see for example Earl, 1996). A typically preferred champion of an ICT project is often described as a senior individual in the organization that people trust and depend on, or a junior individual with strong senior support that gives

empowerment and legitimacy to the champion's opinions and actions within the project. In both cases, the champions at Duke University and Forum Nacka belonged to the latter category, but their respective roles and activities within the tablet projects looked very different. The champion at Duke University had many resemblances with the classical role of a heroic 'entrepreneur' (stemming from for example Schumpeter, 1911) in the sense that this person more or less embodied and drove the entire development process of the tablet project forward with direct support and encouragement from senior management. The Duke University champion was in fact a 'project champion' rather than a 'user champion', because this individual started the whole initiative, purposefully designed the overall goals of the development process and the resulting applications of the technology for use in practice, and was basically the manager for the total execution of the tablet project.

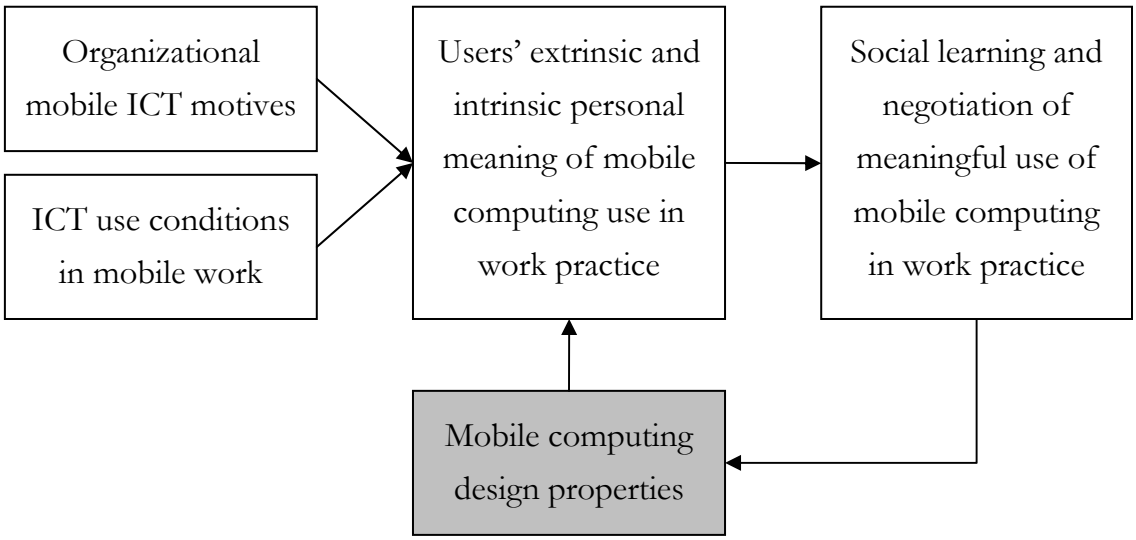
In contrast, the champion at Forum Nacka had a key 'lead user' role rather than a heroic innovator. This person acted as a primary recipient of the tablet computer device to evaluate its functions, opportunities and issues of use in the production site work environment. As mentioned earlier, the user champion at Forum Nacka was selected because of this individual's enthusiasm of new technology, but also because this person had straightforward pragmatic and competitive views on ICT use in construction site management practice. This individual had the ability to identify and evaluate technology that was acceptable for fieldwork requirements, and had the experience and skills for paying attention to practical problems of ICT use in work practice that few others could predict, localize and express (similar to 'the role of the individual' described in Fonseca, 2002). Therefore, the user champion at Forum Nacka was not a heroic entrepreneur, but rather a critical reviewer of the technology and a 'whistleblower' if it was not 'good enough'. On the surface, the user champion's contribution to the Stockholm tablet project may seem trivial, but it was certainly valuable both from an economic business viewpoint and from an ICT usefulness perspective, because it assisted in reducing the risk of implementing malfunctioning technology into the operative production site context. The user champion at Forum Nacka acted as a link in the redundant and messy conversations between the test users and the operating team of the Stockholm tablet project, and helped in conveying ideas and concepts of the technology that both functioned and failed in practice. Through the communicative activities of the Stockholm tablet project champion, a dialog between ICT developers and the

Forum Nacka test users was established and maintained. This was the primary source of information to collectively being able to find appropriate procedures of ICT use in relation to work practice and discuss areas of usefulness of the tablet computer technology, which could then be translated into fitting tools and applications. Even though the collaboration between ICT developers and users in the Stockholm tablet project did not materialize into tangible improvements of technology, the socially shaped development process was essential for identifying new concepts and ideas of usefulness, fitness and acceptance of ICT design for the practical site work context. In this process, the user champion helped in concretizing and personifying the perceived areas of meaningful use of mobile computing for construction site management practice among the test users at Forum Nacka.

It is once again tempting to make simplified and skimming analytic discussions of the outcomes of the two respective tablet projects at Skanska that merely relate to linkages between champion roles and project management. For example, the powerful and determined champion role at Duke University may have lead to enhanced project management capabilities which in turn contributed to the success of the tablet computer trials, while the more subordinate and vague champion role of the tablet computer tests at Forum Nacka did not lead to any further focusing of project intentions which partly may have caused its resulting termination. But such an analysis would leave out the fundamental differences of fieldwork management practice between the two tablet projects, as well as their respective learning processes of technology usefulness that are essential micro level sources of explanation for the divergence of their respective outcomes. Also, outcome analyses of ICT projects often have a tendency of merely evaluating its management processes and economic benefits, but regularly miss out on the resulting functionality of the technology design and how well it is adapted to the operative work setting it is intended to be used in. A too strong focus on evaluating roles, management processes and economic benefits of ICT projects, both during and after their execution, may therefore imply a risk of ignoring and wasting valuable learning of operative usefulness factors of technology design and its meaningful use in the situated work context.

However, it should be acknowledged that the unique and powerful role of the tablet project champion at Duke University made the venture a quite extraordinary ICT project within a work organization. The Duke University champion almost single-handedly identified the current problems of ICT use in site management practice, came up with a possible technical solution, managed the overall development and implementation of the technology and then used it with great enthusiasm in his daily work. During this process the champion also relentlessly and decisively succeeded in motivating and getting fellow colleagues to adopt and use the technology, and persistently received the needed upper management support in order to direct the development of the tablet computer platform further and expand its implementation and use to other construction projects at Skanska. In this way, the Duke University tablet project represents both an exciting and outstanding real life ICT project management case. Nevertheless, its development pattern is not typical for ICT projects in firms and organizations overall. Most ICT projects are not extraordinary and remarkable. Rather they are ordinary, and even 'boring', continuous adaptations of existing technology towards an ever improved ICT platform to match the requirements of the operative work organization. It is in this mundane context and perspective that the tablet project at Forum Nacka should be observed. For the test users and the operating team of the Stockholm tablet project, the tablet computer device was just another interesting concept that might bring new opportunity to the continuous improvement of ICT use in construction site management. It was something 'worth trying', but was hardly regarded as any fundamental solution to a particular problem. Looking at the results of tablet computer tests at Forum Nacka in retrospect, the technology was already at an early stage considered by the site management practitioners to be far from 'ready-built' according to their ICT use requirements. As a reaction to this, new tangible concepts and ideas of meaningful use of mobile computing and ICT emerged within the tablet project group instead. Consequently, it can also be questioned whether the more forceful entrepreneurial management approach of the tablet project at Duke University really would have helped the Forum Nacka tablet project group in overcoming the problem that essentially faced them, namely the shared perception that the technology in practice simply was not 'good enough'. The Stockholm tablet project user-practitioners gradually considered the tablet computer as a 'self-fulfilling prophecy' rather than something that eventually could become a natural part of their day-to-day work practice (compare with Henfridsson, 1999, 2000).

Usefulness as emergence of design



Positioning 'usefulness as emergence of design' in the analytical framework

If complexity and emergence rather than stability are dominant factors of work practice, then ICT development efforts within a work organization may have to be handled according to these changing operative conditions in order to enable usefulness and meaningful use of technology. The emergence of usefulness of ICT can be related to a fundamental 'cybernetic' problem (see for example Ashby, 1956), where the continuous adaptation between the designed technology and the emergent practice is striving towards a 'self-organizing' and acceptable configuration that generate a meaningful use experience in the real life context. In a broad cybernetic interpretation, a 'system' could be anything that deals with human and material agency, for example a system of people, a system of technology, a system of people and technology. Most cybernetic problems relating to design of technology is searching for a self-organizing system that is not purposefully planned and specified in advance, but is continuously and open-endedly reconfigured in response to its inputs. Either the system achieves a stable configuration or it will be adapted again and again until a stable configuration is reached. Similar to social shaping perspectives of technology development, a cybernetic view commonly does not only consider the mere representation of artifacts, humans and the world, but focuses on the activities of doing and performing things in the world and the emergent interplay of humans and artifacts (Pickering, 2002). Cybernetic concepts are compelling seen in the light of design and practical use of complex ICT systems,

because open-ended configuration of technology and self-organization between technology and humans are generally based on some underlying principles that direct a cybernetically oriented transformation process (Pickering, 2002). Translated into the world of ICT development, a complex integrated ICT platform of a firm is regularly constructed on a fundamental set of technology design principles that directly controls its possible configurations to achieve usefulness and meaningful use in practice. Therefore, the adaptive processes towards a useful ICT system design involve a wide range of possible modifications of technology and practice, as well as interfaces between technology, users and practice. Although these achievable alternatives are not endless, the search of ICT usefulness is still highly complex because of the ambiguous and paradoxical real life context in which system applications is used, relating to both designed and unspecified features of the technology as well as intended and unexpected behavior of use in the situated work practice. A cybernetic view on this problem would be to enable adaptive capabilities of ICT systems so that users to through their ongoing interaction with the technology continuously modify and reconfigure information and communication resources according to their emergent requirements in practice.

Truex et al. (1999) discuss the need for an 'emergent ICT systems development' approach in organizations to be able to match the changing information and communication requirements of work practice. One of the fundamental standpoints of this approach is that 'user satisfaction' is improbable. Under emergent assumptions of organization and work practice, user needs may unfold rapidly in directions that are poorly understood by the users themselves. Users can hardly be satisfied in these varying use conditions because their needs are always changing. ICT requirements are most often in conflict with users and can not be fully specified because they are constantly evolving in accordance with real life use. The requirement conflicts, the negotiation of them and the ongoing enhancement and maintenance of system resources are core activities of an emergent ICT development approach (Truex et al., 1999). It does not seek the delivery of stable ICT applications to users, but rather focuses on the delivery of ICT services that continuously tries to adapt existing ICT systems to the changing user conditions in the situated work context (Truex et al., 1999). Instead of stability, an emergent ICT systems development perspective acknowledges the ordinary everyday turmoil of ICT use in the practical work context as the central input to persistent system

requirement adaptations, and that these requirements are always in motion, unfrozen and negotiable in the same way as the inherent nature of real life practice. Because user requirements in practice are in constant motion and include natural ambiguity, useful technical specifications of an ICT development process can not be too specified and complete, but should be intentionally open-ended to facilitate improved adaptability of existing system resources. This must be complemented with comprehensive technical adaptation capabilities that are embedded in the underlying ICT infrastructure to be able to generate the necessary changes of included ICT systems (Truex et al., 1999). The purpose of this open and flexible systems architecture is to enable users to make their own modifications of the ICT resources to better match their dynamic use requirements in practice. The emergent ICT systems development approach also partly redefines the concept of an ICT project, because it acknowledges that every system must evolve continuously and must be constantly adapted to their changing use conditions and environments. A radically new 'ICT project' therefore denotes 'failure' of previous ICT systems development within an organization because the new project can not be fitted in with the continuous pattern of everyday tuning and maintenance of the existing ICT platform (Truex et al., 1999). Furthermore, emergent ICT requirements analysis does not only try to capture the early stages of an ICT system's life cycle and does not have to be cyclical in terms of periods of analysis followed by periods of implementation and use. Instead, an emergent user-system assessment process is an ongoing ICT development activity that is parallel and intertwined with operative use of ICT in practice and the daily maintenance of system resources.

The emergent ICT system development approach can be seen as a combined framework for incorporating ICT projects into the overall governance, management and maintenance of an ICT platform within an organization towards the continuous adaptation of system resources to diverse user requirements. This perspective can be related to a cybernetic view on management of organizations in general, where a business or work environment can be considered as an exceedingly complex and a not fully comprehendible system which requires abilities to cope with its inherent ambiguity and dynamics (see for example Beer, 1959). The fundamental problem of management is then to create an artful design of information and communication flows so that the organization quickly and adequately can be informed of actions of its internal and external environment, and then to act and respond to these flows in

order to adapt to new conditions and events. Similarly, emergent ICT systems development in its extreme form could be regarded as a strive towards a self-organizing cybernetically oriented ICT management model within an organization, where the technology is continuously adapted to the open-ended and changing user requirements in practice. Users' direct interaction with and modification of system applications, as well as the constant flow of information between users and ICT developers would thereby help in improving the user adaptability of the underlying systems architecture. With this perspective, ICT development could then be regarded as a persistent interaction, or an ongoing conversation, between people and technology, and between people and people, where the actual use of ICT in practice both directly and indirectly contributing to system adaptation. This complex and parallel intertwining of designed and emergent aspects of ICT development and use can be described in terms of a mangle, or a dance between human and material agency in real life practice (Pickering, 1995, 2002).

The cybernetically oriented emergent ICT systems development perspectives described above can be related to the studied case at Skanska. Technical legacy and dependency on existing ICT resources, user conditions and ICT requirements of social practice as well as organizational ICT motives generated the 'rules of play' which partly controlled the possible paths for future development within the company. The embarked service oriented architecture ICT development approach at Skanska Sweden clearly directed the course for developing future mobile computing applications and capabilities within the existing integrated ICT systems infrastructure. This selection of possible future adaptations and configurations was large, but still not endless as it showed a clear development trajectory. A similar pattern of open-ended development paths based on a set of service oriented architecture design principles of the underlying ICT platform was present at Skanska USA Building. The chosen ICT development course at both Skanska Sweden and Skanska USA Building seemed to enable improved ability of creating self-organizing configurations between technology and dynamic user requirements, as it highlighted two fundamental aspects of meaningful use in practice, namely 'generic access' and 'personalization' of data.

Relating this ICT systems infrastructure perspective to the studied mobile computing development efforts at Skanska, the participants of the Stockholm tablet

project gradually shifted their focus away from the specific applications of the tablet computer, to think more broadly about the changing ICT needs of site management practice overall. They became less interested in the tablet computer device as such, and more focused on the general principles for enabling flexibility and mobility of ICT resources in practical fieldwork. The test users as well as the operating team of the tablet project at Forum Nacka increasingly understood that their expectations of what a useful mobile computing platform should comprise were more related to the ongoing development of underlying ICT systems infrastructure components towards improving accessibility and adaptability of user applications, rather than adopting and using a specific mobile computing device. Consequently, both site management user-practitioners and the ICT staff developers of the Stockholm tablet project conceptually moved towards a shared vision of the design requirements of a useful mobility enabling ICT platform and its meaningful use in site management practice. This improved mutual understanding between the participants at Forum Nacka of how future usefulness development efforts of existing ICT resources should be prioritized and conducted at Skanska Sweden could be regarded as one of the main contribution of the Stockholm tablet project. The result of the sensemaking processes and the negotiation of meaning of the tablet computer trials at Forum Nacka may in fact offer valuable and complementary insights to the long term development of mobility and usefulness of ICT capabilities at Skanska as a whole. In line with emergent ICT systems thinking, the tablet project at Forum Nacka might not even be considered as a project, but as a part of the everyday mundane enhancement and maintenance of ICT resources for the practical use context, where the tablet computer tests can be seen as one of many tangible approaches for obtaining new user inputs to the continuous improvement of the ICT platform at Skanska. As have been repeatedly pointed out, the pivotal way to really understand user requirements and aspects of usefulness is to straightforwardly experience the paradoxical, emergent and ambiguous use of ICT in its context of professional practice. In this sense, the tablet computer device became a tool and a 'trigger' in the Stockholm tablet project for acquiring these improved insights of usefulness and meaningful use of mobile computing for the fieldwork setting. Relating back to Schön (1983), during the mobile computing trials at Forum Nacka the tablet computer was essential for identifying and 'setting' the problem rather than 'solving' it, because the issues the technology was trying to address was not fully known beforehand, but were unfolding in a trial-and-error fashion.

Useful mobile computing for production site management practice implied different things in the tablet project at Duke University compared to the one at Forum Nacka. While the Duke University tablet project specifically focused on improving mobile document management in the field, the tablet computer tests at Forum Nacka broadly explored the opportunity for mobile online use of ICT resources on site in general. This implied that the expectations of the two tablet projects were quite different regarding intentions, content and scope, which in turn had a direct effect on the meaningfully consistent connections between these expectations and the resulting experiences of using the technology in practice. Going back to the study at Filmstaden, construction site management practitioners expressed that current ICT use procedures were ineffective, inflexible and were distancing production management personnel from the site work teams. Basically, too much time was spent at the computer inside the site office, instead of being in the field coordinating and supervising work. These viewpoints were shared by the test users of the tablet project at Forum Nacka, and similar to the production management team at Filmstaden they had expectations on mobile computing applications as an opportunity to reduce some of these problematic situations of ICT use. Construction site management practitioners at both Filmstaden and Forum Nacka can be regarded as experienced ICT users and they demonstrated competitive and pragmatic views on any use of ICT in their everyday work, most clearly expressed by the user champion of the Stockholm tablet project – 'show me the money!'.

In contrast, the tablet project at Duke University enabled a fresh start of designing useful ICT applications for production site management practice, because ICT was not at all as widely adopted and used by site management personnel at Skanska USA Building compared to Skanska Sweden. Therefore, mobile computing and ICT in general seemed to be rather unproblematic in the tablet project in North Carolina, as the technology enabled novel solutions to fundamental information and communication requirements in the fieldwork environment that had not previously been addressed. The Duke University tablet project team therefore could start building fitting ICT systems and applications as well as establishing the foundations of appropriate and effective onsite ICT use procedures more or less from scratch. The tablet project in Stockholm, on the other hand, had to struggle with deep-rooted legacy and dependency of existing ICT system resources at Skanska Sweden

and their widespread use in site management practice, which directly influenced the feasible development trajectories of adapting and enhancing the ICT platform with for example mobile computing capabilities. These factors combined with the divergence in actual construction site management work practice between Skanska USA Building and Skanska Sweden made the preconditions of developing and designing fitting mobile computing applications quite different at Duke University compared to Forum Nacka. Starting from seemingly similar conditions and requirements, the tablet projects at Duke University and Forum Nacka basically turned into two disparate ventures, from a conceptual, technological, social and practical point of view.

Seemingly two similar technology development projects in apparently identical work environments were to a large extent actually poles apart concerning both technology and practice. It is this 'situatedness' and 'path-dependency' that make each local practice context unique, which also make detailed discussions and comparisons of shared views of expectations and experiences of useful mobile computing design between the two tablet projects problematic. The tablet projects at Duke University and Forum Nacka involved the same domains of professional practice and ICT development, but their respective identification of issues and opportunities of the technology as well as how they framed the context and content of work were still fundamentally different. Also, the fundamental differences in management approaches of the two tablet projects also added to the dissimilarities between them, contributing even further to their diversity in intentions and goals, setup and execution, sensemaking and negotiation of technology usefulness, and development of useful technology design for meaningful use in practice. Consequently, on a general level the two tablet projects can be related to each other in a broad discussion of mobile computing in construction site management practice. But on a detailed level of analysis their expectations and experiences of meaningful use of the tablet computer device in practice and their emerging concepts of a useful mobile computing design have to be considered in their respective work contexts and preconditions for ICT development and use. Therefore, usefulness and meaning of mobile computing can not be described in detail in general social and technological realms, it can only be specified in the situated, emergent, ambiguous and conflicting local mangle of practice (Pickering, 1995). The particular resistances and acceptances of the technology that evolved in the two tablet projects must be

studied separately based on their respective situatedness, path dependency, ambiguity and uncertainty of the locally addressed professional fieldwork environments in order to better understand their unique issues of ICT usefulness and meaningful use. This perspective can also be related to concepts of locally produced and socially constructed symbolic interaction of meaning and meaningful action. Basically, people act toward things based on the meaning those things have for them in their situated social environment and meaning evolve over time and is constantly reproduced, interpreted and negotiated in local and ordinary everyday interaction between people (see for example Blumer, 1969).

However, the starting point for both tablet projects at Duke University and Forum Nacka was based on similar general ideas of empowering production site management practitioners by using new mobile computing capabilities in the field. These intentions can be related back to Skanska's overall organizational ICT motives to improve utilization of existing ICT resources and enhance ICT use conditions in the production fieldwork environment. The form, function and performance of the tablet computers themselves were trajectory components of the learning process towards a useful mobile computing ICT design and its meaningful use in practice. Intertwined with the situated work context, the use of the tablet computers made different imprints and contributions to the development process at Duke University compared to Forum Nacka. This indicates that the tablet computer was not a neutral artifact in the real life use context. The tablet computer generated different expressions of meaningful use at Duke University compared to Forum Nacka, and triggered different processes of sensemaking and negotiation of meaning in the development towards a useful mobile computing technology design for construction site management practice. During the construction site visits at Skanska USA Building in North Carolina it became quite clear that the site management practitioners' experiences of using the tablet computers in their everyday work were to a certain extent in line with their prior expectations, creating meaningful connections between them, and expressed as apparent excitement for the technology and their new found need for it in their work. On the contrary, the tablet computer test users at Forum Nacka did not create this kind of meaningfulness between expectations and experiences of the technology. The Stockholm tablet project participants essentially lead the tablet computer concept to a dead end, but instead they mutually achieved new perspectives and complementary

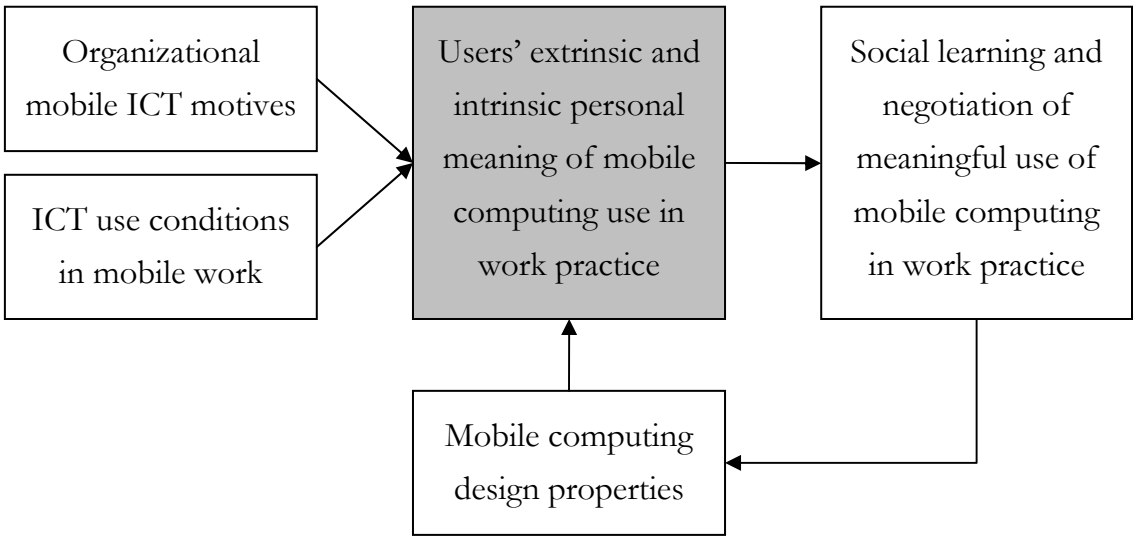
understanding of design and use of mobile computing and ICT in construction site management practice.

Usefulness of technology, both as an individually perceived and socially negotiated concept, is a 'moving target' because the user requirements are constantly shifting, both regarding changing use contexts and from the viewpoint of content and functionality of the technology in the practical work setting. Therefore, usefulness has no closure and no stability as technology always can be improved and users can always be more satisfied. A useful mobile computing design and its meaningful use in practice is therefore only a temporary acceptable condition of the technology that accounts for a 'mere minimum meaning' of its use. This sense of meaningfulness of the tablet computer was rather quickly achieved in the tablet computer project at Duke University, while the explorative sensemaking processes and the conversational negotiation of meaning in the trials at Forum Nacka lead to abandonment of the technology to look for other alternatives and approaches instead. An essential difference in usefulness learning between the two tablet projects can be found in the reduction of ambiguity between prior expectations and actual experiences of the tablet computer in the context of its practical use, which also points to the situated and unforeseen nature of any sensemaking process within an organizational setting. Sensemaking does not always result in action and concrete outcomes as it did in the Duke University tablet project. But it may instead result in a better understanding of a situation or that it uncovers further information of an ambiguous issue (Weick, 1995), as shown in the tablet project at Forum Nacka. As have been pointed out earlier, the value of a learning process towards meaninglessness generally implies learning complementary and often significant aspects of the involved issues instead.

The tablet project at Forum Nacka showed that the existing ICT resources as well as the preconditions of construction site management practice affected the scope and direction of the processes of learning and development of the tablet computer and its use in the field. Some of these factors were enhancing the evolvement of usefulness of the tested tablet computer device, while others were creating barriers of use. Some of them were designed features of technology, organization and practice, while others were unplanned and emergent aspects of practical technology use and operative work. In this complex interaction pattern between technology,

context and people, there is essentially no shortcut in the social shaping of usefulness but to actively get involved in the often paradoxical situations and contexts of using the technology in practice. The tablet projects at Duke University and Forum Nacka both indicated that the search for usefulness and meaningful use of the mobile computing device basically was nothing but situated learning in practice, or situated practice as learning. It was through playing, exploring and handling the tablet computer in practice that shaped various forms of expressions and negotiations of meaning which connected the expectations of usefulness of the technology with the actual experiences of it. However, the fallout of this usefulness learning process in the two separate tablet projects in North Carolina and in Stockholm was vastly different.

Usefulness as meaning in practice



Positioning 'usefulness as meaning in practice' in the analytical framework

The Forum Nacka tablet computer test users' perceptions of ICT and mobile computing displayed a direct analogy to the reflective and adaptive nature of their own professional practice. Construction site management work involved a persistent and ongoing mangle between planned activities and handling on unexpected events, which resulted in a constant reflective conversation with the situation at hand to identify and tackle arisen production issues in the field (compare with for example Schön, 1983). Having access to various ICT resources was a vital component for acquiring and exchanging needed information in order to establish improved understanding of problematic situations and their possible resolutions. The study at both Filmstaden and Forum Nacka showed that the use of ICT in the dynamic and emergent fieldwork environment did essentially not comprise preplanned behavioral patterns of using certain applications for a specific purpose, but was rather based on vague intentions of using ICT resources in response to work events and situations on site. The actual use of ICT among construction management practitioners at Filmstaden and Forum Nacka was as reactive and adaptive as work practice itself, and could not be planned or patterned in advance, because it continuously changed depending on the situation. At Filmstaden, Forum Nacka and Duke University the problems of ineffective administrative work routines of running back and forth between the production site and the site office, as well as the lacking presence of site management practitioners in the field triggered different ideas of mobile ICT use to

improve these deficient conditions. At Filmstaden, production site management staff expressed that extending the use of ICT resources into the field, using wirelessly connected mobile computing devices, would probably make their work more effective. By having instant access to the necessary ICT resources in the field through a mobile computing device, they expected that they could attend to administration and documentation of fieldwork activities without having to leave the site. In the Duke University tablet project, the purpose of using the tested mobile computing technology was more formalized, focusing on digital document management and update processes on plans and specifications in the field. However, the tablet project at Duke University also included a broad motive of simply having access to updated information sources on site. At Forum Nacka, the tablet computer trials were not explicitly seeking formal use procedures of the technology, but were leaning more towards similar general ideas of mobile access, availability and flexibility of ICT resources that were expressed at Filmstaden. The Forum Nacka tablet project tried to find new possible concepts, approaches and development paths in improving the deficient ICT use situation in construction site management practice.

Despite the different perspectives of fieldwork management practice and ICT use of the studied cases at Filmstaden and the tablet projects in North Carolina and in Stockholm, still they collectively show indications of a shared fundamental notion of usefulness of ICT and mobile computing for the practical work context. This mutual sense of basic usefulness was about 'having access to' ICT resources in general, rather than explicitly 'using' certain functions and applications. This can be related the discussion of design and use of computing systems and ICT described in for example Suchman (1987) and Heath and Luff (2000), where technology can be regarded as useful for real world practice if it is intentionally designed as an unspecific multipurpose resource for situated action. In the same way as the work of construction site management practitioners was not a mere execution of a designed plan, but a persistently ongoing response and adaptation to planned work, the use of mobile computing and ICT in general must be designed as intentionally open-ended resources to be able to match and respond to the emergent nature of situated work practice. From user-practitioners' point of view, the fundamental usefulness aspects of ICT use in the studied fieldwork environment was therefore based on availability and adaptability of information and communication resources depending on the

context and content of use, rather than detailed use procedures of ICT applications for specific professional work activities.

This was most clearly showed in the tablet project at Forum Nacka, where the test users expressed that meaningful use of mobile computing in practice was essentially about informal and available utilization of existing ICT resources, all depending on the specific work situation of use. For the Forum Nacka user-practitioners the usefulness of mobile computing gradually became less associated with a specific portable user device, and new ways of thinking emerged that included more dynamic and flexible use of ICT in the production site environment in general. The Stockholm tablet project increasingly shifted its focus away from the tablet computer device to instead address issues of the underlying ICT platform to improve ICT use in construction site management practice. The discussion between the Forum Nacka test users and the operating team gradually became more focused on ideas regarding enhanced integration between existing ICT systems, overall adaptability and personalization of applications and data, as well as improved generic access to ICT resources through both wired and wireless connections. The test users at Forum Nacka were growingly convinced that meaningful use of mobile computing in their field based management practice was about ever present accessibility to a variety of ICT resources using different user terminals depending on the context and content of work. Due to constantly changing information and communication requirements of construction site management practice, appropriate ICT use could mean different things in the diverse situations of practical work, and could therefore only be decided by the user-practitioners themselves during these circumstances. Site management professionals at Forum Nacka expressed a need to be able to 'seamlessly' switch between using handheld and mobile devices during certain use conditions and work events, and fixed desktop computers during others.

The discussion above indicates that usefulness and meaningful use of mobile computing and ICT in general can not be fully designed, only designed for; implying that technology have to facilitate cybernetically oriented capabilities for users to deal with their own adaptability, flexibility and mobility of ICT resources according to their varying needs in practice. That is why a useful design and meaningful use of mobile computing in work practice is more contingent on whether the underlying ICT systems infrastructure can deliver user enabled open-ended personalization and

generic access of data, rather than offer a 'complete solution' to users in the form of specialized applications for certain work activities with detailed use procedures. In that sense, users are not just receivers of purposefully designed technology, as they indeterminately are making sense, negotiating and shaping their own purposes of the technology and its possible meaningful use in their emergent professional work context. This can to a large extent be portrayed as 'informal' use of the technology, which should not be regarded as use 'without form'. The forms of use are however made up in real time by users involved in the practice of work, which essentially is about user-practitioners' changing perceptions, interpretations, sensemaking and negotiation of meaningful use of technology design depending on the actual use situation.

In other words, to better understand the notion of usefulness there is a need to shift away from looking at 'made things' to the 'making of things', from 'made meaning' to the 'making of meaning', which is about grasping the ongoing and open-ended learning processes of meaningful use of technology in real life work practice. Capturing usefulness of mobile computing and ICT use in practice is essentially not about trying to represent it as explicit 'knowledge' of technology, but to continuously learn about its practical use and adapt technology to its situated, dynamic and changing content and context of use in the real world. Analogous to Pickering's (1995, 2002) discussion of agency and performativity in practice, usefulness is therefore not primarily an 'epistemological' concept, but rather an 'ontological' one. This can also be related to the handling of 'Aristotelian' and 'Platonic' concepts in ICT systems development described in Dahlbom and Mathiassen (1993). While an ICT system is designed and represented according to formal structures and principles relating to Aristotelian concepts, human practice is regularly more constructed from communication, learning and action through exemplifications of specific circumstances and social contexts relating to Platonic concepts. One of the fundamental usefulness challenges of ICT design is therefore to understand the Platonic nature of human practice, and to recognize the technology not only as a formal function based on Aristotelian concepts, but at the same time as a tool to support human beings in using and communicating Platonic concepts (Dahlbom and Mathiassen, 1993).

The construction industry itself is actually a good example of the points that is tried to be made in this thesis regarding the concept of usefulness and meaningful use in practice. Decades of development of all sorts of sophisticated ICT tools for construction purposes have more or less left the industry with only a few true 'killer applications' as far as widespread adoption and use is concerned. In architecture and building design the extensive development of 'computer aided design' systems have lead to advanced use of ICT in outlining and visualizing buildings and artifacts in construction projects. But in the dynamic and adaptive production site environment the development and uptake of ICT is still waiting for some kind of breakthrough. Just exaggerating slightly, so far the killer applications of construction site management can be narrowed down to the use of walkie-talkies and fax machines, and more recently the use of mobile phones and e-mail. These ICT applications have played a valuable role in supporting the informal patterns of communication and information exchange in handling unexpected events and critical problems that constantly arise at construction sites. The unspecific general purpose design of the walkie-talkie, fax machine, mobile phone and e-mail is actually matching the spontaneous, emergent and social nature of construction site management work in reality, and is not trying to remodel and redesign practice in order to match the technology.

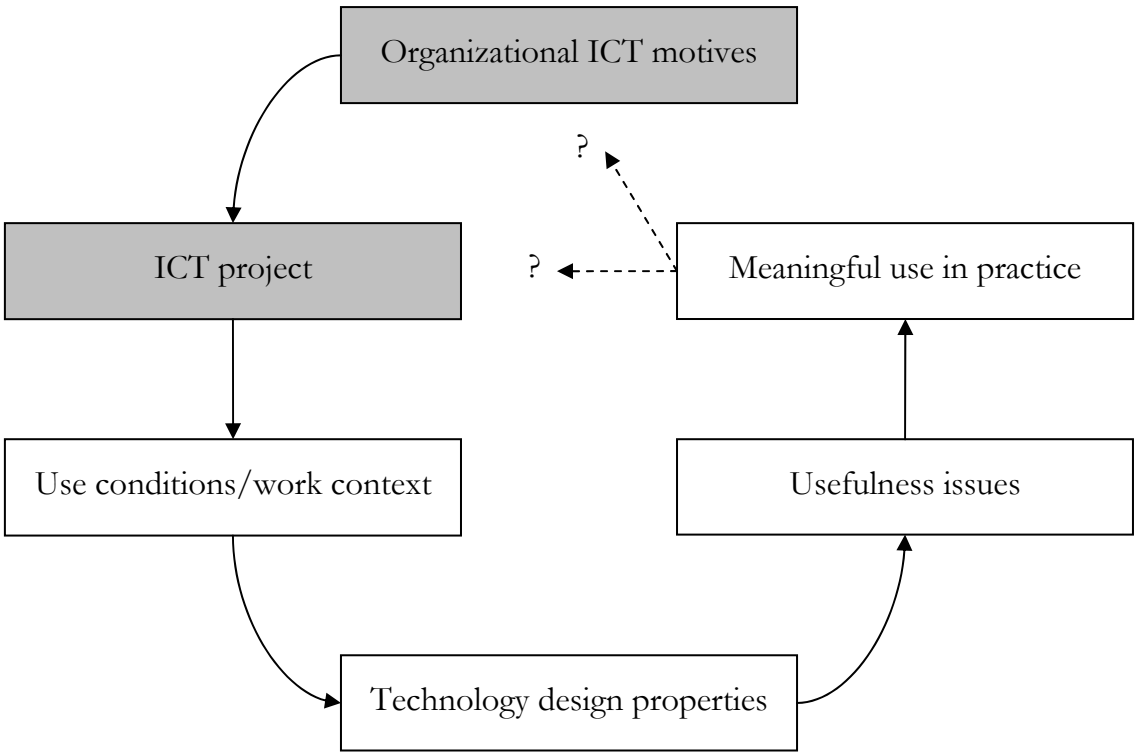
Similarly to the argument above, a useful mobile computing platform in the field must be able to deliver unspecific, available, versatile and adaptive ICT applications that enable the same effortless, intuitive and meaningful use in the context of work as using a walkie-talkie, fax machine, mobile phone or e-mail. This open-endedly personalized mobility enabling ICT use pose a fundamental paradoxical challenge in developing and designing the underlying ICT systems infrastructure, as the technology necessarily is built on a set of design principles that are purposefully planned, while its use in practice inherently is dynamic and changeable. The ICT platform therefore simultaneously have to achieve a sophisticated and purposeful integrated system architecture that delivers structure and stability of ICT system resources, at the same time as end user applications of the system platform must be able to be accessed and adapted by the users according to their practical use context at hand. An important part of developing usefulness of a mobile computing ICT platform is therefore to persistently acknowledge and handle the paradoxical and intertwined duality between emergent and designed factors of both technology and

its use in practice. Boivie (2005) describes this as a balance between the 'formal' design, representation and function of the technology and the 'fluid' complex nature of users' situated work practice, where it is not possible to arrive at a completely preplanned model of ICT use in real life, as it essentially can not be fully captured. Fundamental for a usefulness development process is therefore to find out what elements of both technology and practice can be taken as given prerequisites for their organization and conduct, and what components are inherently variable and vague. Poor understanding of these factors and tweaking the wrong components of the ICT development process may lead to faulty and frustrating outcomes in the context of use.

Consequently, the usefulness challenge in ICT systems development in general can then be described as a contradictory struggle of trying to find an appropriate degree of formalization of both technology and practice. This is about searching fitting technology-practice configuration between factors that are more or less fixed, between open-ended aspects that raise opportunity for improved design and further development, and between features that should be left usefully emergent and unspecific. Useful mobile computing and ICT in construction site management practice, or fieldwork in general, is primarily about developing design and use of ICT which not merely focus on administration of completed work activities that potentially result in additional obstructive work procedures and puts extra burden on professional practitioners. Instead, mobile computing must enable flexible ICT tools that are used in both planned and unexpected events of everyday work, during the time and context that they are actually taking place. Making mobile computing and ICT an intentionally open-ended and adaptable end user resource is one of the core issues of creating usefulness of the technology for the varying information and communication requirements in situated fieldwork practice. These ICT design ideas may seem trivial at first, but is grounded in the profound difficulty of actually understanding the ICT user needs in mobile fieldwork. The research findings presented in this thesis indicate that useful mobility enabling ICT should not primarily support the passive administration of 'performed' work tasks, but should be designed as an active tool that is meaningfully integrated with practice to be used during the actual 'performance' of professional work itself.

6 EPILOGUE

At this point, the thesis has almost gone 'full circle' of its defined scope and journey. However, a missing part of the analysis so far is a discussion of the research in relation to preconditioned organizational ICT motives and the initiation of ICT projects they generate, highlighted in gray in the figure below.



The scope and the journey of the thesis

The kind of organizational ICT motives described in the studied case at Skanska belongs to an incremental change process within the company with the purpose of improving the existing ways of working in production site management through the introduction and use of complementary mobile ICT capabilities. Based on these incremental organizational ICT motives, the tablet projects at Skanska were initiated to stepwise try to improve existing practice in the site management fieldwork environment. In ICT project setups such as the tablet projects, where ICT developers, targeted users as well as the organization as a whole acknowledge the receiving work context of the technology as given prerequisites of the ICT project, there is usually a broad consensus among the involved participants of what the outcome of the ICT venture 'should' deliver. Taking the Stockholm tablet project as an example, the operating team and the test users were almost 'equal' parties in the

project, generating a consensual process of its development. Both ICT developers and users of the tablet project at Forum Nacka shared the fundamental standpoint that the tablet computer should fit the work context and not the other way around. The social processes of sensemaking and negotiation of meaningful use of the technology were based on the shared premise of not changing existing site management practice, but rather to adapt existing ICT resources to better serve the work of site management practitioners. In this consensual and incremental development process, the continuous input from the user-practitioners was vital for the progression of the ICT project, making them an influential part of it. Developers and users were mutually dependent on each other in communicating usefulness issues of the technology in order to produce an outcome that was meaningful and acceptable for practitioners in their dynamic fieldwork context.

However, consensus and equality among involved participants of an incremental ICT project do not necessarily mean that it produces a satisfactory outcome. As shown in the Skanska case, the mobile computing design of the tablet computer and its conditions of use at Duke University created alignment of the development process towards perceived meaningful use of the technology in situated work practice among the targeted user group. The tablet computer technology seemed to address explicit deficiencies of handling information and communication in the field, and by using simple mobile ICT tools construction site management practitioners experienced improvements of their work situation. In contrast, the test users at Forum Nacka lost interest in the tablet computer because it did not bring the expected improvements of their everyday work. Using mobile computing for offline work and wireless synchronization of documents as used at Duke University was very different from using mobile computing for permanent online wireless connectivity purposes as anticipated by user-practitioners at Forum Nacka. Seemingly slight differences of work practice between construction site management professionals in North Carolina compared to Stockholm brought fundamental changes to the context in which mobile computing was used. In addition, legacy and use behavior of ICT resources in the production site environment also influenced the separate approaches of the two tablet projects at Duke University and Forum Nacka. These divergences in context and practice resulted in different judgments of practical application areas of mobile computing in the work setting, which in turn lead to contrasting expectations and experiences of meaningful use of the tablet

computer between the respective tablet projects. Therefore, simply moving a successful technical incremental 'solution' from one use context to a presumably similar one is far from trivial.

What about organizational ICT motives trigging ICT projects that stem from more comprehensive and overthrowing strategic change processes within a firm? Does the discussion on usefulness of mobile computing and ICT made in this thesis also apply to more radical and disruptive organizational ICT development processes? Taking the business context of this thesis as an example, there is currently a general drive in the construction industry towards the development of more 'industrialized' building processes in the anticipation of achieving faster completion of construction projects and decreased production costs. With the car industry as the main role model, a central idea of industrialized building since the 1930's (see for example Hounshell, 1984) has been to try to move from an onsite 'handcraft' building process requiring large human and material resources to more lean 'manufacturing' methods based on prefabricated building elements which are then assembled on site (detailed discussions of industrialized building methods can be found in for example Lessing, 2006; Unger, 2006). Additionally, new ICT concepts and applications have also emerged to specifically support the industrialization efforts in construction. One of those carrying ideas over the past three decades is the development and use of 'building information modeling' in construction projects. Without going into details, building information modeling can roughly be described as the process of generating and managing building data during the whole life cycle of a constructed facility, using object oriented, real time, dynamic building modeling ICT software, with the overall ambition of decreasing wasted time and resources in building design and construction. This process produces the 'building information model', which may encompass for example three-dimensional building geometry, spatial relationships, geographic information, time planning, as well as quantities, properties and procurement of building components. Apart from the complex database standards and ICT systems infrastructure this generally is based on, the building information model is then thought to enable a more efficient ICT platform for sharing and collaborating with construction data between different participants and professional roles during the execution of a construction project. The idea is that each project participant is storing their design contributions of the model into its shared database. And throughout the project, essentially all design and construction

issues are communicated between involved project actors through advanced visualizations of the building model with for example conflict and collision detection of its components and parts (for more on building information modeling technology and practice, see for example Lee et al., 2006; Plume and Mitchell, 2007; Howard and Björk, 2008).

Many ideas of industrialized building and its complementary ICT concepts such as building information modeling can be described as innovation processes partly seeking 'creative destruction' (Schumpeter, 1934), intentionally aiming at profoundly changing some of the existing logic, structure, competence, roles, technology and practice of construction projects. A continuous and emergent ICT systems development path (Truex et al., 1999) of existing ICT resources discussed in chapter 5 will probably not be able to fully support this kind of radical change process, which most likely will require a fundamentally new configuration of technology and practice. In such a case, the ICT development process within the firm will therefore partly abandon the incremental and emergent fine-tuning of current technology in favor of creating new ICT capabilities that are intended to better support the new visions of the organization. The organizational ICT motives supporting this kind of development path are therefore radical and disruptive, rather than incremental and consensual. For example, one of the main ideas of building information modeling is to try to reduce many of the unexpected and improvisational elements of construction projects through a more advanced planning model that the new ICT capabilities facilitate. The organizational ICT motives for introducing building information modeling within a construction firm may therefore imply that design and construction practitioners in the operative business environment are required to fundamentally change their current work practice in relation to the use of ICT in order to proactively plan and execute processes according to the building information model. A corporate agenda that strives towards 'getting rid of the unexpected' through the use of building information modeling may therefore be regarded by practitioners as an explicit threat towards their existing accustomed practice, professional roles and organizational setups of construction projects. Consequently, an ICT project that aims to implement building information modeling is likely to be of a conflicting, rather than a consensual nature, resulting in hierarchical and professional power struggles between organizational ICT motives and individual user-practitioner perspectives, as well as between ICT developers and

users. Increased focus on 'user acceptance issues', rather than 'usefulness issues', will most likely be the guiding managing principle in the sensemaking and negotiation of meaningful use in such an ICT project, because it attempts to radically change some of the preconditions of the work context and its behavioral practice in which the new technology then is introduced. A critical challenge in managing this kind of radical ICT projects is to try to make user-practitioners understand and accept the change, even though it most likely will be painful and incomprehensible for them. Ultimately, however, user-practitioners most often have low influential power on the development process of disruptive ICT projects compared to the decisive mandate that ICT developers possess through the authority of an upper management radical change agenda.

Relating the discussion above to mobile computing use in construction site management, an introduction of mobile ICT into the fieldwork context will probably never be a direct result of disruptive organizational ICT motives triggering a radical ICT project. Mobile computing is merely a complementary technology that in different ways extends the use of existing ICT resources. The usefulness and benefit of mobile computing relies on how well it is adapted to the existing ICT platform, regardless if this is an integrated ICT systems approach such as in the studied case at Skanska, or based on alternative principles such as building information modeling. Furthermore, the industrialization of the construction industry and its building processes will always be regulated by the constraints of site based production (Dainty et al., 2006). Improved coordination of onsite production activities and ICT mobility of construction data will therefore still be driving prerequisites for creating a more effective fieldwork setting, regardless if it is called a traditional 'construction site' or an industrialized 'assembly site'. However, depending on the underlying ICT systems infrastructure and the scope and outline of site management work, a useful design of the mobile computing technology and its essential use procedures may look very different in order to generate appropriate meaningful use in the local setting of practice.

Despite governing organizational ICT motives, setups and management of ICT projects and whatever the ICT system and work context of use might be, one fundamental issue of usefulness and user acceptance is essentially the same – there will always be a discrepancy between how an ICT system is designed for its intended

use and how it actually is used in situated work practice. This distance between the formal design principles of the technology and the fluid use in emergent human real life will never be fully bridged. However, it is still necessary to persistently address this issue because the use of ICT comprises an integral part of work in all contemporary business organizations. Firms still have to continuously try to find new ways of making the technology a less obstructive part of everyday practice in their operative work organizations. The study at Skanska showed that usefulness is an open-ended concept in terms of that there is no definite closure or long-term stability of it in practice. Perceived technology usefulness in the local work context is essentially an impermanent stable pattern of meaningful use that is 'good enough'. This can also be related to the term 'satisficing' (see for example Simon, 1979), where a human 'rational' decision or a solution to a problem are simultaneously 'satisfying' and 'sufficing' an intended outcome, rather than being a maximized and optimal one. Moreover, ICT can always become more useful in terms of adaptation between the designed technology and the emergent work context, making the concept of usefulness a 'moving target' because meaningful situated ICT use in practice takes place and is continuously shaped in the inherent variation and persistent evolvement of everyday work. In the same way as practitioners continuously are affecting and altering their ongoing social practice, users may alter use conditions and find alternative meaning of ICT use in the work context by various forms of adaptive action.

The study of the tablet projects at Skanska showed the value of getting the technology users involved in the development and implementation process from the beginning. Getting appointed test users acquainted with the technology and letting them explore and express potential application areas of practical use of the tablet computer was a central approach of the projects. This process highlighted the ongoing collaborative dialogue between site management users and ICT developers in order to translate practical onsite information and communication requirements to improvements of ICT resources and their corresponding meaningful use in the field. The tablet projects at Duke University and Forum Nacka also illustrated that user champions played a vital role of being the link between technical development and the targeted user group. These individuals were important to get other users acquainted with the technology and its possibilities. Through the champions, a dialogue between ICT developers and the test users was established and maintained

in the search towards a useful design of the technology for fieldwork management purposes. The described way of collaborating and communicating in the tablet computer pilot projects at Skanska enabled vital mechanisms of shared understanding between fieldwork management users and ICT developers. ICT developers enhanced their understanding of the complexity of introducing mobile technology in the construction site setting, and realized that their conceptions of information and communication issues in the production environment as well as the ICT needs of construction site management practitioners were somewhat simplified, or even incorrect. The user-practitioners on the other hand improved their understanding of the potential of the new technology and developed a positive attitude towards adopting new ICT solutions that might possibly be able to improve their work. The users also improved their understanding of how existing ICT resources at Skanska were designed and functioned, and how and why this technological legacy determined the possibilities and limitations in further adapting and developing ICT applications.

The research findings of this thesis can be related to the perspectives of 'soft systems thinking' and 'dialectic systems thinking' of ICT systems development described in Dahlbom and Mathiassen (1993). As depicted in the Skanska case, the usefulness of mobile computing and ICT in the construction site work setting was in many ways acknowledged by the studied participants themselves as a complex, conflicting and contradictory relationship between the formal and fixed design of the technology and its fluid and varying use in practice. This formed a dialectical perspective of what usefulness, in terms of 'meaningful use', essentially consisted of. However, the tablet projects within the company identified the value of an initial 'bottom-up' soft system development approach to address this problem, rather than a pure dialectic or a mechanistic 'top-down' one. Soft systems thinking tries to acknowledge the present situation and nature of ICT use in organizations, seeks to capture the 'big picture' of emergent properties of the social context, and base design decisions of ICT systems on these holistic perspectives and compare the resulting technology with users' views of using it in their everyday work practice. In soft systems development approaches, design of technology is seen as learning and its result is a list of negotiated requirements for outlining new or adapting existing ICT resources (Dahlbom and Mathiassen, 1993). On the other hand, the case study at Skanska also showed elements of a dialectical systems development approach in

the sense that the contradictions of usefulness in practice also became real grounds for various actions. For example, the tablet projects explicitly explored the meaning of using the tablet computer in the site management fieldwork setting by testing it in practice, and then negotiated its different usefulness issues and contradicting perspectives of technology design and use between the involved participants.

Consequently, the analysis of the tablet projects at Skanska can be synthesized into a common perspective that can be called 'dialectic soft systems development'. Similarly to the 'intervening' ICT system development approach described in Dahlbom and Mathiassen (1993), or 'reflective' systems development described in Mathiassen (1998), the approach of the tablet projects combined both top-down mechanistic design and construction of ICT systems as well as bottom-up evolutionary learning and involvement between users and developers. However, in the tablet projects at Skanska, and especially the one at Forum Nacka, the involvement of users in a bottom-up learning process towards outlining the explicit actions of technology development was a dominating activity. The working processes of the tablet projects therefore intertwined the dialectic 'soft' usefulness issues of mobile computing in practice towards the development of 'hard' technical design aspects of ICT resources. First of all, this entailed a stepwise process of understanding the given conditions of technology and use practice among the involved participants. The practical use context of the tablet computer was explored together with users' interpretations of meaningful use of the technology. The tablet projects tried to recognize and understand the complexity and ambiguity of ICT use issues in construction site management practice, as well as the actual limitations of human and technical resources to address these problems. The involvement and interaction between developers and users were central in making sense of technical opportunities of the tablet computer platform in the practical fieldwork context, and these collaborative processes continuously negotiated the possible development actions of the tablet projects towards an acceptable and useful technology configuration. The user oriented development perspective of the tablet projects stressed the 'quality in use' (Dahlbom and Mathiassen, 1993) of how the technology was implemented and adapted to the actual use conditions in the social work context. The study at Skanska showed that there were substantial differences between the quality of ICT resources according to the technical specifications of the systems and their resulting quality in use in practice. In this context, managing the

issues of ICT usefulness was essentially about unrelentingly and open-endedly addressing the problem of the inherent distance between design and use of ICT, but never being able to fully solve it. In this kind of ongoing learning processes of sensemaking and negotiation, the development of useful technology design does not create a definite solution, but rather give rise to a new ICT use situation where the technology hopefully is perceived as more useful than the previous situation. In this sense, one of the core processes of 'design' in general can be described as a matter of continuously 'changing existing situations into preferred ones' (Simon, 1969).

Also in line with the arguments of Dahlbom and Mathiassen (1993), all ICT development projects are ultimately compromises, managed both by rules and by influence of changing situations in the work environment. Radical ICT projects are usually more rule driven, due to the often disruptive organizational ICT motives they are generated from. Incremental ICT projects, such as the studied case of mobile computing development at Skanska, are generally more situation driven, rather than rule driven. While rule driven ICT projects largely determine the design and use of technology from a top-down perspective based on the needs and purposes of an organizational agenda, situation driven ICT projects are generally trying to change configurations of ICT systems through a bottom-up process with the purpose of directly supporting existing user needs in the current context and practice of work. However, the tablet projects at Skanska showed that it is not always a straightforward task to find out at the outset of an incremental situation driven ICT project what the actual 'needs' are, both from the perspectives of individual users as well as the social work organization. The tablet projects could therefore not fully plan the development and design of the mobile computing system in advance, as it had to be tested and negotiated in a conversational trial-and-error learning process between users and developers. Through constantly recognizing the conflicting views of ICT use in the situated work context and seeking to create a meaningful and acceptable platform for learning and change among user-practitioners, the participants of the tablet projects at Skanska improved their understanding of what useful mobile computing in construction site management practice was essentially about.

The model for collaboration and learning between user-practitioners and ICT developers in both tablet projects was essentially the same. Still, this mutual

approach was not a guarantee for developing useful applications of the tablet computer. As a consequence of the positive outcome of the tablet computer trials at Duke University, the technology was considered 'worth trying' by the Forum Nacka tablet project participants. Early on in the tablet computer tests at Forum Nacka however, it became quite clear that the technology was not the proper response to the issues of ICT use in site management practice, and the development efforts relating specifically to the use of the tablet computer were put on hold. However, these experiences enabled the Stockholm tablet project team to learn that a useful mobile ICT platform for construction site management purposes was not primarily about the use of a specific mobile computing device, but rather implied a continued path of integration, personalization and generic access of existing ICT systems and infrastructure within Skanska. While the tablet computer became useful for construction site management practitioners at Duke University, it did not create adequate meaningful use in practice at Forum Nacka. An appropriate model of collaboration and learning between ICT users and developers will not be able to compensate for a deficient initial choice of technology for a specific use context. However, the mutual engagement of participants in the evolving social and conversational processes can assist in halting a chosen technological approach and possibly change the direction of development towards a more useful and acceptable alternative in practice. Furthermore, this kind of local micro level 'engagement model' can be extended into a whole firm-centric negotiation framework of social 'linking mechanisms' between the governance of general organizational ICT motives and the management of specific ICT projects within a business enterprise. Such linking mechanisms may support improved alignment and coordination of different stakeholder perspectives of ICT development processes across organizational levels and functional boundaries to meet both local and company-wide objectives and requirements (see Fonstad and Robertson, 2006).

The research findings of this thesis indicate that managing usefulness and user acceptance of ICT development processes in organizations may require a determined focus on frameworks and approaches for handling the communicative and pedagogical dimensions of these issues. Managing usefulness issues between ICT and work practice does not necessarily imply solving the problems. It rather entails patiently learning how to better understand and handle them in an open-ended and ongoing fashion. Persistently addressing deficient usefulness of ICT

resources does not always have to lead to explicit development and adaptation of its technology design properties, but it may instead generate an improved understanding of problematic situations of ICT use and learning more about what needs to be done in order to better cope with these problems. To make something better, a profound understanding of what actually is wrong must first be in place. This applies to all governing organizational ICT motives and resulting ICT projects, regardless whether they are incremental and consensual or radical and disruptive. Dedicated communicative and pedagogical management approaches of usefulness and user acceptance issues of ICT in organizations may acknowledge the importance of 'learning as action' and 'understanding as change' as fundamental prerequisites of any ICT development process. An ICT usefulness mindset in an organization is certainly not about avoiding or 'weaseling out' of the problems of actual ICT use in work practice, but tirelessly and devotedly 'engaging in' the challenge.

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