Re-innovating the Existing

A Study of Wireless IS Capabilities to Support Mobile Workforces

Pablo Valiente

AKADEMISK AVHANDLING

Som för avläggande av ekonomie doktorsexamen vid Handelshögskolan i Stockholm framläggs för offentlig granskning

30 Januari 2007 kl.10:15-12:00

i sal K.A.W. Handelshögskolan

Sveavägen 65

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Dissertation for the Degree of Doctor of Philosophy, Ph.D.
Stockholm School of Economics 2006

ISBN 91-7258-714-8

Keywords:

IT Implementation
Organizational Innovation
Wireless Information Systems
Capability Development
Mobile Workforces
Blue Collar Workers
Case Study

Printed by:

Elanders Gotab, Stockholm 2006

Distributed by:

EFI, The Economic Research Institute
Stockholm School of Economics
P O Box 6501, SE 113 83 Stockholm, Sweden
www.hhs.se/efi

To Mother and Father

PREFACE

This report is the result of a research project carried out at the Center for Information Management at the Economic Research Institute (EFI) at the Stockholm School of Economics.

This volume is submitted as a doctoral dissertation at the Stockholm School of Economics. As usual at the Economic Research Institute, the author has been entirely free to conduct and present his research in his own way as an expression of his own ideas.

The institute is grateful for the financial support provided by the Swedish Governmental Agency for Innovation Systems (Vinnova) and the Alfa Laval and Rune Höglund foundations. The present volume would not have been possible without the cooperation of the organizations that participated in the study. The Economic Research Institute wishes to warmly thank all involved for their generosity and openness.

Stockholm November 2006

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In Gratitude

Even though a dissertation is a highly individual work, it could never be accomplished without the help of many people. I am indebted to all them. Due to space limitations, I cannot name each and every one of you whom I met over the years and had the privilege to share friendship and work with. Although you might not find your names on this page you should know that you will never be forgotten. Among these, there are, however, some people that deserve especial attention.

I start with the recognition to my main supervisor Professor Mats Lundeberg. Working with a dissertation requires creativity, inspiration and determination. But you also need a great deal of support. I would therefore like to thank Mats Lundeberg for his guidance and patience throughout the process. To have an opportunity to write a dissertation is worth silver and having an excellent supervisor is worth more than gold: thank you Mats!

Professors Per Andersson and Pär Åhlström have supported me and given me valuable advice during the process acting as co-supervisors of this dissertation. Your helpful advice is greatly appreciated. Per has moreover been a great support taking me aboard on a number of different research projects as a young doctoral student and giving advice during the difficult times in the writing process.

I am highly indebted to all the people at Taxi Stockholm, BT Industries and Graninge for their openness to research. All the interviewees have provided invaluable information about their organizations without which this work could never have been completed. Special thanks go to Hans Nyström and Olof Hanssen at Taxi Stockholm; Conny Edlund at BT Industries; and Bertil Lidén at Skogforsk/Graninge.

Professor Udo Zander took the time to thoroughly analyze an earlier draft at the pre-dissertation seminar giving his opinions at a very critical point in time. He pointed out the valuable parts of the dissertation helping me to focus on the best pieces of it and leaving others aside. Professors Anders G. Nilsson and Östen Mäkitalo commented the final draft of the dissertation providing me with insightful last-minute suggestions.

For the financial support, I would like to thank the Swedish Governmental Agency for Innovation Systems (Vinnova) for sponsoring part of the research project that has lead to this dissertation. Ulf Eklund, early appointed as the project manager at Vinnova, has followed this research throughout the whole process. In addition to Vinnova, special thanks on the financial side go to the Alfa Laval and Rune Höglund foundations.

I am also especially grateful to the co-authors in this dissertation. Thank you for teaching me research the hard way. Special thanks go to Hans van der Heijden, Alf Westelius and Anders Mårtensson. There are also other people that have taught me research in the many doctoral seminars held at the Center for Information Management at the Stockholm School of Economics. All my research colleagues and friends at the department played an important role by suggesting new perspectives throughout the research process. Especial thanks go to Magnus Mähring, Pär Mårtensson, Christofer Tolis, Martin Andersson, Björn Thodenius, Niklas Källberg, Lasse Lychnell, Frank Ulbrich, Tina Nilsson and Susanne Ohlin-Kjellberg. I am also highly indebted to Thomas Lavelle for his excellent support in helping me to improve the standard of my written English and for proof-reading suggestions during the later stages of the project.

Acknowledge is also due to all the highly supportive people at the Center for Information and Communication Research (CIC) with Professor Bertil Thorngren as its former director. Special thanks go to Professor Thorngren who has helped me with invaluable research contacts and challenging research opportunities. Special thanks go also to Professor Mats Edenius and Niklas Z. Kviselius for their cooperation in related research studies and to all the other members at CIC.

Finally, I would like to thank all my family and friends both near and far for their interest and care. *Two are better than one, because they have a good return for their work: If one falls down, his friend can help him up. But pity the man who falls and has no one to help him up!* (Ecclesiastes 4, 9-10). Old friends such as Fredrik and Tobias helped me to become immersed in the Swedish culture; Samuel was a great support during my undergraduate studies; Niclas taught me entrepreneurship; Alex helped me to understand the world of Handels; Erik and Mike put up with philosophical discussions throughout the years; Patricio and Sebastian took me out for fishing tours and special thanks go to Johan who helped me with the layout and design artwork. Without your support this work would have never been the same. I owe also a great deal of gratitude to all the people I collaborated with at Klubb Bierkan because they helped me to discover hidden leadership characteristics of great value. Thank you Bierkomanerna for all these years! Special thanks go to all the good friends made at Lärkstadens Studiecentrum for their support and patience. I am especially grateful to Javier[2], Denis, Bengt, Anders, Richard and all the others. You have really helped me to feel at home in Stockholm!

Last, but far from least, my heartfelt thanks are due to my parents. As Aristotle stated, *a sufficient return of thanks can never be made to parents, teachers or to God.* I have therefore chosen to dedicate this dissertation to both my parents who brought me to life and taught me to be curious about existence. They both encouraged me to undertake graduate studies and have followed the development with patience and understanding. As this journey comes to its end, I am happy to be able to dedicate this book to them as a result of their efforts put on me.

Finally, although a large number of people have made their best to improve this dissertation, I alone may be made responsible for whatever deficiencies or ambiguities that may remain.

Pablo Valiente

Stockholm, November 2006

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1 Introduction

The beginning of the third millennium is characterized by rapid technological advancement, especially within the telecommunications industry. Two of the most important technology success stories over the last decade have been the Internet and the cellular phone. The growth and spread of these technologies have been rapid, as this predominantly technology-driven development has over time resulted in substantial and sometimes unforeseen changes in user behavior.

However, the technological competitiveness of nations, industries or firms is determined not only by the pace at which they develop significant innovations, but also by the extent to which these innovations are assimilated and applied to commercial operations. The adoption of new products and processes of production within enterprises is a fundamental means to the growth and transformation of today's businesses.

In a world where the external environment is in a state of change because customer preferences are volatile and the identity of customers is changing and the technologies for serving customer requirements are continually evolving, the firm's own abilities may be the most stable basis on which to define its identity. Hence a definition of a business in terms of what it is capable of doing may offer a durable basis for strategy formulation.

In this context of rapid technological development a key question for organizations is how to manage new technological systems, which are and must be embedded into the existing technological park, structure and culture of their organization. A private consumer adoption of a new cell phone as a stand alone device appears quite simple in comparison to the complex challenges faced by organizations implementing wireless systems, where both telecom and datacom applications have to be integrated seamlessly.

There is a managerial concern regarding whether today's organizations have the adequate capabilities to manage the assimilation of information and communication technologies (ICT) into business operations. One reason for this is that information technology (IT) implementation in organizations means change and change is one of the most challenging issues companies have to confront today (e.g. Lundeberg 1993; Fralix 1998; Sturdy and Grey 2003), especially when change is motivated and driven by emerging information technologies (Day, Schoemaker and Gunther 2000).

The specific character of information technology as an intellectual technology (Curley and Pyburn 1982) may provide a good explanation for why managing assimilation of new technologies represents a challenge today. IT is characterized by functionalities that are not fixed at the outset of the implementation, meaning that IT can be innovated in many different ways depending on its interaction with the people who implement and use it (Lee 1999a). The level of uncertainty inherent in such implementations is thus high. Moreover, technological development in the area is really fast moving. Consequently organizations struggle to adapt to this pace of change, hoping to achieve growth and sustainable advantages through the implementation of new products and work processes.

Often this struggle to adapt to innovations raises concerns not only of a technical character; rather they are strongly intertwined combinations of the social and the technical aspects of change processes (Westelius and Valiente 2005). Let us consider an example of a relatively simple technology: a set of smart phone terminals connected to a network. The organizational management issues associated with these networked cell phones will greatly depend upon the socio-technical system in which they are embedded. An intake unit of an emergency room, administrative staff of a public lab at a university, electricians at the installation, maintenance and error repairs department of a construction company, employees at a risk analysis office in an insurance firm, a military supplier testing manufactured parts, all create very different demands on the management of technology, which originally was apparently the same.

These cases are just a few examples that help us to understand why the diffusion of information and communication technologies has become an important managerial concern, particularly the effective implementation of IT into organizations, business units and groups (Lester and Piore 2004). The implementation of IT is a process of successfully putting an innovation to use within an organization. This organizational innovation process is important because if well-managed it provides organizations with sustainable and even competitive benefits.

This dissertation aims therefore to study organizational innovation processes by describing how wireless information systems (WIS) are implemented in firms[1]. And why would any academic be interested in this issue?

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[1] In this dissertation I will use the term wireless to refer to technologies that use radio waves for communication purposes. Although the term 'mobile technology' is

(cont.)

1.1 Why this Topic?

The constant pressure to achieve increased efficiencies and profitability improvements drives companies to look at new technologies for ways to develop sustainable advantages. However, the process of developing advantages from different technological flavors is seldom simple. The pressure for greater profitability in an era of rapid technological advances leads, not surprisingly, to different misperceptions about the impact of IT on businesses. A number of *myths* have evolved from these misperceptions. Let us look at three of them, namely *IT does not matter*; *IT is easy*; and *Wireless, the next big thing*, which represent some of the research drivers in this dissertation.

First, a high-impact article published in the Harvard Business Review by Nicholas Carr (2003) launched the recent debate about the impact of IT on business, and developed the argument that IT can be understood as an infrastructural technology very much like a commodity input to the process of production. If this were so, IT could never be considered as a source of a firm's competitiveness.

According to Carr (2003), IT technologies used for internal operations such as those managing information within a firm, lose competitive advantage easily. This is because IT, like other types of infrastructural commodities such as e.g. electricity, derives benefits that are easily imitable. Such a conception would enable competitors to wash away any form of advantages derived from technology. But is this really the case? Do IT technologies represent competitive parity? If so, does it mean that managers can reduce attention to IT in the future?

One thing is clear. The debate initiated by Carr identifies a need to be clearer about where the value of IT resides. If managers are to understand better how firms derive both short and long-term benefits, academics need to consider carefully the implementation of emerging technologies in firms. This will help to close the gap between expectations and outcomes.

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more common, I will restrict my use of the adjective *mobile* to users and not technologies. The reason for this will be developed later in Chapter 3. Note that my usage of wireless includes even the term 'cellular technologies', which is used more frequently in North America.

Second, sometimes we can see technology being pushed into firms, as if outcomes would follow in an uncomplicated way. Such a myth presents the emerging technologies as plug and play devices. A quick visit to almost every technology vendor's web site reveals an interesting pattern. These technology based companies are eager to point out the value of new technologies to their customers. Such companies, including telecom suppliers, provide a large number of "success stories" with which most practitioners are familiar by now. While these stories stimulate creativity and assist in envisioning future business opportunities, it is plain to see that they have a number of shortcomings:

(a) They are usually too short to provide any deeper understanding of where the value of IT resides. With the large number of scenarios being envisioned, managers have to evaluate trends correctly, avoid faddish solutions and sort through the many options.

(b) Most of these stories are typically vendor or infrastructure biased. Quite understandably, therefore, the benefits are usually overestimated and the drawbacks understated. In particular, these stories provide little information about the challenges encountered during the implementation process.

(c) They contain technology which is not yet available even in the medium-to-long term. As a consequence, technological shortcomings are overlooked. Enterprises may sometimes find themselves half-way through an implementation process before they discover these shortcomings.

In sum, the credibility of these success stories in terms of actual advantages may be questionable. Other stories included in the popular literature describe technological implementations in colorful terms such as 'inherently thorny undertakings' (Stedman 1998), 'life-changing experiences' (Martin 1998), 'living to tell about it' (Horwitt 1998) and 'war stories' (Tebbe 1997). Why then IT is not that easy? Where do the challenges to these implementations originate from? How are they overcome?

Third, one such technological breakthrough in focus for this study is wireless technologies. Wireless technologies are finally *getting down to business,* expanding beyond blackberries and hyped wireless access points at Starbucks and airport lounges (Fanning 2003). For example, 64% of Computerworld survey respondents (Johnson 2003), considered wireless technology important to their business goals and 38% of them said the economic downturn did not impact their wireless rollouts. Moreover, over half of corporate North America had deployed a wireless solution by the beginning of 2002 according to some IDC survey results (Draper 2003).

However, the ability to generate benefits from wireless technologies has fallen far below expectations (Kurzweil 2004 p.37). General benefits have been widely recognized. They have been mentioned in terms of anywhere and anytime information access, increased freedom, connectivity on the move, etc. Nevertheless, we see wireless technology everywhere except in profitability statistics (Dekleva 2004 p.112 citing Brynjolfsson 1993). Is wireless really the next big thing? Will wireless technologies revolutionize enterprises? Where do wireless benefits come from?

Firms contemplating new technology implementations such as wireless information systems need to find answers to these questions, and it is the responsibility of scholars to question some of the established, straightforward answers.

1.2 Underlying Views and Perspectives

The present study is anchored in the information management (IM)[2] research field because it addresses primarily interactions between organizational and technical issues when studying what look like technological artifacts. An interest in information technology lies at the heart of some IM research, including some of my own. Yet the idea of an information system (IS) is meant to capture more than the presence of information technology. IM research is rooted in technology, but expresses an understanding of organizations.

Consequently, the area of information management is complemented by the study of organizational innovation in general and process innovation in particular. This approach reflects an underlying personal assumption that information systems are technology based innovations, a view shared by other researchers in the IM area (e.g. Keen and Scott Morton 1978; McKenney and McFarlan 1982; Kwon and Zmud 1987; Swanson 1994; Allen 2000; Baskerville and Pries-Heje 2001).

In addition, research in information management tends to borrow theories from other related areas because of its novel scholarly character. Just as this work does, earlier IS investigations have borrowed theories and models from the innovation and diffusion research traditions (e.g. Cooper and Zmud

[2] The academic field of Information Management (IM) is also known as Information Systems (IS) or Management Information Systems (MIS)

1990; Baskerville and Pries-Heje 2001). The combination of these two different theoretical research fields deepens our understanding of underlying organizational innovation processes (OIP).

Lastly, it should be noted that harnessing emerging technologies throughout their life cycle also influences competition among individual companies. Some companies succeed in managing the organizational innovation process, and they develop a number of capabilities that provide them with sustainable advantages, i.e. long-term benefits. This standpoint is supported by the resource-based view of the firm that will be discussed later in this work. The OIP is thus considered here as the implementation of information systems in business process resulting in new work practices in order to obtain sustainable advantages through the development of capabilities (cf. Figure 1 below).

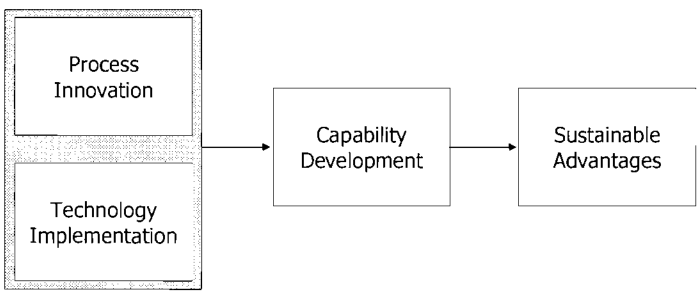

Figure 1 The organizational innovation process (OIP)

This particular study of organizational innovation processes can be placed among the softer management contributions to the IM literature (Currie and Galliers 1999 preface). The harder information management approach, including areas such as database management, programming and information technology, has a stronger focus on technology design issues, whereas the softer emphasizes managerial issues (Currie and Galliers 1999 preface) with a stronger focus on the organizational aspects of system development and implementation.

Within this research tradition the areas of technology management, managing innovation and change management are relevant to this study. These areas consider the organizational innovation process as an instance of IT-related change initiatives.

The area of change management is sufficiently broad to include the management of innovation. Therefore one can find references to change management theories throughout this study. However this investigation does not primarily apply a change management perspective, at least not change management dealing with project management and similar activities.

Furthermore, this study analyzes the implementation of wireless information systems in business processes, and therefore another area informing this work is Business Process Reengineering (BPR) research. Wireless information systems, like any other types of information technology, are typically difficult to study in isolation. There is growing consensus among researchers that the impact of IT-related technology needs to be assessed in conjunction with the business process that is affected or enabled by the technology (Langefors 1966; Lundeberg, Goldkuhl and Nilsson 1981; Davenport and Short 1990; Davenport 1993). Thus, my focus is on the management of new technology when implemented in core business processes. However business process reengineering is not the main focus of this work because of its radical change implications and the "clean state approach".

1.3 Purpose of the Study

Thus, this dissertation investigates the management of technology implementation from an information management perspective in order to understand the dynamics of process innovations inside organizations. We are now ready to state the aim of the study against which the final results of the dissertation will be evaluated.

> *The purpose of this study is to explore how technology intensive firms develop capabilities while managing the implementation of wireless information systems to support mobile workforces*

This research rationale requires some clarifications. First, the development of capabilities is important to firms because capabilities provide with a source of sustainable and competitive benefits that can deliver high performance and outperform competition. In this regard, a capability is considered here as the ability to achieve and sustain superior performance.

The focus of this work is on firms that are technology intensive, i.e. firms that use technology for their operations, without technology constituting a part of their value proposition. In contrast, technology based firms include technology in their strategic intent, and they are familiar with the technical development. One practical consequence of this is the exclusion of firms from the telecom industry. More specifically, the empirical material used in the dissertation is based on three different organizations from the forestry industry (Graninge), the transportation sector (Taxi Stockholm) and a supplier of forklift trucks from the manufacturing industry (BT Industries).

In addition, mobile workforces represent the category of users studied within these organizations.

Finally, although a myriad of different technologies could be used, radio based ones will be studied here. This study will investigate wireless information systems in particular because of their role as emerging technology. While the starting point for this dissertation is wireless information systems, its end point is the development of sustainable advantages. A sustainable advantage represents a long-term benefit developed from an organizational capability.

The purpose of the study will be approached through the investigation of the following research questions:

1. *What challenges did the organizations studied encounter when implementing wireless information systems to support mobile workforces?*
2. *What capability development activities were carried out to meet these challenges?*
3. *What capabilities did the organizations studied develop?*

This research applies an intra-organizational perspective on the use of information technology. Although inter-organizational studies are becoming more popular, the complexity of the issue justifies studying the implementation of wireless information systems within the boundaries of the organization. This places a number of information systems outside the scope of this research, including inter-organizational collaborative systems such as extranets or electronic communities of practice. Of course, this delimitation of inter-organizational systems does not exclude the study of inter-organizational relations between technology developers and consumers, or using the terminology above to be more precise, between technology based and technology intensive firms.

The notion of challenges in this work represents demanding situations which require great effort to resolve. They are triggers of the process of going from a current state to a future desired state; therefore they are treated as precursors of change processes. One assumption is that challenges trigger activities, some of which help organizations to develop advantages.

The dissertation consists of a collection of four different papers included in Chapter 8 through 11 and a preamble. The first seven chapters in the dissertation comprise this preamble. These four papers are based on earlier publications in conference proceedings, a journal and a book. The preamble summarizes and further develops the results included in the papers. Further outline information on this dissertation can be found in Section 1.5 *Dissertation Outline and Reading Instructions*.

The audience of this work is meant to be academics from the information management field. More specifically, scholars from the International Federation for Information Processing (IFIP) constitute the main target group for my research. Some members from the IM community founded in 1994 the IFIP working group 8.6 on "Diffusion, Transfer and Implementation of Information Technology" (IFIP TC8 WG8.6). Researchers from this group represent important discussion partners.

In addition, practitioners within the management function at any technology-dependent organization that cope with change processes and new technologies in their daily work represent an interest group for the results presented in this dissertation. One such example is the managers who evaluate wireless technology investments. This group consists of people that need to understand the potential of the technology in order to identify what expertise is needed and to locate it.

Finally, the purpose of this study is not for prediction of organizational innovation processes, but for the exploration of the specific phenomenon. This research does not try to perform any test nor experiment on pre-defined conceptual models but to increase the understanding of organizational innovation processes through qualitative data analysis gathered through a number of activities such as interviews and other similar sources (see further discussion in Chapter 2 *Methodological Approach*).

1.4 Setting the Stage

In this section, in order to increase the understanding of the subsequent analysis, I describe some of the building blocks used in this dissertation in more detail. This section also includes a discussion about the scope of the dissertation. First, it describes a number of theoretical delimitations and then some empirical material, as illustrated in Figure 2 below.

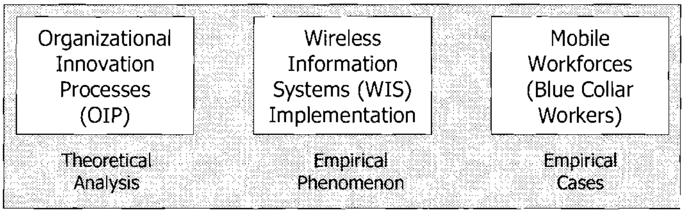

Figure 2 Setting the stage

1.4.1 Organizational Innovation Processes

By way of introduction, let me explain in more detail the meaning of the concept of organizational innovation processes (OIP) as used in this dissertation. More specifically, OIP denotes the process organizations go through when implementing new technology. This approach requires the application of a process theory to the study of innovations inside organizations. This is done by analyzing how innovations emerge, develop, grow and terminate inside organizations. Thus, the temporal sequences of activities are important and studied through qualitative methods in order to decompose the innovation process into its component phases.

Thus, the research focus in this dissertation is the implementation process within organizations, in contrast to other streams of research within organizational innovation studies that stress for example the determinants of the organizations' innovativeness or the diffusion of an innovation over time and/or space (cf. Wolfe 1994).

From all this, it follows that my research focus is on process innovations rather than product innovations (Daft and Becker 1978). Instead of studying the emergence of new technologies or products and their penetration into a certain industry, process-innovation research studies the implementation of new technologies in organizations and the way these implementations influence competition among individual companies.

Process innovations require, among other critical factors, complex implementation decisions involving many stakeholders with different, sometimes contradictory, interests that have to be taken into account. Moreover, the decision to invest in a new technology is followed by the introduction of the technology. The implementation requires users' adaptation to new work practices and organizational change.

Needless to say, this dissertation will study innovation processes concerned with information and communication technology. Consequently, technology plays a significant role in the final solution adopted although the origin of the process may be any kind of perceived challenge or future opportunity. Processes leading to new work practices that are technology independent are outside the scope of this work.

Finally, in this dissertation the organizational innovation process is considered to be cyclical. Mårtensson and Valiente (2006) explain how sequential technology generations are implemented to improve a particular application role in the company. The dispatch application of taxi cabs is gradually improved through the installation of telephones in taxi stands, CB radios in the cars, GPS navigation, etc., i.e. different technological generations. The application role remains stable, but the implementation of subsequent generations of technology (*re-innovating*) results in the overall improvement of the organization's IT platform (*the existing*).

1.4.2 Wireless-Information-Systems Implementation

Let us now define wireless information systems. WIS are treated as a subcategory of information systems in this dissertation. Although there are a number of approaches to what an information system is and is not, I ground my view on a traditional and well accepted definition of Laudon and Laudon (2002), that describes information systems as a set of interrelated components that collect, process, store and distribute data to support decision making, coordination and control in an organization. This definition builds upon Langefors' (1966) view of information systems with one distinction. Langefors includes the users in the concept of information system. For him the people serving and using the IS are an essential part of it. However, for Langefors the users do not need to be people as in the case of the thermostat in a refrigerator (Langefors and Dahlbom 1995 p.56), what we today call machine-to-machine communication. For practical purposes, people are not included in the definition of information systems used in this study.

Moving from here to the further specification of information systems by adding the attribute wireless should be straightforward, one might believe. A good guess could be *an IS without wires*. However, anyone with insight in the telecommunication industry, where wireless technology was first developed, knows that this term and especially the near-related concept of mobility requires a more careful analysis: Does wireless mean mobile? How should we classify fixed wireless devices? But if the devices are fixed should we consider the applications being mobile instead? Is then Microsoft's exchange mail-server mobile when accessed from a stationary computer? I will discuss these and other related issues in Chapter 3.

Next, I would like to address the novelty of WIS as they are considered here IT-based innovations. As stated in the introduction to this dissertation two recent innovations have been the Internet and the cellular phone. The merging of these two technologies creates new possibilities within the industry, which will probably join the list of innovated markets. For example, today 3rd generation systems (a wireless standard commonly known as 3G or UMTS) already provide wireless access to Internet-based services.

While radio-based voice communication has been around for a long time, the possibility of transferring data over radio links has developed more recently. Although technically the difference between voice and data communication is not obvious in today's network systems (both speech and data are transferred digitally), there exist some substantial differences between the two. One important issue is that voice is a standardized application with clearly defined boundaries and functions easily communicated to customers while data applications can be tailored through an infinity of different services depending on the specific needs of the customers. Moreover, requirements such as real-time, delay-sensitive and proprietary technology in the case of voice communication contrasts with best-effort communication, possibility of resending information and open development standards in the case of data based services. This is primarily a distinction that builds on the different mindsets underlying the telecom and datacom industry respectively. I will use a system's functionality in managing data communication as the distinctive element for a WIS even though the difference between voice and data is not crystal-clear. It is often the case in a WIS that both voice and data are used in a complementary fashion.

Another interesting dimension of a WIS definition is its system character. System here is defined according to Langefors (1995 p.55) as a collection of entities with relations among them. Through the relations, the entities are connected to form the whole of the system. This research does not focus solely on specific technologies or terminals, but on a set of interrelated components consisting of standards, applications and devices that in combination are used to make data accessible independent of place and time. However a constituent element of the system studied in this dissertation is the obligatory presence of some kind of wireless technology either in the devices or the system. These ingredients may be both fixed, as in the case of a wireless LAN (WiFi) base station or non-fixed as in the case of a GPS[3] receiver installed in a taxi cab.

In the description above three different dimensions have emerged that are important when characterizing the empirical material used in this study. First, we discussed the degree of complexity of the technology itself, ranging from standalone products such as a handheld device to large and complex organizational information systems like an airline reservation system. Second, communication purposes divide technology into speech/voice

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[3] Global Positioning System used for the location of objects

services and data based services. In the first case we have services such as the plain-telephony service (POTS) and at the other extreme examples like real-time, stock-information applications. Between them, there is a spectrum of services combining both voice and data. Finally we distinguish systems that are independent of wires to function but are heavily dependent on batteries or other types of power mechanisms and wired based technology.

Putting these pieces together we obtain Figure 3 below where WIS is located in the upper, right-hand, back corner of the cube.

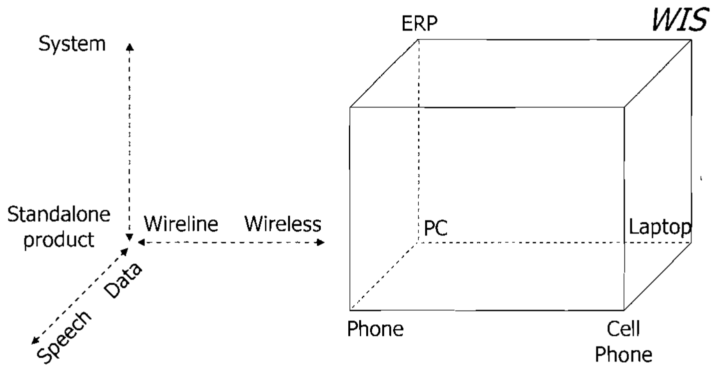

Figure 3 Wireless information systems

Notice the location of Enterprise Systems (ERP) in the cube. Nowadays more and more ERP systems contain modules or applications to support mobile workforces and could thus be placed nearer WIS. However mobility-support functionality is not a necessary feature of the ERP, although in some of the cases studied the ERP included wireless functionality. Moreover implementation of ERP is treated as a separate theoretical area elsewhere (e.g. Robey, Ross and Boudreau 2002).

Finally it is worth noting that wireless information systems represent emerging technologies, i.e. technologies under development. The process of technology diffusion from developers to consumers becomes thus a central issue in this particular context. Therefore new applications are often developed together between technology-based and technology-intensive firms.

Time is ripe to give an example of a wireless information system taken from one of the cases utilized in the dissertation. Articles 1 and 3 in this dissertation describe the WIS implemented at Graninge, a forestry and sawmill company located in the north of Sweden. In order to improve the management of the timber supply chain, the company implemented an information system that used wireless technology. The information system consisted of several components. The units (harvesters and forwarders) operating in the forest were equipped with vehicle computers connected to a radio link. The radio communication module enabled both data transmissions and internal radio communication. At the central office a dedicated communication computer was set up. This communication processor acted as a gateway between the forest units and the central information system in order to update harvest data sent directly from the field and to make prognoses that were forwarded to the mobile operators in the forest units. This is an example of a complex system that uses both voice and data communication enabled by different wireless technologies.

Finally, in this dissertation implementation is considered in its broader meaning as the process of putting an information system (in this particular case a WIS) to use within an organization. This process is denominated as the organizational innovation process if sustainable advantages are obtained through the development of capabilities.

1.4.3 Mobile Workforces and Blue Collar Workers

As I said by way of introduction, technology per se has not been the focus of this study. Therefore the choices presented above have not been clear from the beginning of this research. These have evolved from my initial interest in technology usage. Therefore another dimension that has helped me to specify the object of study is the end-users of the systems.

This new dimension adds a fourth dimension to the description presented above. Although WIS can be used by many different types of people at different levels inside an organization, the primarily category of users in focus here is mobile workforces.

A legitimate question then would be what I mean by mobile workforces. Let me take an example from a completely different area. Musicians play different types of instruments depending on the music they want to perform. These instruments are therefore tailored to their specific circumstances.

In a symphonic orchestra a full size musical ensemble typically uses four groups of musical instruments: the strings, the woodwinds, the brass and the percussions. They most typically perform classical music or opera. Performances take place indoors in a concert hall and may require the audience to remain very quiet. A different type of music is performed by the street musician playing at different places with different instruments that have to be carried along from place to place. At a street concert the public consists of people who happen to pass by. Finally we have the marching band. A marching band consists of a group of instrumental musicians who generally perform outdoors and who incorporate movement – usually some type of marching – into their musical performance.

Whereas the symphonic orchestra has a reduced mobility limited to the performance stage, two different types of mobility can be identified in the other performers. Both a marching band and a street musician require mobility to perform. Yet the former plays while moving whereas the latter plays at different locations. The degree of mobility determines which type of instruments are suitable for each situation, which in turn influences what kind of music they play.

In the same way, different technologies help different groups just as different instruments help different types of musicians. Mobile workforces sometimes have to play on the move (service technicians) or while moving (taxi drivers). The key issue is to be able to provide them with relevant data to perform their work more effectively. In my case studies, I have both the street musician case as in the BT Europe and the Graninge case and the marching band case as in Taxi Stockholm. Some other examples of mobile workforces include sales forces, consultants, service technicians or field engineers. Thus mobile workforces consist of field personnel covering the completion of work away from the company's offices.

However the group of interest is not fully delimited yet. A report published by the Swedish National Post and Telecom Agency (Areskoug 2003) pointed out the tendency of technology developers to stress that wireless data communication services are most beneficial when used by white collar workers such as marketing and sales people, or other management level categories within organizations. However what I have experienced is that people working with service, repairs and installations benefit most from ubiquitous data access. This group has thus been in focus for this study. They are categorized here as blue collar workers (BCW).

In this study, a blue-collar worker is an employee who performs manual or technical labor, such as in a factory or in field environments in contrast to white-collar workers, who do non-manual work generally at a desk. Although the term blue-collar worker has a stereotypical connotation due to some of the distinctive elements such as fewer requirements for formal academic education, the environment of the blue-collar worker makes them a primary target when developing wireless solutions. These technologies often target their informational and communicative needs very well (Brodie and Perry 2001). The technology can really be developed to support the dynamic, flexible and often urgent nature of the work that this type of worker performs.

Blue-collar workers do not usually have extensive experience of information technologies. As training often takes place on the job while working, they have not come in contact with information technologies such as personal computers. However they have extensive experience using cell phones. This fact has attracted the attention of some governmental agencies such as the *Invest in Sweden Agency* (ISA) as an opportunity to expand IT-usage among a new category of people.

Some examples of mobile, blue collar workforces are photocopier repairmen, mobile hairdressers, electricians, electric meter installers, painters and decorators, plumbers, etc.

Before finalizing this section, let me add a few words about the types of companies that constitute the object of study in this work. The distinction discussed earlier between *technology based* and *technology intensive* companies has been used in previous research (e.g. Leonard-Barton 1995 p.140). In the former case, technology has strategic importance. In the latter, companies may also use technology strategically but do so without mentioning it in their strategic statement. The companies studied in this dissertation belong to this latter group. Further discussion about consequences of this choice is included in the methodological part of the dissertation.

In summary, this study encompasses the implementation of wireless information systems framed as complex systems consisting of different radio-based technologies for the benefit of mobile workforces in general and blue collar workers in particular.

1.5 Dissertation Outline and Reading Instructions

This dissertation consists of four articles and a preamble, herein identified as *the dissertation*. The outline of the chapters included in the dissertation appears in Figure 4 below. The disposition follows a traditional arrangement of a dissertation based on the collection of papers. The preamble provides an overall picture of the dissertation and precedes the articles. However, the preamble in this dissertation is longer than usual because it both summarizes the results included in the papers and develops them further.

The preamble consists of seven chapters in total[4]. After the introductory chapter, there are discussions of methodology and earlier research within the area. Chapter 4 includes a summary of the papers, and Chapters 5 and 6 present an analysis of challenges and capabilities respectively. Finally the conclusions close the preamble.

Chapter 4 bridges the gap between the theoretical foundations of the dissertation and the analysis presented in Chapters 5 and 6. Chapter 4 includes a summary of the papers and a brief discussion of each company case used in the analysis. It includes moreover an epilogue with additional interview material collected after three of the four papers were written.

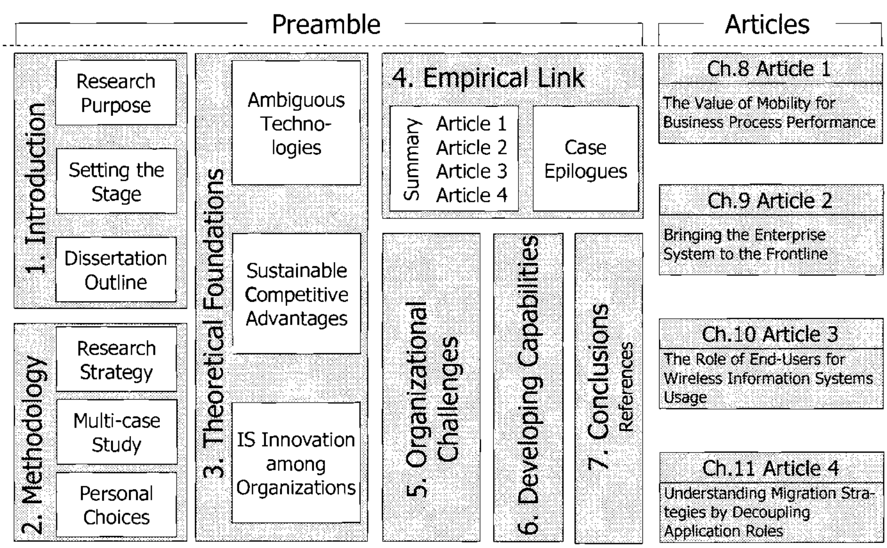

Figure 4 Dissertation outline

Finally, let me offer an additional reading guide. The structure of the dissertation supports the reading of both the preamble and the papers

[4] Often a preamble is understood as a brief section that introduces the rest of a book. The use of the word preamble may be misleading because the preamble in this dissertation constitutes the larger and more central part of it. However, the need to be able to refer to Chapters 1 through 7 unambiguously and the fact that the preamble in this dissertation is longer than normal, leaves limited opportunities for any other term making this the less inappropriate one.

separately. Chapter 4 increases the independent character of the preamble, and Sections 4.1 through 4.4 may be skipped if the papers have been read. However, the descriptions in the epilogue (Section 4.5) are not included in the papers, and they should be read before proceeding to the subsequent analysis.

1.6 Preview of the Study and Major Contributions

This dissertation develops a model[5] of organizational innovation processes that helps us to identify a number of organizational challenges. This conceptualization provides a picture of information systems implementation mainly framed as a development process rather than a formal investment decision. Some characteristics recognized in this model are that these processes are not linear; they comprise the development, installation, use and abandonment of technologies; they include both analytical and creative aspects of change management; and they should take into consideration the future renewal of technologies early in the process.

Next, the organizational challenges are analyzed to see how they were managed to create capabilities that are sustainable over time. This is done by describing a number of capability-development activities that led to a number of advantages in the cases studied. At a general level of analysis, four different types of challenges were identified, namely technology assessment, work system alignment, blue collar worker adaptation and renewal timing. In the subsequent capability analysis, the distinction between operational and improvement capabilities provides a dynamic view of resource management inside organizations that helps us to distinguish between abilities that are longer-lasting than others.

The description covers both a number of wireless-specific capabilities themselves and how these capabilities developed into advantages. The wireless-specific capabilities are the spatiotemporal, radio-engineering and connectivity capabilities that provided the organizations with temporary benefits.

Finally, a number of paradoxes described in the closing chapter emphasize the fact that organizational innovation processes are not always predictable.

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[5] For a detailed discussion about my understanding of the concept *model* see section 2.1.4 *Case Study Research Strategy*

The only way to reconcile apparently contradictory evidence about organizational innovation processes is to evaluate each particular case. Each innovation process in general and each wireless information system implementation in particular has peculiarities along several dimensions, which are important to identify and understand.

2 Methodological Approach

Now that we know what our aims are in terms of the purpose of research, I will describe how to achieve them. Research is often about choices and finding one's way through in the research labyrinth. These choices are sometimes personal and sometimes less so as they are influenced by earlier choices, that are influenced by earlier choices, that are ... and so on.

The section starts with a general discussion about the research terrain to be traversed. This means covering different methodologies within the information management area. It represents the map that permits me to delimit available research strategies when choosing my own personal way.

This trail is the subject of the second part of the chapter. It is here that the discussion becomes more specific, and a path that crosses the terrain is envisioned. This path changes shape along the journey. Sometimes it becomes a rough mountain track, other times a broad trail through the open countryside. And in the end, it has often been my own personal interests that have kept me on track.

These interests are discussed in the third part of this chapter. It describes some personal interests in the area developed along the research journey. These interests represent my own learning process. Finally the chapter closes with a discussion about research quality.

2.1 Research Strategy

Research is about choices. A research strategy represents the glue that holds these different choices together. Hopefully these parts form a credible picture of research. This picture is presented here and consists of a preferred methodology, a research theory and a research purpose.

2.1.1 IM Methodologies

There exist a number of different methodologies that have been used traditionally within information management research[6]. To put case studies, the preferred methodology for this particular study, into this context I will deal briefly with laboratory experiments and surveys, two of the most

[6] For a detailed description of the different approaches see Galliers (1992 p.147ff)

common methods used within the area. In addition, the increased popularity of action research (Baskerville and Myers 2004) justifies its exposition as well.

Laboratory experiments measure dependent variables in controlled environments. This type of study tries to reveal relationships between dependent variables and independent ones manipulated according to previously determined settings. Traditionally *information systems success* has been the dominant variable searched for (DeLone and McLean 1992). A number of independent variables have been used to explain IS success. Some examples are: *System Quality* measured as Ease of Use (Belardo, Karwan and Wallace 1982), Response Time (Conklin, Gotterer and Rickman 1982), etc; *Information Quality* measured as Report Usefulness (Mahmood 1987), etc; *Use* measured as use or no-use of a certain system (Alavi and Henderson 1981), Motivation to Use (DeSanctis 1982), etc.

Surveys are snapshots of situations undertaken using questionnaires from which inferences between the dependent variable in question and the set of independent ones are carried out (Galliers 1992 p.153). Surveys are a better means for looking at a greater number of variables than laboratory experiments. However limited insight is provided regarding the causes behind the phenomena under study.

Action research represents the third type of study used by information systems researchers that has achieved greater acceptance recently. The action researcher not only tries to generate theoretical knowledge about the examined object but attempts to change it by developing new solutions (Small 1995; Kaplan 1998). This dual objective is achieved through intervention and a critical reflection that is followed by a continuous refinement of methods, analysis and interpretation of data based on the experience developed (Dick 1999).

Finally, *case studies* (e.g. Markus 1983) are suitable when the researcher has little or no influence over the studied environment and the study variables are unknown at the outset of the research. In case studies the material consists of multiple sources. They mainly deal with links of events to be traced over time rather than with frequency or formal rules for inference.

All these methodologies can be classified along two dimensions as illustrated in the matrix in Figure 5. The dimensions are the level of influence over the object studied and the method of analysis used. Often quantitative methodologies use variance theories to explain frequency or inference between dependent and independent variables whereas qualitative methodologies use process theories based on sequences of events over time to increase the understanding of phenomena.

	Quantitative	Qualitative
Influence	Laboratory Experiments	Action Research
No Influence	Surveys	Case Studies

Figure 5 Traditional methodologies within IM research

The classification above is not exclusive. It points out the normal and more traditional ways of using the methodologies although these have sometimes been used for other purposes than those identified in Figure 5. For example, surveys can be analyzed in a qualitative way if they consist of open questions (e.g. Thodenius 2005). Nevertheless, earlier studies using surveys have more often than not analyzed the data in a quantitative manner.

2.1.2 Case Study as Preferred Methodology

This dissertation uses case studies as the preferred research methodology. The reason why will be developed below.

First of all, it would be useful to make clear the distinction between case studies as a methodology and case study descriptions used to report research results, often in the form of rich descriptions. For example, action research may also use case study descriptions to report on a particular piece of research performed. However, case studies as a methodology are not only a way of reporting research but also of carrying it out. Case studies as a methodology focus on retrieving facts and data from events in retrospective whereas e.g. action research does so in real-time. Let us therefore describe case study as a methodology in more detail now.

Benbasat, Goldstein and Mead (1987 p.370) affirm that:

> *"[...] a case study examines a phenomenon in its natural setting, employing multiple methods of data collection to gather information from one or a few entities (people, groups or organizations). The boundaries of the phenomenon are not clearly evident at the outset of the research and no experimental control or manipulation is used."*

It seems inappropriate to perform the study of organizational innovation processes outside the organizational context where they occur because of their complexity. A different issue would be to study consumer-oriented solutions for the mass market such as the diffusion of cellular phones, where laboratory experiments could help to analyze the most demanded type of functionality among a particular customer segment. However, case studies are more appropriate when examining contemporary events, such as the implementation of wireless information systems in organizations, and when studying a phenomenon that cannot be manipulated because of its complexity.

The choice of a case study approach is also based on Yin (1984 p.17), who argues that case studies are appropriate when a *how* or *why* question is being addressed regarding a contemporary set of events over which the investigator has little or no control. Benbasat et al. (1987 p.371) also list eleven characteristics of case study research (see Table 1).

Case Studies
Phenomenon is studied in a natural setting
Data are collected by multiple means
One or few entities (person, group or organization) are examined
The complexity of the unit is studied intensively
Case studies are more appropriate for the exploration, classification and hypothesis development stages of the knowledge building process
No experimental controls or manipulation are involved
The investigator may not specify the set of independent or dependent variables in advance
The results derived depend heavily on the integrative power of the investigator
Changes in site selection and data collection methods could take place as the investigator develops new hypotheses
Case research is useful in the study of *who* and *why* questions because these deal with operational links to be traced over time rather than with frequency or incidence
The focus is on contemporary events

Table 1 Eleven characteristics of case study research

Most of these characteristics are self-explanatory and do apply to this research. However, I would like to add a comment on the complexity of the study. As stated above, the complexity of organizational innovation processes is motivated by the agreement process required at different levels inside a specific company. Among other things, contradictory interests have to be taken into account and this leads to complex decision processes. Due to this complexity, case studies may be more suitable than quantitative research methodologies such as surveys.

Finally, a number of practical difficulties hindered the option of action research although in principle it could suit this research also. The final selection of methodology was very much influenced by site accessibility as large number of wireless applications identified were either considered too confidential by the companies involved, in a very early stage of the life cycle or abandoned prematurely. In addition, the impossibility of a multiple-case approach due to time consuming aspects and the manipulation of the events represented additional hurdles to action research.

Different types of tools are available to the case study researcher. The collection of the case study data from a case site can be performed through different techniques. Some examples include *content analysis,* where the researcher analyzes written material in connection to the case in focus such as application descriptions, press articles, system documentation, etc., *interventions* where the researcher is a participant in the implementation of a system or simply *interviews* based on oral interaction with participants, often retrospectively.

These different ways of carrying out case studies are not mutually exclusive and can be combined. They differ in the closeness to the phenomena studied (cf. Mårtensson 2001). Content analysis represents a minimal involvement of the researcher in the phenomenon studied. Interventions, often used in action research, represent the other extreme of the scale where the level of interaction of the researcher with the object of study is high. As we will discuss later, this dissertation uses both interviews and content analysis, which represent degree of intermediate closeness to the phenomena studied.

Having established case studies as the preferred methodology for this dissertation, we will turn our attention to process theories which may help us to understand the changes over time in the cases studied.

2.1.3 Process Theories Applied to Case Studies

Process theories seek to explain outcomes by examining sequences of events over time. These types of theories are suitable for interpreting relationships in organizational innovation processes. The implementation of wireless information systems in organizations can be better understood through moving pictures of change rather than snapshots. Therefore, process theories are suited for the exploration of organizational innovation processes because they provide richer process descriptions than variance theories. There is thus growing support for the use of process methodologies instead of variance theories when studying organizational innovation (cf. Van de Ven, Angle and Poole 2000 pp.31-32).

Van de Ven and Poole (1995) present a topology of process theories based on four ideal types that explain processes of change in the social, biological and physical sciences. The four basic schools of thought that they identified are: *life cycle*, *teleological*, *dialectical* and *evolutionary* theories illustrated in Figure 6 below. I will briefly introduce each of these theories to position my own preferred alternatives (cf. Poole et al. 2000 Chapter 3).

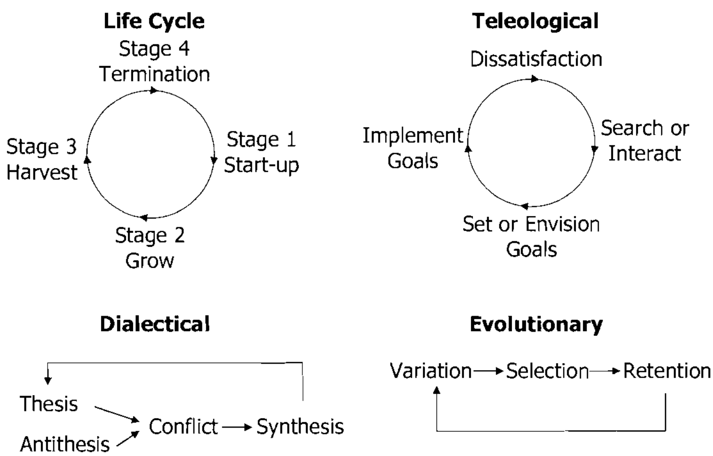

Figure 6 Different schools of process research

The *life cycle* approach is characterized by a linear and irreversible sequence of prescribed stages that unfold along the change process. Normally, this type of approach has a prefigured program or rule regulated by nature, logic or institutions. Examples of life cycle theories include developmentalism, stage theories of child development, organizational development, group-decision making, etc.

The *teleological school* is based on the assumption that development proceeds towards a goal or end state. According to this theoretical perspective entities of change are purposeful and adaptive. These entities, by themselves or in interaction with others, construct an envisioned end state, take action to reach it and monitor progress towards it. Event progression is therefore based on recurrent, discontinuous sequences of goal setting, implementation and evaluation of achieved goals in order to proceed through the change process. Cooperation and goal enactment are the primary motors of change in this particular approach. This approach underlies many organizational theories of change such as functionalism, decision making, social construction, adaptive learning, etc.

The *dialectical theory* uses conflicts and confrontation between opposing forces, interests or classes as the generating force for change processes. This particular approach uses Hegel's theory of thesis, antithesis in order to achieve synthesis as the main explanation for change. Recurrent sequences of conflicts and synthesis between contradictory values or events lead to change. Nietzsche, Marx and Freud are the main pioneers in this area.

Finally the *evolutionary* approach was influenced by Darwin's evolution theory. The key metaphor used in this type of study is the natural selection based on competitive survival. From this perspective, change is based on recurrent and cumulative probabilistic sequences of variation, selection and retention of events. A more detailed description of each of these approaches can be found in Van de Ven and Poole (1995) and Poole et al. (2000 p.56ff).

These approaches can be considered as ideal-types, and they describe different motors of change. However combinations of these ideal types are possible and can be found in earlier literature giving rise to hybrid change theories (cf. Cule and Robey 2004). For the purposes of this particular study both the life cycle approach and the teleological change theory will be used.

The dialectical and evolutionary approaches will not be used in the study. The dialectical approach can be more appropriate to use when conducting action research. In action research the researcher comes closer to the phenomenon studied and it is easier to understand confrontations present in the organizations. However, the purpose of the study and the choice made in this research to keep the original cases non-anonymous (to increase research transparency) makes the use of dialectical theories less suitable. Evolutionary theories explain change based on natural selection, better suited to explain development in the natural world. Nevertheless, it is acknowledged that these other theories could complement and provide further understanding of the phenomenon in focus. Their contribution is however more limited than the preferred strategy and at the end of the day one needs to delimit the study.

2.1.4 Case Study Research Strategy

Finally, there are different purposes for research. Yin (1984 pp.15-16) describes research performed for exploratory, descriptive or explanatory purposes. Case studies can be used for these three different purposes. For example, an explanatory case study would try to explain causal links in real-life interventions; a descriptive case study would describe a real life context in which an intervention has occurred; an explorative case study would explore situations in which intervention has no clear, single set of outcomes. As the boundaries between the strategies are not sharp they may sometimes be combined within the same study.

The purpose of this research is primarily exploratory. This dissertation develops a model of organizational innovation processes that helps us to better understand how firms obtain sustainable advantages through the development of capabilities. It develops a set of concepts and their mutual relationships through the exploration of situations in which intervention has no clear single set of outcomes. This exploration increases the understanding of how innovation processes develop inside organizations.

It is important here to be clear about the difference between model, framework and methodology. *Model* is used in this work as a detailed description used to help visualize something that cannot be directly observed such as a possible system of human relationships. This is often done in a simplified way. This use of the concept model is very similar to the definition of *framework*, namely a conceptual scheme, structure or system that limits or outlines a particular set of circumstances. The terms model and framework are used interchangeably in this work.

This definition of model differs from *methodology* (the process, technique or approach employed in the solution of a problem) and *method* (a procedure or process for attaining an object) and will not be used here when referring to the organizational innovation process developed. The term *theory* will not be used either. This term comprises a broader perspective referring to the body of generalizations and principles developed in association with the practice in a field of activity and forming its content as an intellectual discipline[7].

Another important choice when working with case studies is the selection of the number of cases. In this research, case studies are used to extend frame-

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[7] *Merriam-Webster's New International Dictionary*, 3rd ed., s.v. "model", "framework", "methodology" and "theory".

works (analytical generalization) and not enumerate frequencies (statistical generalization). Yin (1984) calls this type of generalization analytical generalization or level-2 generalization. Lee and Baskerville (2003) use the expression generalizing to theory. This is done through generalization from empirical statements to theoretical statements (Lee and Baskerville 2003 p.235). Several other authors have stressed the importance of generalizing from empirical statements to theoretical statements (e.g. Walsham 1995; Klein and Myers 1999).

There exist two alternatives regarding the selection of the number of cases, namely a single-case study or a multiple-case study. According to Yin (1984) a multiple case is better suited for theory building. This study explores how firms develop capabilities while managing the implementation of wireless information systems to support mobile workforces through multiple cases. The exploratory research process is therefore based on literal replication (literally finding the same results). According to Yin (1984) this is the most appropriate way for exploratory and descriptive cases to work out new frameworks. The alternative would be to use sampling logic as in the case of explanatory case studies. Therefore the research strategy in this dissertation is to use a multiple case approach as depicted in Figure 7 below.

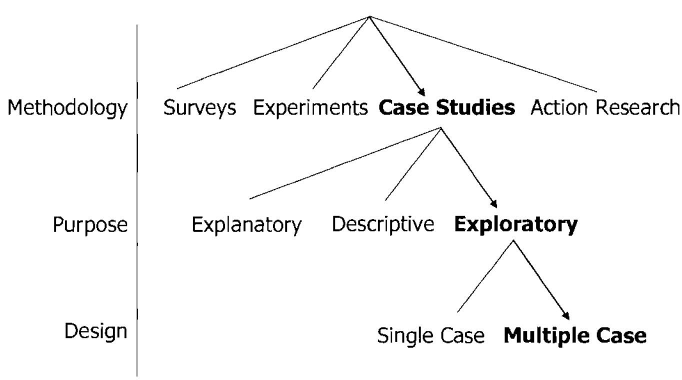

Figure 7 Research approach

Let us conclude this section by saying that this dissertation uses an explorative, multi-case study research strategy to explore how firms develop capabilities while managing the implementation of wireless information systems through the development of a model of organizational innovation processes. Given this overarching research strategy, let us now proceed to explain the more specific choices made in the study.

2.2 The Exploratory Multi-case Study

The disposition in this dissertation follows an arrangement based on a collection of articles. Therefore the dissertation consists of four articles and a preamble. The preamble provides an overall picture of the dissertation, and it appears before the articles. Nevertheless, the three different cases represent the main empirical material of the dissertation and these are described in this section before the articles.

2.2.1 Case Study Companies

This study consists of an exploratory multi-case study. The organizations in focus have been *Graninge*, a forestry and sawmill company in mid-Norrland (Northern Sweden) that uses wireless information systems to improve the supply chain management of timber; *Taxi Stockholm,* a 107-year-old Swedish taxi driver cooperative with a membership of about one thousand taxi owners using wireless technology to increase efficiency in the customer dispatching process and finally *BT Industries,* a supplier of forklift trucks that has equipped its service technicians with handheld terminals to improve the service-order process.

Let us discuss now the distinction between *technology based* and *technology intensive* companies (e.g. Leonard-Barton 1995 p.140) introduced earlier to place these companies in a broader context. This classification distinguishes firms that encourage the development of radio-based systems (e.g. Ericsson, the Swedish provider of telecommunications equipment and related services) and those that utilize technology in its own processes such as Taxi Stockholm.

In the first case, technology has strategic importance. These firms enjoy a high degree of familiarity with technology, and their search for new sources of technological competence ends up in acquisitions of other smaller firms. This often requires having financial resources. On the other hand, technology dependent companies may sometimes use technology strategically, but technology is not an explicit part of their mission statement or strategy documents. Technology has operational importance, and their level of familiarity with emerging technologies is limited.

From this emerges a difference between the level of technological familiarity and its strategic importance. This distinction helps us to place different types of companies in the chart below (cf. Figure 8). The case study companies of this study are also placed in the chart.

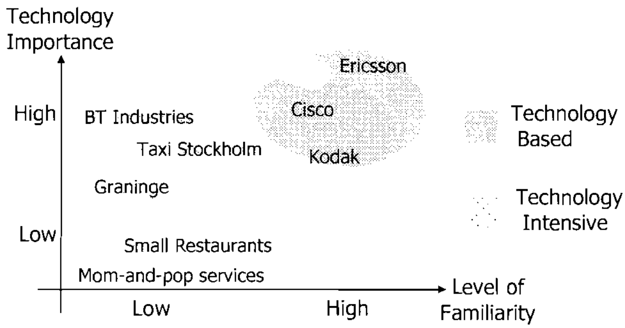

Figure 8 Classification of firms according to the role of technology

Sometimes the terms technology developer and technology consumer have been used in similar ways (Klein and Sorra 1996; Mårtensson 2003). Because these terms are also used in the dissertation it should be useful to clarify the relationship and the difference between technology based/developer and technology intensive/consumer as these two pair of concepts are not completely synonymous. The confusion concerns the term technology consumer and technology based firms. Firms exist that do not develop technology but put together different systems to deliver technological services. These firms can be classified as both technology based and technology consumers. Taking an example from the industry in focus for this dissertation, telecom operators such as Telia (the Swedish incumbent telephone operator) does not develop technology (it buys the technology from e.g. Ericsson) and therefore can be classified as a technology consumer firm. Nevertheless, Telia includes technology in its mission statement and therefore can be considered technology based also (cf. Figure 9 below).

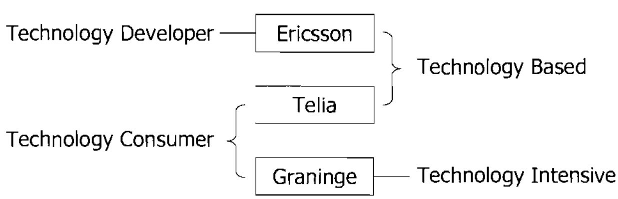

Figure 9 Technology-developer and technology-intensive firms

Therefore, it should be noted that the term technology-intensive firms completely delimits the type of organizations studied in this dissertation. The terms technology based and technology consumer are also used in the dissertation but only when there is no risk for confusion.

Selection of cases

Given the choice to study technology intensive companies, the question remains why the selection of the particular case companies. The choice of the organizations presented above was driven by three primary criteria: (1) proven wireless applications were demonstrably used; (2) the technology was implemented in core business processes, not in peripheral parts of the organizations and; (3) the applications were used to support mobile workforces, sometimes also called field workers. As indicated earlier, the selection of companies was finally influenced by motivations of site accessibility. Many implementation of wireless information systems were considered too confidential by the companies involved.

The case companies were approached progressively and different degrees of contact have been kept with all of them during my entire research period. The first case was Graninge which actually triggered my interest in the implementation of wireless information systems into organizations. The first contacts were made in 2001 in connection to a student master's thesis at the university (Nilsson 2000). A follow-up study in the spring 2005 was carried out consisting of interviews with managers from both Graninge and Svenska Cellulosa Aktiebolaget (SCA), the new owner of Graninge since late 2003.

Next case selected was Taxi Stockholm. The first study was performed in the fall of 2001, and a follow-up project with additional interviews was carried out during the spring of 2005. Both Taxi Stockholm and Graninge were included in an early project called *The value of mobile business processes – Evidence from Sweden and the Netherlands*. This was a comparative study of different wireless cases in the Netherlands and in Sweden. The main cases from the Swedish side were the two mentioned above. Moreover, we included a case about a parking payment service that uses cell phones implemented in the Netherlands. This study resulted in a couple of papers theoretically anchored in both mobility and business processes. One of these papers is included in this dissertation as Article 1 (cf. Chapter 8).

Finally, during this descriptive, international study I came across another interesting case from BT Industries. The similarities of this case to the earlier ones and the fact that I aimed at an exploratory research process based on literal replication made it attractive for my dissertation project. In addition, personal contacts with another researcher that had investigated an earlier implementation of the company's new Enterprise Resource Planning (ERP) system facilitated accessibility and provided background material on the company. The first study took place in 2003 and the follow-up study in the spring 2006.

This last case study was carried out within the context of a larger research project called "Mobile Solutions in Organizations". Among other activities, we built a database with small case studies called *caselets* alongside the data collection for the BT Europe case in cooperation with other colleagues. The idea was to find similar cases both published in journals, identified in the popular press or carried out ourselves that could serve as examples of wireless technology in practice. This database consists today of around 30 caselets and although they are not mentioned in the dissertation they have been very useful for orientation purposes.

Summing up, this dissertation consists of three retrospective case descriptions each covering a time period from the early 1990s until 2006 (cf. Figure 28 later in this dissertation). However the data collection activities were carried out at different points in time between 2001 and 2006. The collected material will be discussed next.

2.2.2 Data Sources from the Cases

Yin (1984) distinguishes six sources of data collection in case studies. These are documentation, archival records, interviews, direct observations, participant observation and physical artifacts. We will now discuss what each of these sources consists of and how it has been used in the dissertation.

Written documents

I have collected written documents during each visit to the case organizations, either in connection to interviews, field visits or direct observations. These documents consist of annual reports, marketing brochures, product information, application descriptions, etc. This type of documentation has been mainly used for verification purposes and to corroborate information from other sources. One special form of written documents consists of press material such as journal articles, press news and similar material. I have collected around thirty articles during the period in relation to the three cases. Finally, one dissertation (Gäre 2003) and an article (Westelius 2006) about BT Industries and a master's thesis about Graninge (Nilsson 2000) were also used in this study. These documents have provided me with an outsider's perspective on the cases.

Archival records

I have also used archival records in this study. Archival records consist mainly of digital documents provided by individuals, either in connection to interviews or through e-mail conversation. Part of this material is classified as confidential, such as evaluations of the projects, performance metrics, power-point presentations for the board, business cases, etc. This material is highly quantitative and its use has been limited in the case descriptions. This material has always been used in accordance with the guidelines agreed with the organizational sponsors in each case.

Interviews

This study consists of around 50 interviews, and they represent the main data collection activity in this dissertation. Appendix 3 presents a list of everyone interviewed for this work. They are divided case-wise. In addition, interviews from an early pilot study with managers from the telecom industry and other industries are included. These interviews were carried out early in my research project and helped me to delimit the object of study in this dissertation.

The list includes general managers, IT specialists, project managers and users of the systems. All the interviews lasted between one and three hours. When more than one person participated it is indicated in the appendix. The interviews were semi-structured and open-ended. This means that an informal protocol was prepared before each interview. The protocol was discussed with the other researcher in the cases were more than one researcher carried out the interview. These protocols were seldom sent in advance to the interviewees. However, background information was always provided via e-mail. The interviews consisted of questions about facts and opinions about events. Often the interviews were used as a basis for further contacts in the organization.

Transcriptions of the interviews were made directly after the interview. In the case when a digital recorder was used (all interviews since 2003), transcriptions could be postponed. In these cases transcriptions were literal whereas in the earlier interviews, notes were carefully collected during the interview, and complemented with additional annotations and site impressions for further analysis.

Direct observations

According to Yin (1984) field visits to the case study site permits direct observations, which serve as another source of evidence for the case study. Direct observations of the phenomena studied were possible because of the contemporary events studied, although the interviews were always performed retrospectively.

The main field visits carried out consisted of a number of visits to the call-centre at Taxi Stockholm, one visit to the Bollstabruk sawmill in Sundsvall

(Sweden), a quick overview of the IT support centre at BT Industries in Mjölby, a demonstration of geographical information systems used in transportation vehicles and control-offices during a forestry conference in Knivsta (Sweden) and finally the demonstration of BT Industries' application at the system-supplier development lab. Observational protocols from these visits were used as part of the case study protocol.

Participant observations

One important practice during this study has been the observation of the technology studied in use. Thus, participant observation is another type of data source used in this study. I have, in agreement with the organizations, traveled with a taxi driver and followed a service technician from BT to gather experiences from the field. In addition, interviews with researchers from the Swedish Forestry Research Institute (Skogforsk), who had carried out participant observation at different sites of forestry-machine operators, provided additional insights about usability aspects of forestry applications.

These observations of the technology in use at work were carefully documented after each visit, and they represented invaluable aid for deeper understanding of the user problems, some of which I could experience personally. For example, at BT Industries I could experience myself some of the input difficulties when searching for reserve parts in EASY, while helping one service technician to report a work order at the customer site.

Physical artifacts

Finally, physical artifacts were not collected actively during this research but I came across several when present at the different interview sites or in similar contexts. For example I had access to the handheld terminals used by field technicians, the dispatch terminals in taxi cabs, the computers installed in harvesting machines, etc.

In connection to these artifacts, namely the wireless terminals, I had access also to system manuals and documentation of the devices both digitally and in paper.

2.2.3 Analyzing the Data

The discussion about data analysis included in this section refers only to the additional research performed in preparing the preamble of this dissertation. Each article of the dissertation describes its own data analysis methodology that, in some cases, differs from the one explained here.

The analysis of all this material aimed at the development of three different case descriptions. A timeline of the cases was developed to organize the material collected.

The first step in the data-analysis process consisted of the identification of events. Events were defined as descriptions of happenings or occurrences originating from empirical observations. These events could be derived from an interview extract, a press release, an observation at a case site, etc.

The next step consisted in the classification of events. A number of theoretical constructs from aggregated observations were developed. An event could be thus classified according to the following list.

- *Activities*. These were major recurrent events. For example prototype tests at Graninge represent activities carried out periodically to improve the usability of the wireless system.
- *Context-internal incidents*. These are events in the organizations housing the innovation. For example the new appointment of a CEO represents such a context-internal incident.
- *Context-external incidents*. Events that are external to the organization studied are considered context-external incidents. For example, Taxi Stockholm's system supplier (Digital Dispatch) opened a sales and customer support office in Stockholm because of their cooperation with the company.
- *Observations*. They represent the result of carefully watching something at the case site. The problems experienced with spare-parts stock in the service vans of field technicians at BT illustrate this.
- *Ideas*. These were suggestions related to the development of the core innovation. The possibility to automatically attach marketing flyers to work order notifications e-mailed to customers emerged as an unexpected opportunity after the system launch of EASY at BT.
- *Outcomes* represent the result of a prior event or action course. The press conference held at the Vilhelmina district in Northern Sweden after the finalization of the pilot implementation at Graninge is such an event.
- *People*. Role changes connected to the core innovation were classified as people events. One example of a people event is the development of a businessman-like role of service technicians at BT.

These different types of events described above are not mutually exclusive. This is however not a problem because some of the events identified could actually provide insights into different dimensions of analysis. For example the appointment of a new CEO could be both a context-internal incident and the result of a prior event or action course (outcome). Moreover, different people could interpret events differently, sometimes even contradictorily. An outcome, Pathfinder's halt (the dispatch system at Taxi Stockholm) was interpreted differently by the company and the system supplier. These different perspectives about an outcome, activity, incident, etc. formed a holistic picture of what was going on at the organizations.

The analysis was done through a database with event tables consisting of the following fields: *Event_id*, *Event_Type*, *Date*, *Title*, *Description*, *Data_Source*, and *Classification*. The field *Description* contained the necessary information about an event connected to a specific point in time (*Date*) and subsequently categorized as an indicator of a theoretical pattern (*Classification*).

Finally, these events were classified for pattern-matching purposes according to three different levels of analysis described later in Chapter 5 and 6. These categories were (i) Development Stage; (ii) Type of Challenge and; (iii) Type of Capability observed.

Although the data analysis could be interpreted as a neat and straightforward process according to the protocol described above, the process has been anything but orderly. For example, the selection of types of events has changed many times during the research. The categories for analysis were developed late during the process and applied to the timelines after their conclusion. This required, among other things, that I revise the categorization of events which influenced earlier selected events and so on so forth.

2.2.4 Dissertation Articles

This dissertation, although it uses a number of case descriptions as its primary empirical material, it consists of a collection of articles. This means that both the articles and the preamble have their own separate value and additional value when combined together. There are a number of advantages and disadvantages with the article approach compared to a classic monograph. As Tolis (2005) explains, a collection of papers enables the reader to follow the development of ideas over time. Moreover the material has been subject to public scrutiny throughout the process. On the other hand restrictions in length require more condensed accounts than in monographs. Finally the requirement for congruence is not the same as in the case of monographs (Tolis 2005 p.27).

It should be noted that there is also an important difference between this dissertation and traditional dissertations consisting of the collection of articles. The preamble in this dissertation contains empirical descriptions, which is not standard practice. This is so because some empirical material was collected after most of the papers were written. The final research contribution, established late during the research process, required additional empirical material. This material is described in the case epilogues included in Chapter 4. Due to the brief summary of the cases also included there, Chapter 4 acts as a link between theory and analysis thus providing the preamble with a larger independency than normally.

The articles are my earlier publications both in refereed conference proceedings, a chapter in an edited book and a reviewed journal article (cf. Table 2 below). The articles are included in the final chapters of this dissertation in Chapters 8 through 11 after the references for the preamble. These articles are referred to in the preamble of the dissertation as Article 1, 2, 3 and 4 (instead of using the Harvard reference style) for clarity purposes. The Harvard-based references of the articles are included in one of the columns of Table 2.

	Publication	*Reference*	*Participating Researchers*
Article 1	The Value of Mobility for Business Process Performance: Evidence from Sweden and the Netherlands		
	ECIS 2002[8] Conference	(Van der Heijden and Valiente 2002) See Chapter 8	Cooperation with Vrije University Amsterdam (Ned.)
Article 2	Bringing the Enterprise System to the Front Line: Intertwining Computerised and Conventional Communication at BT Europe		
	Idea Group Publishing	(Westelius and Valiente 2005) See Chapter 9	Cooperation with Linköping Univ. (Sweden)
Article 3	The Role of End-Users for Wireless Information Systems Usage		
	ISD 2005[9] Conference	(Valiente 2005) See Chapter 10	Cooperation with CIC (SSE)[10]
Article 4	Understanding Migration Strategies by Decoupling Application Roles and Technology Generations		
	Technovation Journal	(Mårtensson and Valiente 2006) See Chapter 11	Cooperation with IM Department (SSE)

Table 2 Overview of articles included in this work

As indicated above, each paper does not include all the cases but make use of different cases for their main purpose of research. Table 3 below illustrates the relation between the articles and the cases carried out in this study. A brief description of the cases is included in Chapter 4 of this dissertation. A more detailed description of Taxi Stockholm and BT Europe can be found in the articles included in Chapter 8 and 9 respectively. Graninge is described in Chapter 10.

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[8] The 10th European Conference on Information Systems (ECIS) held in Gdansk (Poland) 6–8 June, 2002.

[9] The 14th International Conference on Information Systems Development (ISD 2005) held in Karlstad (Sweden) 14–17 August, 2005.

[10] Center for Information and Communication Research at the Stockholm School of Economics (SSE)

Empirical Cases	Article 1	Article 2	Article 3	Article 4
Graninge	√		√	
Taxi Stockholm	√			√
BT Europe		√		

Table 3 Empirical investigations

Having established the more scientific account of this exploratory multi-case study, let us now describe the personal interests that have driven the choices made about the work carried out in this dissertation project.

2.3 Personal Research Choices

This section is intended to describe the development of the ideas in the dissertation over time including my own views about research. I will thus try to describe the background to the articles included and how they helped me to shift focus during the research. First, I would like to present both the theoretical and practical interests that have guided my research.

2.3.1 Evolving Interest in the Research Area

My research interests have always been related to areas in the frontier between technical and economic issues due to my background as an engineer, I suppose. Technological phenomena can no longer be studied apart from economics and vice versa.

My theoretical interests have evolved from the hard management information systems literature towards the softer management part of this area alongside my research. From being interested in the technical and design aspects of wireless technologies, I have shifted focused more and more to explanations about the organizational consequences of technology management. The combination of implementation literature and innovation theories became my way of addressing this interest.

The underlying view of technology management that has evolved during these years is that innovation consists of two fundamental processes: *analysis* as in problem-solving activities and *improvisation* as in the interpretative and more unplanned parts of the process. If the first deals with problem identification and providing solutions, the second prepares managers for the unknown part of the innovation process. As discussed later in Chapter 3, the implementation area has provided support for the analytical part of the technology management process whereas innovation theories assist the creative part, although in practice the distinction has not always been so clear.

The main reason for the choice of implementation and innovation theories is their potential when studying the problem of technology in a complex social setting. Allen (2000 p.212) puts it as follows:

> *"[...] technological innovation theories from the social sciences might help IS research account for the important aspects of technology itself while not losing a rich picture of organizational context."*

Regarding my practical interests, both earlier preferences about data communication and radio technologies combined with my work carried out in Sweden, considered as a test bed for the telecom industry (Adams 2000), influenced my decision to study wireless information systems in a broader context. My original interest for a deeper understanding of the dynamics within the telecommunications industry drove my research focus towards the actual users of these products, especially within the enterprise market. Therefore the need to understand what makes technology management exciting from a user perspective drove my initial choices of case studies.

When I started my research many practitioners considered wireless technologies and mobility to be some sort of hyper-trendy phenomena. The interest from both private customers and organizations willing to invest in this new technology was very large (e.g. Collet 2003). Moreover, different players interested in technology overestimated the possibilities of technology and overlooked the difficulties (Jutila, Kaukonen and Schmitgen 2001).

Consequently a number of organizations made investments in wireless technology partly driven by the technology suppliers' visions. However, large investments are risky and difficult to manage. This was e.g. the case when telecom operators across Europe invested huge sums of money in 3G wireless communication systems. The consequence of such an acquisition rush was a large recession that affected the telecommunications industry for some years afterwards.

By then, many organizations had already started to question the value of new technology for new technology's sake. A tension between technology developers and technology consumers started to appear because many organizations both reconsidered and slowed down investments in new technology.

At this point in time I came across a master's thesis that described the implementation of a wireless application at a forestry company that attracted my attention. From then on, I started to shift my focus from industry-wide issues such as the allocation of UMTS licenses for 3G wireless communication networks (cf. Andersson, Hultén and Valiente 2005) towards the reasoning of organizations behind investment decisions connected to the use of wireless information systems at specific companies.

I carried out a study on a number of firms including Taxi Stockholm to investigate the value of wireless communication for the company. Soon I realized that identified value drivers within a business case or even within an implementation project group represent just one part of the work necessary to make the system both useful and used. A number of implementation and usage challenges were eagerly discussed alongside the value drivers of technology investments. Often the ability to manage the unplanned activities in the projects had a large impact for their success.

The next study was carried out at BT Europe where a colleague and I analyzed the innovation process when the company decided to implement a wireless application (EASY) for the after-sales order process. There was recognizable tension between technology developers and the users of technology, which was taken care of through a number of uncertainty reduction steps during the change management project.

Summarizing, this study has combined an empirical analysis in a classical inductive way with a theory driven analysis. I started my research with an idea of what I was looking for. The initial question was how the implementation of wireless information systems was carried out at organizations. This guided the selection of cases and the interviews performed in each case. Then the purpose of my research was refined in iterative cycles.

To sum up, my theoretical and practical interests have influenced this dissertation. Innovation theories have been central in my study from the beginning. The main reason for this is that they have helped me to study the implementation of technology in a complex social setting. Both my earlier interests about data communication and radio technologies influenced my decision to study wireless information systems.

2.3.2 Personal View of Research

Carrying out social research reflects a particular view on ontology and epistemology. The first refers to the researcher's own view about reality, whether objective or subjective and the latter to what constitutes knowledge. In this section I will briefly discuss both these subjects.

Regarding ontological assumptions, two different approaches represent the extremes of a continuum, namely a realist stance that considers reality as it is and perfectly accessible and social constructionist stance that considers interpretation of reality as the only reality that exists being moreover socially constructed (Gregg, Kulkarni and Vinze 2001). If the realist stance has been criticized for assuming that we always can gain reliable knowledge of reality, the other extreme denies the possibility of objective knowledge at all.

In my opinion, I believe there is a world independent of the people that inhabit it. Ontologically this means that some parts of this world are objective, and they can thus be understood by people independently of other people's knowledge about them and some other parts are subjective, i.e. part of the interpretation of particular individuals. In the case of information systems, it is my opinion that it is important to distinguish between certain types of entity such as physical objects, artifacts, technologies, etc. that exist in the world independently of the interpretation of human beings although many of these objects in the physical world are the result of workmanship, and the knowledge about them, highly influenced by individual's interpretations and other people's understanding.

Epistemological discussions are more intricate as they ultimately deal with the philosophical question about what constitutes valid knowledge and truth. Different ontological views influence the relationship between knowledge and factors such as data, information, experience, etc. Mingers (2004) describes four different schools of thought with distinctive philosophical traditions being used within information systems research. These are the positivist, interpretive, critical and postmodernist theories with different views about what constitutes knowledge. These schools represent a gradual shift from considering information systems to be technical systems towards their being considered as social systems. For a more detailed description of these different schools see also Myers (1997).

If the adoption of one of these research perspectives means ruling out specific research methodologies, this dissertation does not represent a commitment to a single form of research school presented above. However, due to the inevitable weaknesses of different research methodologies, it is particularly important, especially in social contexts, to be aware of the assumptions and the limitations of one's own research approach. In this research both a positivist and interpretative approach are used. Although there is a wide spread assumption that these approaches are opposed and irreconcilable I support the thesis that these two approaches are mutually supportive in line with Lee (1991). Lee (1991) integrates them into a single framework and focuses on different levels of understanding. There are both facts and patterns that can be empirically observed. However it is important to accept that an understanding of different interpretations of these facts can increase the holistic picture of phenomena.

2.4 Research Quality

The evaluation of one's own work is both necessary and difficult. This is particularly true of case studies because it is harder to assess their quality than that of other types of research such as experiments or surveys based on established statistical methods (Mähring 2002). Doing so in advance makes the process even more complicate. This section discusses some guidelines for what constitutes research quality given the research strategy chosen in this work. These criteria represent evaluation dimensions which will be re-visited in the concluding chapter of this dissertation.

A first question is what constitutes research quality. Ever since the field of information management emerged as an academic discipline, it has been a requirement to produce both academic rigorous and practitioner relevant research (Mårtensson and Lee 2004). This is so because the study of information systems involves the activities of a profession or corporate function. Information management is an applied research field that copes with real business-oriented problems of corporations (Lee and Baskerville 2003 p.221). This state of affairs calls for both rigorous and relevant IS research.

However, earlier researchers have identified an inverse relationship between rigor and relevance (e.g. Keen 1991a; Robey and Markus 1998; Lee 1999b), such that the greater the rigor, the less the relevance and the other way round. Robey and Markus (1998) introduced the idea of *consumable research* as a solution to this problem. Consumable research means producing research that both maintains a rigorous academic level and is consumable by practitioners.

Robey and Markus (1998) provide a number of techniques for producing consumable research, such as supporting non-traditional publication outlets, producing consumable research reports, pursuing practitioner sponsorship, etc. Although these techniques are less applicable when writing a doctoral dissertation, the idea of consumable research is still attractive. Therefore, my own interpretation of what constitutes consumable research follows based on the work of Håkangård and Nilsson (2001) and Mårtensson (2003).

Håkangård and Nilsson (2001) consider three criteria for what constitutes "good research", namely research that is original (interesting knowledge contributions), credible (valid knowledge) and communicable (transparent knowledge). Mårtensson (2003 p.37) further develops these criteria and describes three similar parameters for evaluating research; research that can be characterized as *credible*, *contributory* and *communicable* becomes satisfactory research. Credibility describes research that builds on consistency, rigor and transparency. Contributory research focuses on the relevance of research. The relevance of a particular research can be evaluated in terms of, for example, its originality. Finally communicable research refers to the accessibility of the results.

There are few, though important, differences between these two approaches. First, transparency is considered differently as a characteristic of communicability and credibility respectively. Second, instead of originality, Mårtensson uses the label credibility which is more general. Third, Mårtensson (2003) describes generalizability as an important aspect of contributory research.

Lee and Baskerville (2003) focus specifically on the issue of generalizability, and they describe generalization as forming general notions by abstraction from particular instances. They discuss four different types of generalizability in a 2x2 matrix depending on generalizations made from empirical/theoretical statements to empirical/theoretical statements (Lee and Baskerville 2003 Figure 5 p.233). Generalizations made from empirical statements to empirical statements (EE-generalizations) consist of e.g. generalizations about the situation in a firm made by researchers after interviewing different people at the organization. Generalizations made from empirical statements to theoretical statements (ET-generalizations) are typically used in case studies and represent part of the theory building process in case study research. Yin (1984) calls them analytical generalizations. In this study both EE and ET generalizations are made.

ET generalizations are in turn of two types: generalizations of observations to theory and generalizations from the domain studied to other domains (Lee and Baskerville 2003 pp.235-236). The former refers to pattern recognition and the latter to the applicability of a particular sample beyond the field of study. Walsham (1995) explains that beginning with the descriptions of a case, the researcher can generalize to concepts, to a theory, to specific implications, etc. These are all examples of generalizations to theoretical statements.

One possible criterion for assuring the quality of ET generalization is multiple sources of evidence (Lee and Baskerville 2003). Through alternative explanations one can perform a quality check for this type of generalization. One such type of alternative explanations is achieved through triangulation.

Traditionally, triangulation is considered as an specific method to enhance the quality of the case study research (Yin 1984). The main idea behind triangulation is that the application of multiple perspectives in research may enhance the quality of the final research. According to Denzin (1989 pp.236-246) triangulation can be performed at different levels. He distinguishes between data, theory, methodology and investigator triangulation.

In this study both data triangulation and research triangulation have been applied. Methodology triangulation, the use of different research methodologies, was not applied in the study. Case studies were the overall methodology used in this research. As indicated earlier, the case studies carried out in this research rely on different data sources (data triangulation). Investigator triangulation was achieved by co-authoring the research papers with other colleagues in all three case studies. In addition, the Taxi Stockholm case was co-authored in two different papers with two different researchers. Finally, the case descriptions were also checked by the contact persons in the organizations.

As far as co-authoring the papers is concerned, it has been a priceless experience. This has given me an opportunity to learn research in close cooperation with both demanding and supportive researchers, which helped me to develop my own approach. These researchers all had different research styles, which was both positive and challenging. I am convinced my own approach has been improved through these contacts.

Finally, the discussion above about what constitutes consumable research as interpreted in this dissertation is illustrated in the following figure.

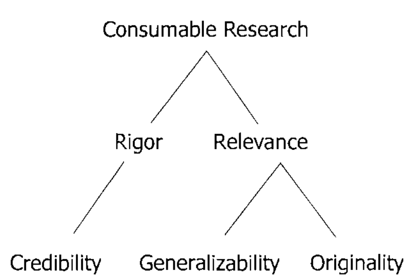

Figure 10 Consumable research

Worth noting is that communicability is not included in the figure above because the dissertation itself represents the communication channel used for the dissemination of the results, and its value is left to the readers' own judgment.

3 Theoretical Foundations

In the previous chapters, theories about the implementation of information systems, innovations and capabilities were found to be important for this dissertation. This chapter presents and discusses this theoretical basis in more detail. These theories represent earlier research contributions relevant for the subsequent analysis of how firms develop capabilities while managing the implementation of wireless information systems to support mobile workforces.

The section is arranged as follows. A brief background to information systems is included in Section 3.1 on ambiguous technologies. There follows a discussion about the benefits of implementing information systems in terms of developed capabilities. As this project tries to link the implementation of information systems and organizational innovation, these two areas will be covered next. Finally, the chapter ends with a description of the model of organizational innovation processes developed in the section.

3.1 Ambiguous Technologies

More and more companies choose to invest in different breeds of information systems to support business activities. However the process of creating value out of these investments is usually fairly challenging. The reason why will be developed in this section. But before the analysis of the particular motives for this, I would like to put wireless information systems into context.

Information systems can be considered a sub-category of information technology. However an information system is not just the technology, but also its implementation within a certain organization. A compact way to put this fact is that an information system is an instantiation of information technology within an organization (Lee 1999a p.7). Therefore the analysis of an information system has to take into consideration the technology and the organizational context where the technology is implemented.

The introduction of an information system is often considered a dynamic process of mutual adaptation (Leonard-Barton 1988), where a simultaneous re-invention of the technology and an adaptation of the organization takes place (Hong and Kim 2002 p.27). In this regard Information Systems research differs from related disciplines such as computer science where the main object of study is the technology per se.

One reason for this mutual adaptation process is that information technology in general and information systems in particular can be considered as an intellectual technology (Curley and Pyburn 1982). Information technology is a general-purpose technology that allows the user to configure its functionality because the functionality of the technology is not always fixed at the outset of the implementation process, in contrast to, for example, industrial technologies. This functionality can be innovated endlessly both during the development, installation and use of the technology. Thus, uncertainty accompanies most instantiations of information systems in organizations.

This uncertainty has been addressed in many different ways. For example Earl (2003 p.42) proposes that IT is an ambiguous technology. As he suggests, the ambiguities of an IT-related venture can be analyzed in terms of three essential uncertainties: enabling, commissioning and impact uncertainties (see Figure 11 below). He means that managers have trouble to identify the real scope, the functionality and the impact of information technology. These uncertainties are reinforced in the case of emerging information technologies such as wireless information systems, where the functionality of the technology is under development. Therefore, these uncertainties need to be handled in the organizational innovation process.

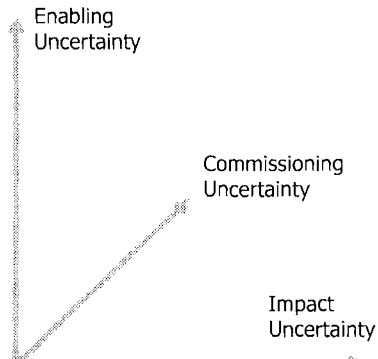

Figure 11 IT as an ambiguous technology[11]

Handled differently these uncertainties may result in diverging results. There is an underlying view that both technology and organizations influence each other. There occur interactions like "*reagents that react to and change each*

[11] In Earl (2003).

other's properties in a chemical compound" (Lee 1999a p.8). Different answers to questions such as: What can technology do for us? Will it work? And will users adopt it? will lead to different outcomes (cf. Table 4 based in Earl 2003). There are a number of studies that show how the same information system when implemented differently can lead to completely different results (e.g. Barley 1986; Caldeira and Ward 2002).

Uncertainties	*Description*	*Area*
Enabling	What can technology do?	Scope
Commissioning	Will technology work?	Functionality
Impact	Will users adopt it?	Introduction

Table 4 Technological uncertainties

According to the discussion above, the implementation of IS can be considered a process of making technology less ambiguous, useful and even used by the organization (Article 2). Therefore, as Markus, Tanis and van Fenema (2000 p.44) point out, great skills in managing organizational change are required to succeed with the implementation of information systems.

The next section discusses the resource based view of the firm. This represents a potential perspective that can trace the path from IS implementations to business benefits (Bharadwaj 2000) through ambiguity-reduction activities. This perspective recognizes the challenges of these uncertainties especially if we are to create benefits of a sustainable character.

3.2 Sustainable Competitive Advantages

The recruitment of new employees in an organization consists of a seeking for a match between the requirements of the job and the knowledge or experience of the individual. The resource view of the firm takes this reasoning to the organizational level (e.g. Penrose 1959; Andrews 1971; Wernerfelt 1984; Barney 1986a, 1986b, 1989; Dierickx and Cool 1989; Prahalad and Hamel 1990; Barney 1991; Peteraf 1993). The focus of this theoretical perspective lies on the matching between certain business-oriented requirements and particular abilities of the organization. Penrose (1959) treats the firm as a set of resources broader than labor and capital for conducting business. Andrews (1971) phrases strategy in terms of the resource position (strengths and weaknesses) of the firm. In brief, the resource-based view presents the notion that firms are fundamentally heterogeneous in terms of their resources and internal abilities (Peteraf 1993).

There is a link between these particular abilities, also called capabilities, and the successful implementation of information systems. This link starts with the analysis of the theory of the firm. Such a theory should address two basic questions, according to Conner (1991). These are why do firms exist and what determines their scale and scope. Ultimately, what differentiates theories of the firm from each other is how the performance differences between firms are explained (Conner 1991 p.123). For instance the neo-classical approach (e.g. Holmstrom and Tirole 1989) describes firm performance as determined by a combination of labor and capital under the assumptions of perfect information, resource mobility and divisibility. A Schumpeterian view (Schumpeter 1934) describes firm performance in terms of adopting innovations that make rival's positions obsolete, etc.

The resource-based perspective stresses the importance of internal firm-specific factors in explaining variations in the performance of organizations, particularly over a period of time (Wernerfelt 1984). Although the perspective is still under development, some of the basic assumptions are that heterogeneity and immobility of resources give competitive advantages (Barney 1991); that resources, and not only products, are source of advantages through the creation of resource-position barriers (Wernerfelt 1984); that a firm's competitiveness derives from its ability to build core competencies more speedily than competitors (Prahalad and Hamel 1990); and that the sustainability of a firm's competitive advantages depends on how easily assets are substituted and imitated (Dierickx and Cool 1989). In summary the resource-based view has deepened our understanding for how resources are mobilized, what makes competitive advantages sustainable and the origins of heterogeneity among firms (Peteraf 1993).

IS implementations correspond to a particular form of resource mobilization. A chosen technology represents one type of physical resource that, if successfully implemented, may generate some capabilities and advantages. As discussed in Chapter 1 earlier, this is one important object of scrutiny, i.e. the ability to identify what type of benefits can be expected from such implementations (cf. the first myth discussed earlier about *IT does not matter*). This is moreover a challenging process because capability development processes are not orderly and predictable. The view proposed here considers capabilities as difficult to identify and linked to each other in complex nested ways (cf. Kaplan 2002).

The reason for the creation of competitive advantages can be traced back to traditional economics. In the production process firms turn inputs, which are also called factors of production, into outputs. These outputs should be of higher value than the inputs used in the production process and outperform those of competitors. Developing capabilities is a variation on the same theme. However, one distinction is that classical microeconomics does not account for how this process takes place while, for example, strategic management scholars describe extensively how the organization manages the process of creating advantages (e.g. Porter 1980, 1985).

These competitive advantages also need to be sustainable. This is so because easily imitable advantages are short lived, and their benefits thereby limited (Barney 1991). The sustainability of advantages is also an issue debated within the Information Management field, where researchers seek a better understanding of the mechanisms that lead to sustained competitive advantages through the deployment of information systems (cf. Peppard and Ward 2004 p.171).

It is important to note though that the benefits of the advantages do not depend solely on calendar time. Barney (1991) explains that sustainability of advantages depend on the abilities in question being valuable, rare, imperfectly imitable and difficult to substitute by other resources (Barney 1991 p.105). Mata, Fuerst and Barney (1995) pose three questions of relevance for the sustainability of capabilities: Is a resource or capability valuable? Is it heterogeneously distributed among competing firms? And is it imperfectly mobile? An affirmative answer to these three questions indicates a sustained competitive advantage.

The distinction between competitive and sustainable advantages may be further refined using the three questions above: Competitiveness of advantages are derived from their heterogeneous distribution, i.e. the answer to the second question above; the sustainability of benefits can be derived from imperfect mobility (cf. question 3 above); and the answer to the first question (Is a resource or capability valuable?) gives us a pre-requisite when discussing both competitiveness and sustainability, i.e. the advantages (cf. Figure 12).

Competitive	Competitive Advantage	Sustained Competitive Advantage
Non Competitive	Disadvantage	Sustained Advantage
	Non Sustainable	Sustainable

Figure 12 Sustained and/or competitive advantages

This line of reasoning assumes that advantages can be competitive and/or sustainable. A temporary competitive advantage provides short term benefits. These benefits can be rare at the moment of acquisition or development, and they can be improved by making them imperfectly mobile. We achieve then sustained competitive advantages. The imitable sustained advantages represent long-term benefits that can be copied. This characteristic assumes a gradual aspect of the benefits and stresses the importance of continuously developing capabilities. Advantages are not digital (either you have them or not). It takes some time to develop them, and therefore two organizations can have the same type of advantage but in different degrees. The advantage is imitable thus non competitive, but at the same time sustainable because of constant development.

This fact stresses the importance of continuous capability development activities. Therefore a more process-oriented view should be used to analyze how these capabilities change over time. This aspect of capabilities will be further developed later in this chapter when discussing capability development activities (cf. Section 3.2.2).

More specifically, sustainable advantages are shaped according to their level of re-usability, temporal duration, path dependency (history), etc. whereas competitive advantages are dependent on their level of rarity, difficulty to imitate, etc. Therefore, the focus of inter-organizational studies lies on the competitiveness of advantages whereas intra-organizational studies are more suited for the analysis of sustainable advantages instead.

For purposes of clarity, I would like to mention that this work focuses on organizational capabilities and not on individual's capabilities. Although organizational capabilities depend on personal capabilities such as managers', users' or integrators' capabilities, they refer specifically to a firm's capacity to undertake a particular, productive activity providing sustainable advantages, and they reside in business processes.

It should be noted here that there is a considerable amount of terminological ambiguity in the resource-based literature. Theorists have used concepts such as resources, assets, competencies and capabilities in a rather liberal manner, and sometimes different meanings are attached to the same concept by different theorists. This terminological ambiguity stems partly from the fact that the resource-based view is still far from being a coherent perspective (Foss 1998).

3.2.1 Organizational IS Capability

Let us now look in greater detail at the research vocabulary in order to lay a basis for the discussion to follow. The aim of this section is to develop a setting, in terms of concepts and links between the concepts, to facilitate the later analysis of capabilities derived from the implementation of wireless information systems. The results of this analysis are summarized in a number of concepts (cf. Table 5) and their relationship illustrated graphically in Figure 14.

Generally speaking, a capability is the ability to achieve and sustain superior performance. Richardson (1972) introduced the term of firm capabilities to refer to the skills, experience and knowledge that a firm possesses. Panzar and Willig (1981) described capabilities more specifically in terms of attributes that firms build upon when choosing the scope of their activities. Although fruitful in clarifying the importance of resources for the development of competitive advantages, early researchers did use the terms resources, competencies, capabilities, skills, etc. indistinctively, which has sometimes been a source of confusion (cf. Peppard and Ward 2004). For example, this is the case in Barney (1991 p.101), which follows Daft (1986) and defines firm resources as "*all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm*".

In contrast, further development by Grant (1991) introduced the distinction between resources and capabilities. He defined resources as inputs into the production process and capabilities as the capacity to perform some task or activity. Firms thus create competitive advantages by assembling resources that work together to create organizational capabilities (Grant 1991 p.119).

It is important to make this distinction clear because resources per se are not a source of sustainable advantages. On the contrary, it is the ability to mobilize and deploy these resources that becomes a source of competitive advantage and thereof a capability (Bharadwaj 2000; Marchand, Kettinger and Rollins 2000). Since investments in IT are easily duplicated by competitors, technological resources per se provide only limited advantages. A wireless dispatch system itself does not provide sustainable advantages as this particular technology can be easily imitated. Rather it is how firms leverage their investments to create unique advantages that determine a firm's overall effectiveness (Bharadwaj 2000).

Another distinction between resources and capabilities is that organizational resources can be hired and fired, bought and sold (Christensen 2001), and thus they differ from capabilities, which cannot be bought but should be developed instead. The distinction between acquisition of resources and development of capabilities is especially important when analyzed within a change management setting. Resources are assets most managers instinctively think of when assessing whether their organizations can successfully implement changes that confront them. However, the capabilities available are at least equally important, and these capabilities cannot be acquired as easily as resources.

Contrary to the opinion of Wernerfelt (1984 p.175), capabilities need to be developed. He mentions mergers and acquisitions as an opportunity to buy or sell resources in bundles and thereby acquire new capabilities. However, in my opinion a firm acquisition does not automatically provide new organizational capabilities. They still need to be developed during the post-merger period. This is but an example how resources can be acquired more or less easily but the ability to confront challenges still has to be developed within the organization. This distinction is similar to the one drawn by Kogut and Zander (1992) between hiring new workers and changing the skills of a firm.

Information system researchers have identified a number of capabilities that can become potential sources of competitive advantage (e.g. Mata et al. 1995; Ross, Beath and Goodhue 1996; Feeny and Willcocks 1998; Marchand et al. 2000). Instead of analyzing these capabilities, I would like to discuss the term *IS capability* instead. This term represents a more general and higher-level construct described in Peppard and Ward (2004).

The idea of a meta-level capability has been introduced earlier. For example Marchand et al. (2000) refers to "information orientation" as one general capability that comprises other capabilities to effectively manage and use information. Kettinger et al's (1994) description of "organizational infrastructure" can also be understood in a similar way to the above mentioned concept of IS capability. I subscribe to the view of Marchand et al. (2000 p.69) and refer to IS capability as the ability to connect technology to its business performance (further discussed in Peppard and Ward 2004 p.173).

Finally, I accept the assumption (ibid 2004 p.179) that all organizations have an IS capability, but they differ in their ability to mobilize resources. A strong IS capability implies faster assimilation and agility in adopting and implementing changes whereas a weaker IS capability implies a slower response when assimilating technology-related change.

Static and dynamic capabilities

Kaplan (2002) describes different types of capabilities based on the growth of the firm and on change over time. This distinction originates in some early research from the resource based view of the firm (Penrose 1959) and it has been developed recently by the dynamic capability approach (cf. Teece, Pisano and Shuen 1997; Eisenhardt and Martin 2000; Zollo and Winter 2002; Winter 2003).

As Kaplan (2002) explains, a particular firm makes use of a number of capabilities in producing any customer offering. He calls them *static* capabilities. However, if the firm starts developing new abilities that could also be re-used in the future, the firm is engaged in capability acquisition requiring other type of 'process' capabilities called dynamic capabilities (Teece et al. 1997). In comparison to traditional capability research, the dynamic approach focuses on how capabilities develop rather than what capabilities are developed. This approach moreover shifts focus from capabilities' first development to their subsequent renewal (Teece et al. 1997). Kaplan (2002) thus distinguishes between static capabilities, critical routines that underpin the competitive advantage of the firm, and dynamic capabilities defined as the ability to acquire static capabilities.

Though interesting, Kaplan's idea of capability acquisition can be somewhat misleading. His description objectifies capabilities into the process of buying or selling activities. As discussed earlier, capabilities are best understood as the result of a development process and not merely as objects in a balance sheet that are easily bought or sold. Even though Kaplan himself uses the term "beyond plain ownership aspects", it is best to be overly explicit to avoid terminological ambiguity and use the concept of capability development processes instead of capability acquisition processes.

In addition, Kaplan's definition of capabilities as routines may clash with the creative aspects of innovation processes that will be described later in this chapter. The reason for describing capabilities as routines, which was also the case even in earlier research (cf. Nelson and Winter 1982), is to stress their sustainable character (see also Grant 1991). The fact that abilities can continue to exist after the efforts to realize the ability have ceased highlights the importance of developing short-term into long-term advantages. The routinization of short-term advantages has been considered as one such approach. However routines can be confounded with something repetitive that is unvarying or boringly repetitive. Thus capabilities are described in this work as abilities instead of routines.

Although not in focus for this work, I will illustrate the discussion so far with some examples of dynamic capabilities, namely product development, strategic decision making, alliance making, post-acquisition integration and innovative R&D. Eisenhardt and Martin (2000) describe *product development* as the routines by which managers combine their varied skills and functional backgrounds to create revenue-producing products and services; *strategic decision making* as the routines in which managers pool their various business, functional and personal expertise to make the choices that shape the major strategic moves of the firm; and *alliance making* as the routines that bring new resources into the firm from external sources. Furthermore, Zollo and Winter (2002) describe *post-acquisition integration* as the ability to plan and effectively execute post-acquisition integration processes and Winter (2003) describes *innovative R&D* as a dynamic capability that can become disadvantageous for a firm in the presence of strong rivals who invest only in imitative R&D.

Kaplan's (2002) distinction between static and dynamic capabilities is straight forward and useful. However, I would like to develop further these concepts based on his definition. In my opinion it should be more accurate to speak of *operational* and *improvement* capabilities. The label static is somehow one-sided as it may be confused with unchangeable abilities. This interpretation runs counter to the very nature of capabilities, which can always be improved. In addition the term dynamic should refer not only to the fact that these capabilities develop over time, because static capabilities can also develop, but also to the fact that they represent change motors. Instead the adjective improvement focuses the discussion on second-order changes, which are similar to the concept of double loop learning (cf. Argyris 1977) and more suitable for the purposes of this dissertation[12].

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[12] Argyris (1977) developed the ideas of single-loop learning and double-loop learning. In Argyris and Schön (1978), the authors discuss how learning involves the detection and correction of error. When something goes wrong, it is often suggested

(cont.)

This distinction between operational and improvement capabilities originates in Andersson (2005 p.199), who refers to *operative work* and *improvement work* to distinguish between the daily operative work and work that is carried out to improve the results of operative projects in general. The distinction between operations and improvements is also used within the process-management research area (Davenport 1993). For example, business process reengineering focuses on work that is carried out to improve business processes representing a type of improvement work (Davenport and Short 1990; Davenport 1993; Hammer and Champy 1993).

The combination of Kaplan's (2002) definition of dynamic capabilities and Andersson's (2005) notion of improvement work help us to develop the notion of *improvement capabilities*. These are general abilities that help organizations to develop new capabilities originating from certain business challenges. They are moreover accumulative in a similar way to the notion of combinative capability in Kogut and Zander (1992). This means that these abilities apply current and acquired knowledge. One additional and important distinction is that improvement capabilities relate to the change process primarily and they are not dependent on any underlying technology. In contrast, *operational capabilities* are considered here as abilities that underpin a superior performance for the business processes that are devoted to the production and delivery of a particular firm's products and services (based on Slack, Chambers and Johnston 2004).

In this work, we treat operational capabilities as developed from the particular characteristics of technologies or information systems such as WIS. By way of illustration, a freight delivery company may be able to provide customers with timely information about the location of parcels. The ability to deliver timely information represents the operational capability developed through the implementation and use of e.g. wireless RFID (radio frequency identification) technology.

Therefore we use the term operational capabilities to refer to abilities developed from technologies such as wireless information systems, robotics, genetics, etc. Improvement capabilities, on the other hand, are more general,

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to look for another strategy that will address and work within the given system. According to Argyris and Schön (1978), this is single-loop learning. An alternative response is to question the governing system itself. They describe it as double-loop learning. Such learning may then lead to a shift in the way in which strategies and consequences are framed.

independent of underlying technology even though they can be technology related and often benefit change processes. The discussion so far is illustrated in Figure 13 below.

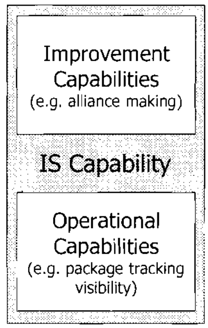

Figure 13 IS capability compound

It should be mentioned that the earlier concept of IS capability comprises both the improvement and operational capabilities because every organizational innovation process requires change-management abilities and specific technological competencies.

3.2.2 Capability Development Activities

This section develops some arguments about capability development activities. But before discussing different strategies for capability development, we must draw a subtle but central distinction between improvement capabilities and the capability development process. Improvement capabilities help to develop operational capabilities. These should not be confused with the process, or set of events, actions and activities through which firms develop capabilities (cf. Table 5).

This distinction is similar to the discussion in Lundeberg (2003) about constructed patterns and observed phenomena in the operations-information-people model (Lundeberg 2003 p.54). This distinction emphasizes both the processes of achieving results and the results of the processes when describing business operations. Constructed patterns can be described as classifications of reality similar to the capabilities described earlier. Observed phenomena have a clearly temporal dimension, and they can be compared to capability-development strategies. This distinction was originally introduced by Bateson (1972) when he explained the difference between classifications and processes to treat reality that exists in time (see also Andersson 2005).

Developing capabilities is a continuous process. This idea is reinforced by the fact that the quality of the advantages created depends upon their level of sustainability. A firm can stay ahead of its competitors by developing its capabilities on the basis of sequences of activities that in time become path-dependent (Dierickx and Cool 1989). The dynamic character of competition and the importance of time underscore the idea of using existing capabilities to develop new ones. For example Barney (1991 p.107) stresses that imperfectly imitable resources are dependent upon unique historical conditions; Dierickx and Cool (1989) explain that non appropriable assets (read capabilities) need to be cultivated; and Grant (1991 p.122) identifies repetition as a requirement for the development of capabilities.

Concepts	*Definitions*
Resources	Assets that can be bought or sold being used as input in any production process
Capability	An ability to achieve and sustain superior performance
Operational Capability	Abilities that underpin superior performance for the business processes which are devoted to the production and delivery of a particular firm's products and services
Improvement Capability	An ability that helps organizations to develop new operational capabilities originating from certain business challenges
Capability Development Activities	A set of events, actions and circumstances through which firms develop capabilities
WIS Capability	A type of operational capability derived from the characteristics of wireless technologies
IS Capability	A meta-level ability that connects technology to its business performance and comprises both improvement and operational capabilities

Table 5 Defining the terms of our analysis

Nevertheless, there exists a general difficulty for handling the more dynamic issues of capability creation within the resource-based view (Foss 1998). Foss points out that one important reason why the resource-based perspective lacks a clear model of the endogenous creation of resources may be the predominant role of equilibrium in strategy research (Foss 1998 p.142). Equilibrium assumptions can seriously impede the development of models of endogenous change because they introduce a static bias. Thus there is a need to bring process issues more directly into the focus of this perspective. This is one of the theoretical gaps the analysis presented in this dissertation tries to bridge.

One idea connected to the dynamic-capability approach is that of routinization. Although the label routines will not be used in this work, I would like to stress the importance of the development process of capabilities. As already mentioned, the fact that abilities continue to exist after the capability development process underlines the importance of developing sustainable competitive advantages.

Another theme closely related to the dynamic capability approach is that of specialization. The benefits of specialization stem from the principle of division of labor. According to this principle, firms are encouraged to deepen their expertise in what the firm knows well to achieve competitive advantages. Capability development can be considered as a form of specialization to develop activities that result in advantages that are valuable, rare, imperfectly imitable and not strategically substitutable by other resources (Barney 1991). Such abilities are neither easily imitated nor duplicated and thus have a high performance improvement potential.

The degree of specialization also influences the level of value-chain integration. Different types of capabilities lead to specialization at different levels. For example, the development of complementary capabilities leads to vertical integration while supplementary capabilities lead to horizontal integration (Sen and Egelhoff 2000). This relationship between capabilities and integration has a clear impact on the capability development process. Among other issues, the search of missing abilities can be explained. Organizations inclined to the development of complementary capabilities may be more motivated to seek new abilities through in-house development tools. On the other hand, supplementary capabilities could lead to the creation of strategic alliances with external suppliers.

Earlier researchers employing the dynamic-capability approach have identified a number of activities about how firms develop capabilities (e.g. Hamel and Prahalad 1994; Kettinger et al. 1994; Volberda and Baden-Fuller 1998; Christensen 2001; Kaplan 2002; Grant 2005). According to Hamel and Prahalad (1994) it is a firm's ability to leverage its resources that constitutes the primary source of capabilities. They describe five alternatives for resource leverage (cf. Table 6). These can be interpreted as capability development activities. However, this dissertation differs from their analysis in that the IS capability analysis starts with challenges rather than resources. This does not mean that resources are less important. However, this choice provides a more technology-neutral analysis.

In this dissertation resources are considered factors of production (cf. Teece et al. 1997) i.e. inputs to the production process such as capital, technology, land, labor, etc. However challenges are demanding situations that trigger change. For example, the IT infrastructure platform of a company is a resource, whereas the upgrading of the technological platform to meet future customer demands represents a challenge.

Kettinger et al. (1994) propose preempting as a strategy for capability development. The early entry into a market provides advantages over later entrants. However, the advantages of early entry are not automatic nor always sustained. Often technological and economic uncertainty produces, at most, temporary advantages (Kettinger et al. 1994 p.37).

Further, we can distinguish between internal capability-development activities such as in-house innovation (Kaplan 2002) or internal capability creation (Christensen 2001); and external activities such as firm purchasing or strategic alliances (Kaplan 2002; Grant 2005).

One interesting approach is described by Grant (2005) namely product sequencing as an example of capability development activity. The pushing of the development of products can pull the development of sustainable advantages (cf. Table 6 below).

Hamel and Prahalad (1994)	*Kettinger et al. (1994)*	*Christensen (2001)*
Concentrating Accumulating Complementing Conserving Recovering	Preempting Creating Switching Costs Developing Response Strategies Managing risks	Firm Purchasing Internal Capability Creation Creation by spinout

Volberda and Baden-Fuller (1998)	*Kaplan (2002)*	*Grant (2005)*
Selection Hierarchy Time Networking	In-house Innovation Cloning Collaboration Firm Purchasing	Mergers and Acquisitions Strategic Alliances Incubation Product Sequencing

Table 6 Capability development activities

Finally, note that one assumption guiding this work is that improvement capabilities, all things being equal, provide superior sustainability than operational capabilities. For this reason future discussions about capability development activities will focus on those leading to improvement capabilities and not to operational capabilities.

It is time to put all these pieces together. This is done in the conceptual model of capabilities, resources and challenges illustrated in Figure 14 below.

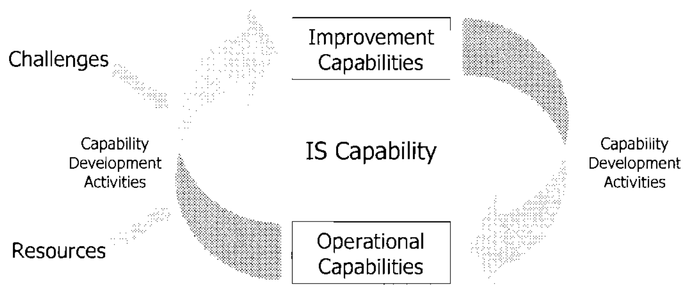

Figure 14 Capability-based conceptual model of OIP

It should be observed that capability development activities link organizational challenges and capabilities. The idea of connecting challenges and capabilities is not new. Feeny and Willcocks (1998) also discuss a number of capabilities arising out of some general challenges.

Challenges, among other factors, represent demanding situations that increase change pressure. This pressure for change may or may not have an effect in any given organization. If it leads to change, the development of sustainable advantages may follow.

It is however important to remember that challenges are but one change pressure factor. Other factors include market contacts, experimentation, weakness discovery, etc., all of which Miller (2003) refers to as discovery paths.

In this dissertation we define challenges as demanding situations which require great effort to accomplish. The use of the term challenge in this dissertation is similar to the concept of problem or threat with a subtle but important difference. Challenges, considered as *demanding* situations, are often *stimulating* whereas problems are most often not stimulating. Thus, all problems are not always challenges.

Klein (2004) discusses how challenges represent true pull for changes. If changes are pushed into organizations they often become short-lived. Instead challenges that are important and of some urgency to a subset of individuals cause people to question internal assumptions and thereby trigger what she calls *true change processes* in organizations.

3.2.3 WIS Operational Capabilities

Armed with these definitions (see Table 5 above), this section describes some operational capabilities derived from wireless technologies. These capabilities belong to the group of operational capabilities and originate from specific characteristics of technology.

Despite the wide variation of views about how to achieve advantages based on wireless technologies, the presentation in this section will focus on three capabilities deemed important in the papers included in the dissertation and earlier research. These are spatiotemporal, radio-engineering and connectivity capability. The selection of capabilities has been an iterative process. The inspiration for selecting the capabilities comes from earlier research and the description of each capability was developed from findings in the papers.

This section examines these three operational capabilities in more detail, but a discussion of the actual choice of capabilities precedes this examination.

Selection criteria for wireless operational capabilities

Let us start our analysis by revisiting what characterizes wireless information systems. In the introductory section, I described three dimensions that define wireless information systems. The first dimension was the degree of complexity of the technology itself. WIS were classified as complex organizational systems. The second dimension rests on the distinction between voice based services and data based services. Finally, the third rests on the presence or absence of restrictions imposed by wires. There are systems that require wires to function and others that do not require wires but are heavily dependent on batteries or another power mechanism. WIS was thus located in the second category of both descriptive dimensions. In addition, the users of the system were characterized by the fact of their changing environment working while moving or on the move.

The selection criteria for WIS operational capabilities come from the information management discipline, specifically from an analytical framework for perceiving situations based on different levels of abstraction (Lundeberg 1993). The main idea behind this framework is to simplify complex analysis by identifying levels into which a certain problem may be categorized.

Three levels are specially related to information systems development according to Lundeberg (1993) namely activity studies, information studies and information system design. In further analysis, Lundeberg (1996 Figure 3) describes business activities, information needs and information systems as central for placing technology in a meaningful context. The framework's main advantage is that it helps the researcher to get a broader perspective. The focus on technical issues broadens by considering other aspects such as the information requested and the players involved. This is, among other things, at the base of the information management field. This framework has been used in other change processes where IT has a dominant role (e.g. Mårtensson 2001).

These three levels (activities, information and systems) were used to select appropriate capabilities. The three capabilities included in this section can be therefore derived from these levels. The radio-engineering capability is related to systems, the spatiotemporal capability to information and finally the connectivity capability is related to the communication between people engaged in the business activities studied. The role of the model in this work has been that of organizing principles.

The selection of capabilities is also based on a selective review of literature from the following disciplines. Literature about how to achieve advantages based on wireless technologies was consulted from the areas of *mobile commerce* (e.g. Siau, Lim and Shen 2001; Jarvenpaa et al. 2003; Lee and Benbasat 2003); the more technology oriented area of *mobile communications* (e.g. Kleinrock 1996; Abowd et al. 1997; Sarker and Wells 2003); *mobile information systems* (e.g. Mennecke and Strader 2001; Smith, Kulatilaka and Venkatramen 2002; Varshney 2003; Krogstie et al. 2004) and closely related areas, such as *enterprise mobility* (e.g. Barnes 2003; Liang, Xue and Byrd 2003; Kakihara and Sorensen 2004); *mobile informatics* (e.g. Kristoffersen and Ljungberg 2000; Kakihara and Sorensen 2002; Kim et al. 2002) and *computer supported collaborative work* (e.g. Bellotti and Bly 1996; Harrison and Dourish 1996; Dix et al. 2000), which studies how to enhance support through human-computer interaction.

Krogstie et al. (2004) propose three different areas of differences between wireless and traditional information systems. These are *user orientation and personalization*; *technological functionality* and *methodology for development and operations*. First, the user orientation difference can be explained by the fact that wireless information systems address a wider user-group. This puts pressure on the development of user interfaces and on privacy because of the individualization of wireless devices. Second, technological differences consist of limited processing, memory and communication capacities; the wide-alternative requirement imposed by, for instance, multi-channel technologies; etc. Finally, there are some methodological differences because mobile clients still develop rapidly (Krogstie et al. 2004 pp.223-224).

The area of wireless specific capabilities is rarely addressed in this literature. Nevertheless, a number of topics are closely related to this discussion and I could take advantage of them here. For example, challenges derived from the unique characteristics of mobile commerce have been discussed earlier (e.g. Lee and Benbasat 2003). In cases where general challenges or problems were discussed, a translation from challenges to capabilities was performed. For example, Bellotti and Bly (1996) identified the location of people as a challenge (they call it problem) for distributed collaboration. The ability to locate people represents the corresponding capability to the challenge they describe.

However, the wireless technological challenges were often discussed in relation to research (e.g. Krogstie et al. 2004). In these cases a second translation from research challenges to organizational capabilities was required. Krogstie et al. (2004) discuss security issues and protection as important challenges for the development of effective m-commerce applications. This is a typical challenge for those designing and developing the technology. In these cases capabilities were translated to organizational equivalents such as trust management in the security example above.

Finally, these three capabilities, namely spatiotemporal, radio-engineering and connectivity capability are also relevant with other types of IS and contexts, but they have special relevance when analyzed together and in connection to mobile workforces as we will see below. Note that even though connectivity capability for example can be developed through other technologies, this section focuses on the advantages derived specifically from wireless technologies.

Let us now look in more detail at each one of the capabilities presented earlier.

(i) Spatiotemporal operational capability

This capability represents the ability to use time-variable geospatial information to meet spatiotemporal challenges through the use of wireless technologies. Mobility enabling tools such as wireless information systems help to overcome physical (Krogstie et al. 2004) or geographical constraints (Article 1). The removal of geographical constraints has been identified as an important part of mobility (Abowd et al. 1997). Location theory emphasizes geography as a factor for location decisions and has been used fruitfully to describe the role of location-based mobile services (Mennecke and Strader 2001). Siau et al. (2001) define the essence of mobile commerce as the possibility of reaching customers, suppliers and employees regardless of where they are located.

According to earlier research, mobility can be spatial, temporal and contextual (Kakihara and Sorensen 2002; Lee and Benbasat 2003; Krogstie et al. 2004). This idea has been driven by the intention to broaden the understanding of technological opportunities beyond location-based benefits (Dix et al. 2000). Kakihara and Sorenssen (2002) contend that mobility is not just a matter of traveling but rather of the interactions people perform. They (ibid.) describe *spatial mobility* as the geographical movements of persons, objects, symbols in space (Kakihara and Sorensen 2002 p.2); *temporal mobility* describes each actor's interpretation of time beyond the simple desire to save time and accelerate the pace of social activities (Kakihara and Sorensen 2002 p.3); and *contextual mobility* as the way people continuously reframe their interactions with others including people's cultural background, particular situation or mood, degree of mutual recognition, etc (Kakihara and Sorensen 2002 p.5).

Lee and Banbasat (2003) also define mobile settings according to these three features. They define spatiality as the ability of consumers to roam, i.e. the ability to use different networks from different telecom providers; temporality as the access to Internet instantly and contextuality as the milieu in which users conduct their tasks. Kim et al. (2002) also adhere to this three-part separation and define the contextuality of mobility as any personal and environmental information that may influence the person when using mobile internet.

Even if this approach has opened new research avenues, a broad all-inclusive definition of mobility also has disadvantages. A number of questions were raised in the introductory chapter in relation to the concept of mobility because of terminological confusion. Does wireless mean mobile? How should we classify fixed wireless devices? But if the devices are fixed should we consider the applications as mobile instead? Is then Microsoft's exchange mail-system mobile when accessed from a stationary computer? Although a broadening of the concept of mobility may serve some purposes, we prefer a more narrow interpretation for reasons of clarity. Mobility can be defined as the ability and willingness to change or move[13]. One direct observation on this definition is that it applies primarily to the users and not to the devices. This will be further discussed in the next section about radio-engineering capability.

Given this definition of mobility, I may agree that mobility can be spatial and temporal. Spatial mobility is the most obvious one and relates to changes in geographical position. Thus a central object of analysis is *location* (Dix et al. 2000). An important distinction here is the one between place and space introduced by Harrison and Dourish (1996). We are located in space but we act in place. Therefore space is the opportunity for understanding collaboration whereas place is the understood reality. Space can be further described with either Cartesian or topological coordinates (Dix et al. 2000).

Temporal mobility is more difficult to interpret because intuitively no one can move along time. However, different tools can help us to manipulate the temporal aspects of activities. In this sense we can speak about temporal mobility, considered here as the changes or the abilities to change the temporal aspects of actions. In this sense a number of central aspects emerge as object of analysis such as duration and sequence (Barley 1988); speed and timing, etc.

However my interpretation of mobility excludes the contextual aspects mentioned earlier. In discussing contextual mobility, Kakihara and Sorenssen (2002) describe how a Post-it Note discretely placed on a desk can affect the modality of interaction between people. Their assumption is that because modern technologies influence the contextuality of interaction we are now relatively free from contextual constraints. Thus, they conclude ICT technologies give us increased contextual mobility.

In my opinion the mobility of people should solely indicate changes of spatial and/or temporal character. Other types of contextual changes apply more specifically to other contextual dimensions apart from mobility. For example, the Post-it Note described above influences the interaction context through e.g. interruptions. An interruption represents a change in the interactive context but it is less clear its relation to the mobility of people.

This does not mean that there are no other relevant contextual changes when studying wireless technologies apart from the spatiotemporal ones. But in this dissertation the mobility of users indicates contextual changes of

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[13] *Merriam-Webster's New International Dictionary*, 3rd ed., s.v. "mobility".

spatiotemporal character only (cf. Figure 16). Therefore, the argument supported here is that any type of contextual mobility can be reduced to spatiotemporal aspects, and therefore linked more tightly to the mobility concept. These distinctions are illustrated later in Figure 16.

It should also be noted that Kakihara and Sorenssen themselves in further research (cf. Kakihara and Sorensen 2004 p.184) abandon the distinction mentioned above and talk instead about locational, operational and interactional mobility of mobile professionals.

Given these clarifications, let us now proceed to describe some advantages directly derived from this operational capability, namely increased visibility, coordination and control.

One advantage derived from the spatiotemporal capability is the increased visibility of the business process affected by the wireless technology. This can be explained as follows. The adoption of wireless technologies improves a firm's infrastructure in terms of reach and range (Keen 1991b), i.e. the types of transactions made available to employees, suppliers and customers. *Reach* refers to the locations technology is capable of connecting, while *range* refers to functionality in terms of the activities that can be shared for collaboration. The level of reach and range influences business process performance in terms of reduced lead-times, flexibility, etc. Theoretically, increased reach and/or range lead to increased level of visibility for that process.

Furthermore, visibility is closely related to the management of risk and the creation of confidence (cf. Hanebeck and Tracey 2003). Normally, a particular business process' lack of visibility leads to building up buffers that introduce new delays as a result of lack of confidence. The lack of confidence in turn affects the coordination of the process.

In the cases described (cf. Article 1), the wireless information systems were implemented to address the difficulty of coordinating operating actors. The value of mobility was therefore contingent upon the costs of not being able to coordinate during the period in which actors were difficult to reach. Its benefits are also related to the costs of available substitutes for wireless technology in a business process. Therefore, wireless technology's attractiveness depends on the level of coordination required and the attractiveness of substitutes.

Wireless information systems through increased visibility, risk management and confidence creation improve the internal coordination mechanisms implemented in a particular organization. Since the very early beginnings of organizational studies, the coordination mechanisms of organizational systems have been major object of study (cf. March and Simon 1958; Lawrence and Lorsch 1967; Thompson 1967; Mintzberg 1979). Coordination is therefore at the heart of many explanations and descriptions of organizational processes.

Thompson (1967) introduced a conceptual scheme to explain the interdependencies among organizational members. He distinguishes three ways in which work can be coupled (Thompson 1967 p.54): (1) *Pooled Interdependence* where members share common resources but are otherwise independent; (2) *Sequential Interdependence* where members work in series; and (3) *Reciprocal Interdependence* where the members feed their work back and forth (see Figure 15). These three types of interdependence are gradually more difficult to coordinate because they contain increasing degrees of dependency and are therefore more costly to coordinate.

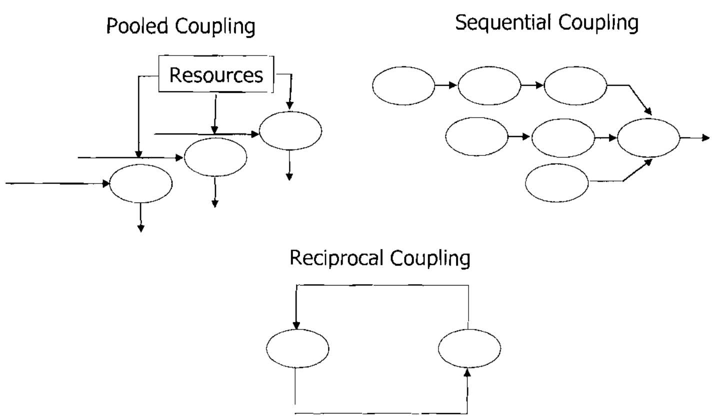

Figure 15 Interdependence in processes[14]

In a situation of interdependence different coordination mechanisms can be applied. Although the literature about such coordination mechanisms is abundant, I will describe three main mechanisms discussed by Rehme (2001). He describes standardization, plans and mutual adjustments based on Thompson (1967). Coordination is thus achieved through *standardization* applicable to stable, repetitive and few enough situations; *plans* appropriate

[14] Adapted from Robey (1986 p.187).

for more dynamic situations; and *mutual adjustment* involving the transmission of information during the process of action.

(ii) Radio-engineering operational capability

This capability refers to the ability to design wireless solutions so that user-friendly applications can be developed. This capability is the most technical one and links to the systems level in Lundeberg's analytical framework (Lundeberg 1996).

The choice of the radio-engineering capability rests on a combination of design issues (Lee and Benbasat 2003; Krogstie et al. 2004) and technology characteristics (Sarker and Wells 2003). It comprises different technological aspects of wireless information systems apart from the hard technological issues such as electrical interference management, wave latency, protocol design and the like. Thus, the term engineering in this work is associated with the technical design choices made by the implementing organizations. More specifically, it translates into the specification of the appropriate mix of attributes for a particular wireless application in terms of interface characteristics (Sarker and Wells 2003); compatibility and ease of use (Liang et al. 2003); weight, size and battery life (Kleinrock 1996); etc.

Lee and Benbasat (2003) discuss design issues for successful consumer adoption of m-commerce services. An important ability they identify is to provide task-relevant services by improving the design elements of systems. This can be done through context-aware applications that take into account some pre-defined user preferences and the terminals employed (Lee and Benbasat 2003 p.50). Although their discussion is primarily consumer oriented, the recommendations provided also apply to enterprise studies.

The fact that we are dealing with radio based technologies adds a number of constraints to the advantages derived from the implementation of this technology. These constraints can be described at two different levels of analysis, namely the logical and the physical level (Langefors 1966; Krogstie et al. 2004).

At the logical level, engineering capability consists of the ability to manage the separation between content and medium (Krogstie et al. 2004). The variety of wireless terminals available for displaying content makes difficult the design of interfaces suitable for content display. This is an important ability based on the experience that similar content will need to be displayed on a multitude of different terminals such as pagers, cell phones, personal digital assistants, portable computers, etc. This ability permits the development of user interfaces that are general enough yet also tailored for the different types of terminals.

The logical level functionalities are dependent on a number of physical constraints that are also present when working with radio based technologies. But let me first make one further terminological clarification. The term mobile has been applied indistinctly to devices, applications, users, etc. People often talk about mobile mail, mobile phones or mobile Internet. This is also the case within the research field. Kakihara and Sorenssen (2002) define spatial mobility as the geographical movements of persons, objects, symbols, etc. Krogstie et al. (2004) employ also this definition.

However, the term mobility should be reserved to the users given my earlier interpretation of mobility as the ability and willingness to change or move. Only users are capable of deciding about change. In this work the term mobile is therefore reserved for the users. In my opinion other adjectives should be used to refer to devices and terminals. For example, the term portable may be more appropriate for describing laptops than the term mobile. Other similar modifiers may be wireless, radio-based, personalized, etc. The advantage of this approach is increased clarity.

Two constraints of a physical character are discussed now, namely screen-size constraints and network management (Article 2). These are two general factors also identified by Sarker and Wells (2003) that affect the implementation of wireless applications. They call them interface characteristics and network capability.

Sarker and Wells (2003) discuss how problems with the adoption of handheld devices may impact the development of m-commerce. They trace this impact to the lack of understanding for the motivations and circumstances surrounding the use of wireless devices. As an example they mention problems with sub-menu navigation, messaging systems, etc.

Another physical constraint is the management of network characteristics. They (ibid) mention the lack of coverage as an important constraint that has to be taken care of. Another problem is the lack of interconnection between different networks that make it difficult for users to roam between different technologies. For example an important distinction is that between licensed and unlicensed spectrum-based technologies. This is mainly based on the fact that frequency is a scarce resource and licenses are often required to operate wireless systems. However, new technologies operating in unlicensed spectrum may provide much cheaper and more effective alternatives.

Summarizing, this capability represents the ability to create the right mix of attributes for the solutions developed, and a number of advantages are derived from this capability.

User friendliness is one important advantage especially considering the user group in focus for this study. Mobile workforces are often early adopters of cellular phones but late to adopt other information technologies (Brodie and Perry 2001). In addition blue collar workers represent organizational employees that use information systems decided upon by someone else in the organization. If these systems are too complex to operate, the adoption rate drops substantially and the activities are carried out differently.

The ability to separate the content and the media of a particular application may increase the ease of use and consequently the system's user acceptance. Screen size, battery time and similar aspects should be taken into account to increase the system's user friendliness.

Finally, radio technologies are expensive because they are costly to deploy. Thus, smart solutions that use synchronization and unlicensed frequency technologies may serve as *good enough* alternatives.

(iii) Connectivity operational capability

This capability is treated here as the ability to link people in order to assure feedback functions between workforces and central units in the organizations such as back-offices, call-centers, etc.

This capability represents the individual level of analysis in the framework for perceiving situations (Lundeberg 1993) mentioned earlier. More specifically connectivity here refers to the ability of wireless technologies to enhance communication and collaboration between coordinating and operating actors in the organizations (Article 1).

User connectivity is often discussed in the literature in technical terms (cf. Smith et al. 2002). It often refers to the connection alternatives between devices and radio-communication backbones. This discussion has already been touched upon in the previous section in relation to physical constraints and network management. Thus, we now will describe more personal aspects of this ability and the advantages derived from both collaboration and communication abilities.

The ability to maintain connections between the communicating objects is generically called connectivity, and it can be described as the property of being connected or the degree to which something has connections. These connections or links permit the transfer of data between devices and people, and thus increases the possibility of being linked to other people or systems for better collaboration.

Connectivity is a relative concept, and therefore depending on the type of connections used, the following types of connectivity can be identified. At a large aggregation level we may distinguish between disconnected, connected (Kleinrock 1996) and intermittent connectivity.

The use of wireless information systems influences the communication channels used to interact with other organizational members. The ability to develop and manage them results in benefits such as feedback loops.

Belloti and Bly (1996) describe a number of problems for distributed collaboration caused by the mobility of employees. In their study of collaboration between consultants in a large and successful architectural consulting firm distributed over several buildings in the U.S., they found problems such as locating people and lack of awareness. Mobility makes it hard for distributed members to stay in touch with colleagues.

These interconnection problems identified are related to one particular type of mobility modality, namely wandering. Apart from wandering, Kristoffersen and Ljungberg (2000 p.141) describe two other types of mobility modalities in relation to the mobile worker, namely traveling and visiting. They distinguish between *travelers* that perform activities while moving between different locations usually inside a vehicle; *wanderers* that perform activities while moving between different locations; and *visitors* that perform activities at different locations.

These mobility modalities can help an organization when developing the communication modes of their employees. For example, the difference between on the move and while moving help us to identify different technologies required for communication. A service technician may be satisfied with intermittent technologies as long as connectivity is assured at the point of interaction with the customer. However, a taxi driver working while moving in the taxi cab benefits from communication modes based on continuously connected systems. Thus an important part of developing this capability is the advantage of observing users through participation activities as described in Article 3.

Connectivity also presents a trade-off between freedom and supervision. The possibilities of supervision through wireless systems have a number of consequences for how users experience the use of the systems. This trade-off can be observed in the conflict between connectivity and freedom described by Mulgan (1997) as connexity. Connexity is based on interaction asymmetries. If the communication initiator seeks rapid feedback, the recipient may experience pressures or interruptions by being forced to respond. Although freedom suggests that we can decide when and to what degree we want to participate in network exchanges, work norms and expectations come increasingly in conflict with independence (Jarvenpaa et al. 2003).

Finally, the benefits of connectivity capability are related to the opportunity costs of not being able to communicate during the time when actors are difficult to locate (Article 1). It is simply the case that without wireless technology there would not be opportunities for remote interactions. This was described in Article 1 as the *price-tag-of-non-mobility,* indicating that the opportunity costs of not being able to interact determined the eventual value placed on the wireless application.

Before finalizing this section about WIS capabilities, I would like to summarize graphically the main arguments discussed in this section about mobility concepts and their relationships. This is done in Figure 16 below. The picture builds upon the definition of mobility above, and it includes the distinction between spatial and temporal mobility as attributes of context. It also shows how the concept of mobility applies primarily to the users and not to the devices and moreover indicates the nature of relationships between devices and users.

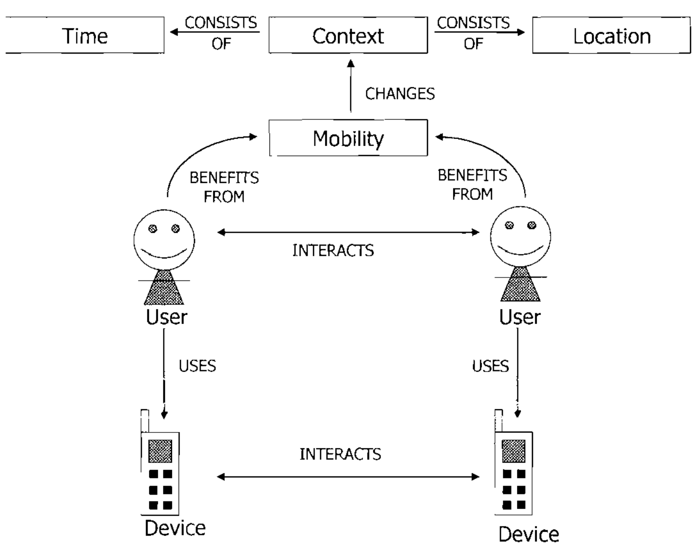

Figure 16 Mobility concepts and relations

This picture represents my interpretation of different aspects of mobility that have evolved during my research. It is a tentative mobility framework inspired in the literature and it includes insights developed during my work with the different articles. This is a product of this research and therefore these terms have not been always applied consistently in the articles included in this dissertation.

Let us now move on to consider IS implementation and innovation theories. These can help us to understand better how organizations develop sustainable advantages through internal, organizational assessment processes rather than the external factors, more popular in the environmental models from the strategic management literature (Barney 1991).

3.3 IS Innovation among Organizations

Organizational innovation has been considered a key source of competitive advantage. New ideas help organizations diversify, adapt and reinvent themselves in changing market and technical conditions. In this context it is important to be clear about where the value of technology resides. This section analyzes how firms manage the implementation of emerging technologies to achieve competitive advantages.

The implementation of information systems is considered here as an evolutionary initiative, and the way it is handled inside organizations to obtain sustainable benefits is framed as a process that I call the *organizational innovation process* (OIP). In this section this process is explored in more detail through the analysis of two different research fields, the innovation area and the IS implementation field.

The main advantages of such a combination are that innovation research (such as product diffusion studies) has focused on the early stages of this process while implementation research studies later usage aspects also. Moreover, implementation theories employ analytical methods whereas innovation recommends creative theories. Finally implementation theories use an intra-organizational perspective and diffusion studies focus on extra-organizational analysis.

There are also areas in which one of these fields is stronger than the other. For example, reviews of current innovation models suggest that there is little attention paid to the role of human factors in the process of innovation, such as the role of organizational culture (Schein 1994; Dougherty 1996; Pervaiz 1998). Socio-technical issues like user involvement have on the other hand been in focus for implementation research. Innovation research however has an accepted track record of studying pre-conditions for ongoing learning during the innovation process, which is especially important when the technology studied is flexible and reconfigurable. Implementation has sometimes been criticized for being too focused on the formal planning aspects of technological change, clearly a weakness when dealing with complex problems where outcomes cannot be always anticipated (Allen 2000).

These two different, though related, areas form a huge body of research. The successful application of different innovation theories to explain IS implementation phenomena testifies to its usefulness (Allen 2000). As it is very difficult to exhaustively cover these two areas in the limited space offered in this dissertation, I will limit the discussion to the contributions most directly linked to this study.

Finally the aim of this section is to develop a model of the OIP based on a process description, critical factors, concepts and their relationship. This model will be used for the analysis to be carried out in subsequent chapters.

3.3.1 Organizational Innovation

A great effort has gone into the study of innovation theories to scrutinize what makes different ideas successful. Innovation theory is today a well-established field that over time has developed a theoretical platform mainly concerned with the diffusion of new ideas. Within this research tradition, innovations are new ideas, objects or practices that reach acceptance through a particular diffusion process (Rogers 1995). According to Rogers (1995) diffusion is the process by which an innovation is communicated through channels over time and among members of a social system, and it is the result of this process that is called the innovation. If the concept of innovation seems to be fairly clear, the process through which an innovation arises and develops is however still subject of debate (Kautz 2000).

Many of the studies performed within the innovation area concentrate on the spread of innovations through a population of potential adopters. The objective has been to predict patterns of diffusion over time and/or space. One such example is the Diffusion of Innovation (DoI) framework (Rogers 1995). This research tradition is characterized by the study of single product-based innovations, and cumulative adoption over time has been described as an S-shaped curve. It differs from the process-oriented innovation approach (Abernathy and Utterback 1978). The former studies new products or services for a particular market whereas the latter evaluates new elements introduced into an organization's production or service operations to become increasingly effective.

Product and process innovations

This key distinction between product and process innovations has a long history within innovation studies dating back to Schumpeter (1934 p.66). Later research has also argued for a distinction of different types of innovation (e.g. Damanpour 1991; Wolfe 1994). Among others, Utterback and Abernathy (1975), Clark (1985), Rogers (1995) and Van de Ven (2000) apply the basic product-process distinction as a useful tool in their analysis.

Process innovations can be further classified according to their nature. Utterback and Abernathy (1975) introduced the distinction between technological and organizational innovations. Edquist, McKelvey and Hommen (2001 p.14) define technological process innovations as "*the use of new material goods or technologies to improve the ways of producing goods and services*". On the other hand, organizational process innovations are new ways of organizing work in order to improve the organization's efficiency. For example, increased supply chain benefits due to the implementation of a new ERP system could be considered a technical process innovation whereas Business Process Reengineering (BPR) may be classified, according to Utterback and Abernathy (1975), as an organizational innovation. For clarification purposes the taxonomy of innovations described above is depicted in Figure 17 below with the preferred choices in this dissertation highlighted.

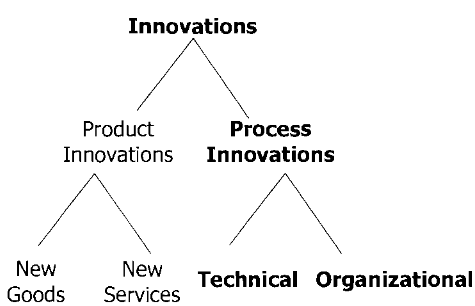

Figure 17 Topology of innovations

There are additional distinctions that will not be used here. One depends on the extent of changes originated by innovations. Damanpour (1991) underlines the difference between radical and incremental innovations based on Dewar and Dutton (1986) among others. This distinction will not be applied here as it mainly relates to the diffusion of innovations within industries (cf. Christensen and Rosenbloom 1995). Other authors use the term administrative innovations (Daft and Becker 1978; Kimberly and Evanisko 1981; Damanpour 1987) to indicate organizational structure and administrative processes directly related to the management functions in an organization. This term is similar to the organizational label used above.

Figure 17 above shows that the focus of this dissertation is both on technical and organizational innovations. The reason is that technical and organizational process innovations are very much interrelated. The primary reason for separating technical and organizational innovations is that the distinction relates to the more general dichotomy between social and technology structure (Evan 1966) and the fact that there seem to emerge two different models of decision-making in each of these groups (Daft and Becker 1978). However earlier studies show how technical innovations impact largely organizational concerns such as work practices (Markus 1983) and vice versa.

Moving up a level in Figure 17, another issue worth mentioning here is the problems that arise when operationalizing the distinction between product and process innovations. Actually, Archibugi, Evangelista and Simonetti (1994) found in a number of studies that the classifications were not being used consistently. One such problem is related to the location of the innovation. As we will see innovations are not static and may thus alter shape during their lifetime depending on their location. For example a personal digital assistant (PDA) may be a product innovation for Palm Corporation whereas part of a process innovation for a supplier of forklift trucks when integrated into the service-order process.

Clearly the implementation of wireless information systems represents a process innovation of techno-organizational character: wireless provides the technological flavor, information system the organizational complexity and it is moreover a process innovation because it impacts work practices and business processes.

Process innovations inside organizations

Most broadly, organizational innovation refers to the adoption of an idea or behavior that is new to the organization adopting it (Daft and Becker 1978 p.197). Damanpour (1991) defines organizational innovation as the adoption of an internally generated or purchased device, system, policy, program, process, product or service that is new to the adopting organization on the basis of earlier work by Daft (1982), Damanpour and Evan (1984), and Zaltman, Duncan and Holbek (1973).

Due to the complexity and the context-sensitive nature of these particular innovations (cf. Damanpour 1996), Wolfe (1994) underscored five criteria that should be addressed by organizational innovation researchers. These are (1) the preferred research stream(s) among organizational innovation studies; (2) the stage(s) within the innovation process in focus in the study; (3) the types of organizations included in the study; (4) how the outcome of the innovation is conceptualized; and (5) the attributes of the innovation (Wolfe 1994 p.406).

While agreement is present at a general level of abstraction, several parallel theories of organizational innovation co-exist (cf. Wolfe 1994; Slappendel 1996). Different comprehensive literature reviews describe several of these theories. For example, Swanson (1994) makes a review of 22 studies on IS innovation; Fichman (1992) covers 18 empirical studies including 11 beyond the list in Swanson. Slappendel (1996) divides the existing work in the field in three categories based on Pierce and Delbecq's (1977) perspectives on action. These categories are (a) the individualist, (b) the structuralist and (c) the interactive perspective. Kautz and Nielsen (2004) use these categories including a longitudinal process view from Pettigrew (1985) in order to extend the interactive perspective.

Another review made by Wolfe (1994) describes three streams which developed sequentially. First, the diffusion of innovation research (DI) addresses the diffusion of an innovation over time and space; second, the organizational innovativeness research (OI) focuses on the determinants of the innovativeness of organizations; and last, the process-theory research (PT) addresses the process of innovation within organizations.

More recently, Baskerville and Pris-Heje (2001) selected three different models (interactive model, the chain-linked model and the emergent model) in order to represent two underlying views representative of the diffusion of organizational innovations. These are based on the dichotomy between conflict and competition as opposed to consensus and regulation. Their two views are described as the genealogical and the ecological view. The first view applies a micro perspective whereas the latter a macro-meso perspective on the phenomenon.

Slappendel (1996)	*Wolfe (1994)*	*Baskerville and Pris-Heje (2001)*
Individualist Perspective	Diffusion of Innovation Research (DI)	The Genealogical View
Structuralist Perspective	Organizational Innovativeness Research (OI)	The Ecological View
Interactive Perspective	Process Theory Research (PT)	

Table 7 Research streams among organizational innovation studies

This dissertation applies primarily a genealogical view, based on a micro perspective and focusing on the process inside organizations according to Wolfe's (1994) process-theory research (PT). We are interested in the process of innovations and not in the determinants of innovativeness (OI), nor the diffusion of an innovation over time and space (DI).

Finally, process-theory research on organizational innovation has developed a number of stage models that identify the sequences of events that occur during the technology implementation process. In these models organizational innovation encompasses a process that includes the generation, development and introduction of new ideas or work practices within organizations (Damanpour 1991 p.556).

This issue will be treated in more detail in Section 3.3.3 about stage models, but one such model is the organizational innovation process described by Rogers (1995) that distinguishes a typical sequence of five stages: two in the initiation sub-process and three in the introduction one. These are agenda setting, matching, restructuring, clarifying and routinizing.

According to the innovation literature, implementation is considered one of the last steps of the process of innovation. However implementation has a central role for the whole organizational innovation process. Often innovation benefits are gained only if implementation has a positive outcome (Linton 2002 p.67). Klein and Sorra (1996 p.1057) call implementation as the critical gateway between the decision to adopt and the routine use of an innovation. So, let us now consider the field of implementation of information systems in more detail.

3.3.2 IS Implementation

There is a body of research on the implementation of technology that has been identified since the 1960s (e.g. Schultz and Slevin 1975; Doktor, Schultz and Slevin 1979; Schultz and Ginzberg 1984). More specifically information systems (IS) implementation is a field of scholarly research undertaken to develop a better understanding of IS implementation problems and how these can be resolved (e.g. Schultz and Slevin 1975; Doktor et al. 1979; Markus 1983; Schultz and Ginzberg 1984; Kwon and Zmud 1987; Eason 1988; Cooper and Zmud 1990; Davenport 2000; Robey et al. 2002).

IS implementation is truly a multidisciplinary subject. The research field has grown out of a number of related areas (cf. Bjørn-Andersen, Henriksen and Larsen 2003) such as the implementation of operations research/ management science (Schultz and Slevin 1975; Doktor et al. 1979); information systems development (Eason 1988; Avison and Fitzgerald 1995); and innovation research (Klein and Sorra 1996; Linton 2002). Schultz and Slevin (1975) explain that the implementation process can be treated as a special case of the process of management innovation and organizational change (ibid p.3).

Therefore, there are different designations for the same phenomenon such as the implementation of innovations (Klein and Sorra 1996; Linton 2002), IT implementation (Cooper and Zmud 1990), IS implementation (Kwon and Zmud 1987), ERP implementation (Parr and Shanks 2000; Robey et al. 2002), etc.

All these have a common denominator, namely the word implementation. There exist different views about what implementation is and is not (cf. Table 8). In this dissertation, implementation is considered in its broader meaning as the process of putting an information system to use within an organization. This process is denominated briefly as the organizational innovation process if sustainable advantages are obtained through the development of capabilities.

Implementation
[1] A problem involving human participants, social interaction, organizational structure and management change, in short a complex behavioral process (Schultz and Slevin 1975 p.8)
[2] An organizational effort to diffuse an appropriate information technology within a user community (Kwon and Zmud 1987 p.231)
[3] A dynamic process of mutual adaptation, i.e. the re-invention of the technology and the simultaneous adaptation of the organization (Leonard-Barton 1988 p.253)
[4] The acid test or the critical phase within the process of embedding an information technology system in the organization (Eason 1988 p.157)
[5] An organizational effort directed toward diffusing appropriate information technology within a user community (Cooper and Zmud 1990 p.124)
[6] An IT application being developed, installed and maintained; organizational procedures are revised and developed; organization members are trained both in the new procedures and in the new IT application (Hong and Kim 2002 p.27)
[7] One of the last steps in user based and dual-process models of the innovation process (Linton 2002 p.65)

Table 8 Implementation defined

After the mid 1960s, serious attention began to be directed towards understanding the reasons behind IS successes and failures (Kwon and Zmud 1987). Implementation became a very popular field during the 1980s among IS researchers. In this research field, the origins of IS implementation can be traced back to the analysis of systems development, also called Information Systems Development or simply ISD (Avison and Fitzgerald 2003). As the area matured, some system-development researchers started to pay more attention to issues on system implementation partly because the integration of standard application packages replaced the in-house development of applications[15]. After a partial slowdown, it took off again when the implementation of standard software packages like ERP systems became more and more popular. In short, later IS implementation research has focused on specific software applications such as Decision Support Systems

[15] Although it could be interesting to look in more detail into the system development area, we assume it is usually carried out outside the implementing organization and therefore we focus on system implementation instead.

(Ramaprasad 1987), Electronic Data Interchange (Iacovou, Benbasat and Dexter 1995), Enterprise Resource Planning (Markus et al. 2000; Robey et al. 2002), etc.

Research paradigms

Based on Mohr's work (1982), Robey et al. (2002) organize their review of academic research on implementation around variance and process based paradigms. Their conclusion is that variance studies offer limited insights because they lack a theoretical framework that adequately explains why the investigated project and business outcomes occur (Robey et al. 2002 p.19).

Although I share their opinion that more process-based research is needed, variance research, such as factor studies, can likewise contribute to the body of knowledge within implementation research. Although some of these factors have been adopted as general and always valid, the position taken here is to consider these as a starting point for the analysis of capabilities utilized later on. Taken less seriously than in many variance studies, these factors represent good hints about where to start looking for organizational challenges. Thus both process research and variance-based paradigms will be described in this and the next section on stage models.

Implementation risks

The implementation of IS has become a single body of research partly because of the difficulties and problems that accompany implementation efforts. Eason (1988 p.11) compares IS implementation to a human organ transplant. The range of outcomes is similar in that if the implementation is successful, it will enhance the effectiveness of the organization. However, if the process fails, the outcome becomes the rejection of the system.

Difficulties often plague implementation initiatives (cf. Sumner 2000). Although companies spend millions on both the packages and the implementation process, there is some evidence that companies experience considerable problems, particularly during the actual implementation project (cf. Parr and Shanks 2000 p.289). Some of the researchers that consider implementation as a phase within a larger change process call it the critical phase. Eason (1988) writes:

> *"Many times has the enthusiasm of those engaged in the design been washed away in the fear and resistance of those who were to use the system. Implementation is the acid test in many ways" (Eason 1988 p.157).*

The popular literature such as Fortune, Infoweek, Computerworld, etc. contains numerous stories which describe ERP implementations in colorful terms such as 'endurance tests', 'fiascos', 'living to tell about it' and 'war stories' (Tebbe 1997; Horwitt 1998; Martin 1998; Stedman 1998).

There is a body of research that has focused on the antecedent conditions that explain the successful implementation of information systems. Most of these studies develop a number of critical success factors. They have sometimes been called implementation factors (e.g. Bjørn-Andersen et al. 2003), critical success factors (e.g. Hong and Kim 2002) or simply risk factors (e.g. Sumner 2000). Appendix 1 summarizes the discussion included in this section about all these factors grouped in clusters. Here we will only discuss the references more directly linked to this work.

The division of factors into organizational factors, technological factors, human factors and others (cf. Appendix 1) can be compared to Kwon and Zmud's work (1987). They reviewed both empirical and non-empirical studies to organize existing knowledge about key forces contributing to successful efforts to introduce technological innovations into organizations. They divide existing factors into five groups according to the constituent elements of Leavitt's (1965) organizational model. The choice of cluster factors in this dissertation is similar except for the exclusion of task-related factors as a cluster. These factors are included in the project-management section instead. In addition, structural factors are labeled here organizational factors. Worth highlighting are the *role involvement* factor included in the individual-factors group and defined as the attitude of users towards change; *complexity* defined as the difficulty of users understanding and using the innovation; and *uncertainty* related to the variability of organizational environments (Kwon and Zmud 1987 p.233ff).

People's resistance to change has also been an important obstacle for successful implementations of information systems (Markus 1983). Different motives for resisting change have been identified in earlier research such as inadequate technical design, cognitive stiles, interaction of system with division labor, etc. For example (Keen 1981) captures the active nature of users' reactions in what he calls *counter implementation strategies*. Some of these are lay-low, rely on inertia, keep the project complex, minimize the implementer's legitimacy and influence, exploit their lack of inside knowledge, etc. Another example that studies individual's technology adoption within organizations is the Technology Acceptance Model (TAM). This framework aims at predicting information system acceptance and diagnostics of design problems before users experience the system. TAM identified two main attributes of IT technology to become accepted by individuals within organizations: usefulness and ease of use (Davis 1989).

Linton (2002) organizes the main success factors in a model with technology, organization and individual implementer as general factor clusters (Linton 2002 Figure 2). This is based on his in-depth review of current knowledge within the implementation literature. Four additional subgroups of factors include divisibility, complexity, social interactions and project management.

Linton's list (Linton 2002 Table 1) shows the variety of approaches taken. The list includes aspects such as fidelity of implementation, workflow integration, operational effectiveness, flexibility, economic performance, etc. He considers this list a source of inspiration and encourages its use through adaptation to the particular implementation case.

Linton's enumeration, based on earlier publications, is interesting although I would like to express my doubts about the viability of his proposal to resolve the ambiguity about what determines a successful implementation and not. I find it hard to accept his statement that "*measures [of successful implementations] should have sufficient generality to be used across most innovations and be acceptable to practitioners and academics*" (Linton 2002 p.67).

Robey et al. (2002) divide earlier research on the basis of definitions of success. Some researchers define success in terms of project management metrics such as meeting deadlines, working with budgets, relationship between project members, etc., and others define success in business benefits terms (reduced inventory, decreased labor costs, faster financial closes, etc.). Additional factors they found were top management support, effective project team and organization-wide commitment (Robey et al. 2002 p.20).

Hong and Kim (2002) describe organizational misfit, i.e. the incongruence between the original artifact and its organizational context as a critical factor when introducing IS, such as an ERP system, into organizations. This may very well be the case because of knowledge barriers. Robey et al. (2002) describe knowledge barriers as another type of obstacles when implementing ERP systems. System implementations challenge existing knowledge because they require firms to re-configure and assimilate new business processes and management structures.

Eason (1988) described the complexity of benefit identification. He presents a number of different technology benefits that are achievable at different organizational levels (Eason 1988 p.13 Figure 2.2). Benefits are aligned along a continuum from resource reduction to work enhancement. He groups the benefits into four types: cost savings, improved productivity, improved support and organizational enhancement. While cost savings represent the more tangible type of benefits, organizational enhancement (the last group) falls at the other end of the scale, namely the intangible benefits side. A similar idea about the IT value that dilutes at different levels in the organization being difficult to track was picked up and further explained in Weill and Broadbent (1998 p.65).

Finally, the work done by Feeny and Willcocks (1998) has similarities with this one although it is not mainly an IS implementation study. Feeny and Willcocks (1998) identified three challenges or risks in exploiting IT: (a) the challenge to address the need for two-way strategic alignment between business and technology – what technology can do and how to use it; (b) the challenge to deliver IS services at low cost and high quality – sourcing strategies; and (c) the challenge to shorten the design of IT architectures. Similar to this work, they develop nine capabilities out of these challenges.

Given the factor-based approach to implementation success described above, let us now move on to consider some source of other, softer influences developed within the socio-technical perspective explained in more detail in the next section.

Socio-technical approach

Unfortunately there is still evidence to suggest that organizational issues are not properly treated during the systems implementation process (Eason 1988; Hornby et al. 1992; Clegg et al. 1997). The socio-technical systems (STS) approach[16] represents a research stream within information systems development that has discussed implementation widely and has tried to incorporate such issues into its research methodology. This type of research shares many common features with this dissertation in that the increasing

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[16] I would like to make a distinction between different types of socio-technical perspectives. To make this distinction clear I subscribe to Lamb et al.'s division of different research traditions within the socio-technical field (Lamb, Sawyer and Kling 2000 p.1613). They divide these research traditions into two groups: (a) the social-shaping-of-technology (SST) approach (Williams and Edge 1996) and the tradition used in this dissertation (b) the Tavistock Institute's Socio-Technical Systems (STS) perspective (Cherns 1976; Eason 1988; Mumford 1995; Mumford 2000). A similar distinction is made in Kling, McKim and King (2003 e.g. Table 2 p.55) though the focus in their article is on the SST approach instead of STS.

interconnection between the social and the technical aspects of our world is highlighted through the potential value of conceptualizing such arrangements as socio-technical systems (Lamb et al. 2000).

The socio-technical systems (STS) approach, which emphasizes workplace interactions with various technologies, refers mainly to the interactions between people, organizations, institutions and a range of technologies in rather intricate arrangements in which what is social and what is technical cannot be isolated in practice (Lamb et al. 2000).

The STS research approach has its roots back in the 1940s. The main idea developed within this research stream is that the most effective work system is not the one with the most efficient technical features, but the one with the best balance of the technical and the social characteristics. The automation in the Welsh coal mines represents one of the earliest applications of socio-technical systems analysis. The automation in the mines resulted in a decrease, not an increase, in productivity (Scott et al. 1963).

Socio-technical design was founded in the Tavistock Institute of Human Relations in 1946 to bring together the psychological and social sciences in a way that benefited society (Mumford 2000 p.33). The socio-technical theory was first applied in the Scandinavian countries. Although different approaches were implemented in Norway, Sweden and Denmark, many similarities can be found (Cooper and Mumford 1979). As Mumford (2000 p.34) puts it, socio-technical theory was developed so that human needs would not be forgotten when technical systems are introduced. Some of the key assumptions in socio-technical approach are:

1. Introduction of technology changes the entire work system of an organization. Therefore you should design the new work system first and then design the technology to accomplish the desired change,

2. Technology is only cost effective if it fundamentally changes the work system to reduce non-value-added work and increase the productivity of the outcomes of the organization, and

3. Technically efficient tools are not the goal; implementing new technologies means revising the total work system that enables productive workers.

The concept of occupational community (Gerstl 1961) can be used to describe workplace interactions, as in the STS approach because both are based on exchanges between different groups of people engaged in the same sort of work [17]. This is interesting because blue collar workers can be described as one such community.

Van Maanen and Barley (1984) defined an occupational community as a group of people who consider themselves engaged in the same sort of work, whose identity is drawn from their work, who share with one another a set of values, norms and perspectives that apply and extend beyond work related matters and whose social relationships meld work and leisure (Van Maanen and Barley 1984 p.287). In this regard occupational communities can be understood as a type of intra-organizational distributed networks of practice (Teigland 2003).

As discussed by Teigland (2003), the early research on occupational communities developed an understanding of the problems of social conflict and organizational control at work (Gerstl 1961; Salaman 1974; Hill 1981). This research often described the power struggle between management and occupational communities (Hill 1981) and sometimes in a negative light (Van Maanen and Barley 1984).

Involvement and initiative are also discussed in relation to occupational communities (e.g. Salaman 1974 p.120). Involvement is often described as a positive attitude towards work and as such a valuable and meaningful characteristic to be promoted among occupational communities. However, the power struggle between management and occupational communities can sometimes affect involvement negatively. This is for example manifested in the way work is evaluated. Often the work tasks must be seen as important, valuable and meaningful by other people than members of the occupation itself.

A more positive approach to occupational communities has been developed in research about networks of practice (Teigland 2003), where membership and knowledge management have been in focus rather than power struggles. In addition, there have been few studies that have investigated how factory work is influenced by computer technologies and its impact on the related occupational communities (Barley 1996 p.408). One exception is Lawrence (1998), who investigated membership in networks of practice by analyzing a small Canadian Forensic community, where membership was discussed in terms of both formal and informal rules.

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[17] For an early and thorough review of the literature about occupational communities see Salaman (1974 Chapter 2).

All the examples of blue collar workers in this study, taxi drivers, field technicians and forest machine operators, represent members of different occupational communities. These occupational communities create unique work cultures consisting of, among other things, task rituals, standards for proper and improper behavior, work codes surrounding relatively routine practices and compelling accounts attesting to the logic and value of these rituals, standards and codes (Van Maanen and Barley 1984).

Furthermore, the analysis of workplace interactions with various technologies requires an analysis of cross-community interactions. Often language and perspective barriers occur between different communities resulting in communication difficulties between them. Carlile (2002) in a study of the car-manufacturing industry showed how knowledge that is situated in local practice (such as occupational communities) becomes problematic when transferred across functional boundaries. He explained how *boundary objects* facilitated the process. In 1989, Star and Griesemer (1989) introduced the term boundary object to describe information that is used in different ways by different communities of practice. Boundary objects can be artifacts, documents and even vocabulary that help people from different communities build a shared understanding. Bechky (2003) performed an ethnographic study of an American high-technology organization and found that artifacts were used to mediate across occupational boundaries during episodes of problem solving. When problems arose in the building process, both drawings and machines were used as boundary objects between occupational communities to help solve them.

Boundary objects facilitate the communication process by making problems concrete. Within the community of Information Management researchers, academics have started to use boundary objects to explain the transferring of data and mobilize action (Briers and Chua 2001; Pawlowski and Robey 2004; Levina and Vaast 2005). Earlier studies have looked at different types of boundary objects such as information systems (Pawlowski and Robey 2004), Intranet-based FAQ (Levina and Vaast 2005), document archives and ideas (Briers and Chua 2001), etc. Many of these studies have looked into intangible objects such as software applications. In this study we concentrate on the use of the mobile terminals, i.e. hardware artifacts, to understand the interactions between different occupational communities.

Before finalizing this section it would be honest to indicate that a number of critics of the socio-technical systems research have also grown throughout the years. One of the criticisms that has been raised is that the approach is more management oriented than truly user centered (Ehn 1988). Another issue is the overly simplistic view of job satisfaction (Dillon and Morris

1996). However success in shifting focus away from financial and technical issues when implementing technical systems has been one of the main achievements of this approach (Dillon and Morris 1996 p.17).

Implementation strategies

We shall finish this section by describing a number of implementation strategies that can be applied when introducing technologies into organizations. Earlier research has identified a number of strategies and their advantages and disadvantages. Eason (1988; 1993) describes five different strategies for implementing new information systems. These are big-bang approach, parallel running, phased introduction, trials and dissemination, and finally infrastructure and incremental application (Eason 1988 p.158ff). These are summarized in Table 9 and will be described here.

Big Bang: One of the most difficult kinds of implementation is to discontinue an existing system in its entirety at the end of one day, and replace it with a new system on the following day. Although this ensures that the implementation takes place, it requires extra resources and meticulous planning.

Parallel Running: One way of minimizing the risks of an instant changeover is to introduce the new system alongside the old one, and to run them in parallel until everyone is confident that the new system will be effective. The backup alternative is always present but this is a costly alternative.

Phased Introduction: The problems of making massive changes can be eased by phasing in the changes over a period of time. Either the functionality of the technical system is introduced in phases or the system is introduced in different parts of the organization at different times. A combination of these two approaches can also be used. In the first case users cope with change little at a time.

Trials and Dissemination: This strategy focuses on small-scale implementations to test the system gradually. It explicitly recognizes that there will be problems, and by holding a major trial or pilot project before embarking upon full-scale implementation the risks are minimized.

Incremental Evolution: The growing sophistication and flexibility of technology is making this strategy an increasingly practical proposition. The more evolutionary the approach, the more time the users have to adjust, but it is also increasingly likely that the momentum of the project is lost.

Strategy	*Definition*	*Suitability*	*Pros*	*Cons*
Big Bang	Instant changeover	Required when critical mass argument is vital	• Integrated and centrally managed way of insuring that implementation takes place	• Requires meticulous planning • Needs extra resources before and after the change
Parallel Running	Run the old system alongside with the new	Minimize big-bang risks	• Controlled migration • Backup alternative always present • Provides an insurance policy against failure	• Extra resources are essential • Motivational problems if staff make comparisons • Inhibit organizational change • Costly alternative
Phased Introduction	Introduction over a period of time	System built modularly with independent parts	• Technical staff can concentrate on the system • Users cope with change a little at a time	• Familiarity to implementation team may blind them from new user needs
Trials and Dissemination	Small-scale implementations to test the system for live working	Need to test the technical system	• Once tested dissemination much easier	• Lessons from a trial cannot be easily transferred to new groups
Infrastructure and Incremental Application	Evolutionary and user-led process which mixes design and implementation	Used where a failure to match needs exactly leads to system rejection	• User involvement resulting in user-led applications	• May turn into long, part-time activity

Table 9 Implementation strategies

Common to all these alternatives is that they represent strategies for managing change. It should be noted that these strategies are not mutually exclusive and that different parts of an implementation project may combine different alternatives given the requirements. Often factors endogenous to the project impose the selection of a particular strategy, and not always the most suitable one.

3.3.3 Stage Models

Unlike *variance research*, which speculates about critical success factors and the effects of IS implementation, *process research* seeks to explain how change emerges, develops, and diminishes over time (Newman and Robey 1992; Poole et al. 2000; Robey et al. 2002). Descriptions using process theories often rely on the narrative of events that relate what led to what (Poole et al. 2000 p.13).

Process-based research on technology implementation has developed a number of different approaches trying to characterize the implementation process as a sequence of generic stages. This approach has thus received the name of stage models (cf. Earl 1989 p.28). In my view, two main forces have driven the development of stage models, namely (1) the research area that has come to be known as the systems-development life cycle and (2) the development of stages related to technology management and organizational innovation. Let us explain these in more detail below.

(i) Systems development life cycle

The first force, that of systems-development life cycles, goes back to the 1970s. Avison and Fitzgerald (2003) call this period the early methodology era. During this period focus was placed on building computer-based applications based on a number of stages[18]. These stages often represented the system's life cycle. The aim was to better control the management of the development of information systems. One of these models came to be known as the waterfall model (Boehm 1976). Although not directly implementation research oriented, it is often brought up as an example of a stage model approach. It is a methodology that goes through seven steps from documenting the system concept to deployment and its operation (Boehm 1981).

However the waterfall model has been strongly criticized for a number of reasons (Avison and Fitzgerald 1995). The main limitations have been the failure to meet the real need of business due to the focus on technological improvements of the systems; lack of flexibility when design changes are required during the development process because of modifications in business processes; user dissatisfaction caused by the impossibility of seeing the system before it is operational (e.g. Avison and Fitzgerald 1995 p.30ff), etc.

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[18] The different models are compiled in Appendix 2 for better overview.

As a result, the software development community has experimented with a number of alternative approaches. During the late 1980s and early 1990s, a number of stage methodologies emerged and Avison and Fitzgerald (2003) have classified them into different groups. These newer methodologies have tried either to expand the scope of analysis to fill various gaps, or to blend together a number of themes into one methodology. However, many of these approaches still do have a number of limitations because they come from application-solution vendors or consultancy companies (Avison and Fitzgerald 2003).

In my opinion the main problem with all these approaches lies in the underlying epistemology that drives the application and use of the methodologies in very unambiguous and standardized ways. This is in line with Avison and Fitzgerald's (2003 p.80) definition of methodologies as "*recommended collection of phases, procedures, rules, techniques, tools, documentation, management and training used to develop a system*". The problem is not the conceptualization of software development based on the life cycle of the systems because in a number of cases these methodologies have guided the division of projects into phases of manageable tasks and thus helped to avoid their escalation. The problem has been the operationalization of underlying philosophical ideas consisting of ontological and epistemological assumptions into a set of prescriptions and guidelines that recognize as always valid and applicable particular methods or techniques.

The alternative proposed here is to consider these approaches not as methodologies where recommendations can lead to prescriptive ways of performing system implementations, but as models or frameworks, i.e. simplifications of reality that aim principally at conceptual clarity. Stage models considered as theoretical models instead of methodologies represent conceptual schemes that can help us to understand how processes unfold. The dividing line between these two approaches lies along the continuum of descriptive and prescriptive character of the approaches. Stage models in this study are therefore treated as models in first place. Such models aim principally at conceptual clarity by bringing special attention to stages relevant for the particular process. They do not try to identify stages that are right nor wrong (always and everywhere) because IS implementations vary depending on the organizational context where applied.

One such descriptive model was introduced in 1974. Gibson and Nolan (1974) published a seminal article describing a framework for managing data processing in terms of four distinct phases of development. They discovered that across different companies, expenditures on data processing systems followed an S-curve over time. The curve seemed to represent a path of organizational learning. This path could be described as a four stage model: (1) the initiation stage; (2) the contagion phase; (3) the control stage; and finally (4) the maturity phase, where the organization becomes as confident in managing computer resources as other resources.

There are three key articles, based on Gibson and Nolan (1974) above, in which McFarlan set out his ideas about stages of growth in IS/IT within organizations (McKenney and McFarlan 1982; McFarlan and McKenney 1983; McFarlan, McKenney and Pyburn 1983). In addition to the four phases McKenney and McFarlan describe in these articles (McKenney and McFarlan 1982 Exhibit IV), they also describe three possible stagnations representing technology assimilation pitfalls along the process (cf. Appendix 2). They are explained in the article as the result of mismanagement of the technology-assimilation processes.

Other examples of descriptive stage models focusing on the system's life cycle are Nilsson (1991 p.53ff. Figure 2.4), Andersen (1991 p.45) and Thodenius (2005 p.155 Figure 40). Worth noting in the first two models is the presence of a final stage in the model called abandonment or phase-out of systems (cf. Appendix 2). Stage models do not usually consider this step, and they normally end their description at the system usage phase (e.g. Eason 1988; Cooper and Zmud 1990; Clark et al. 1992). In Nilsson (1991) and Andersen (1991) however the abandonment phase is considered a terminal state. This is quite natural due to the underlying assumptions of the life cycle approach.

An alternative to considering the abandonment phase as a terminal state could be to consider the process as a continuous enhancement of existing systems. One such approach is the recent effort within the field of systems-design methodologies called the incremental or evolutionary approach (see Avison and Fitzgerald 2003 p.81). One example is the dynamic systems development method (Stapleton 1997) that focuses on enhancing previous versions of systems rather than developing new systems every time. It addresses the problem of changing requirements throughout the process and aims at reducing the time needed to develop a system.

Other treatments of the abandonment phase as a continuous enhancement include Swanson and Dans (2000) who discuss renewal indirectly when elaborating on the expected end life of systems as part of a company's maintenance efforts. Based on Zvegintzov (1984) they describe five reasons for replacing a system: (1) it is no longer needed; (2) no longer runs on its hardware; (3) hardware replaced; (4) not adapted to changed real-world conditions; and (5) superior alternative software has been developed.

However they state that research on retirement and replacement is still scant (Swanson and Dans 2000 p.278).

Finally, Thodenius' model (2005), although more specifically focused on a particular type of system and using the organization as the unit of analysis, manages to stress the importance of recurrent stages in contrast to the linear character of earlier approaches.

(ii) Technology management and organizational innovation

The other important force that emphasizes the development of stage models comes from the organizational innovation research area and more specifically from the fields of managing information technology and diffusion of innovations (cf. Appendix 2).

Innovation may be considered an organizational process with various stages or phases. Thompson (1965) defines innovation as a three-stage process consisting of generation, acceptance and implementation. New ideas within an organization increase the pressure to change due to envisioned opportunities. Next, a decision to invest resources is evaluated and, if accepted, implementation is carried out, including development and installation. This model is representative of the literature and conceptually economic (Pierce and Delbecq 1977; Kwon and Zmud 1987; Swanson 1994)[19].

There exist other models that develop and investigate each step in more detail. Cooper and Zmud's model of the IT-implementation process (Cooper and Zmud 1990) is one such model often cited in the literature (Swanson 1994; Bjørn-Andersen et al. 2003; Banker and Kauffman 2004; Kautz and Nielsen 2004).

This model is based on earlier work done by Kwon and Zmud (1987) based in turn on Lewin's (1952) change model, and it consists of six different stages (Cooper and Zmud 1990 p.124)[20]:

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[19] It is worth observing that Pierce and Delbecq (1977 p.29) use initiation instead of generation and adoption instead of acceptance. This nomenclature has sometimes been wrongly ascribed to Thompson (e.g. Swanson 1994 p.1071). However, for simplicity and due to the fact that the content of each phase remains the same we will also adopt it.

[20] Note that in this work we focus on the processual aspects of Cooper and Zmud's model (1990).

- Initiation: Active and passive scanning of organizational problems/opportunities and IT solutions is undertaken. Pressure to change evolves from either organizational needs (pull), technological innovation (push) or both.
- Adoption: This step comprises the rational and political negotiations to get organizational support for the implementation of the IT application.
- Adaptation: The IT application is developed, installed and maintained, and organizational work practices are revised and developed. Organizational members have to be trained in the new procedures.
- Acceptance: When the IT application is put to work, commitment to its usage has to be achieved among the users.
- Routinization: Usage is encouraged as a normal activity, and the artifact is not any longer considered as something out of ordinary.
- Infusion: Finally larger effectiveness is achieved by more integrated use within the organization.

These stages can be contrasted with the model developed by Rogers (1995) from the organizational innovation research field. Apart from the less significant fact that Rogers' model consists of one stage less, it is worth noting that Cooper and Zmud's (1990) adoption stage is labeled by Rogers as *matching*, in my opinion a better description of the logic behind this stage. Matching describes more accurately the dynamic character of the process for contextualizing technological opportunities inside organizations. Moreover the use of a gerund better describes the processual character of the stage.

Furthermore, Rogers' stage one and two (agenda setting and matching) can be included into Cooper and Zmud's initiation stage. This distinction between initiation and later stages is moreover consistent with Zaltman, Duncan and Holbeck (1973) two-stage adoption process. This represents one of the pioneering studies within organizational innovation that emphasized the importance of the process prior investment decision. They studied the process prior the decision to implement an innovation and found that the adoption process occurs in two stages: a firm-level decision to implement the innovation (primary adoption) followed by the actual introduction of the system, which includes individual adoption by users (secondary adoption).

Rogers describes this toll gate between primary and secondary adoption as a *watershed*. This idea is compelling because without investment approval the symbolic planning will never take off. Moreover, the idea of watersheds reinforces McKenney and McFarlan's (1982) concept of stagnation of technology assimilation processes. These watersheds represent pitfalls that can kill the process. Thus, for our purposes, Thompson's second phase will be re-labeled as *investment approval*.

Putting all these different pieces together offers a first attempt to conceptualize the stages of the organizational innovation process, which is presented in the table below. Note that the framework distinguishes between two different types of stages. The term *phases* will be used to refer to the more general steps of the organizational innovation process and the term *stages* to the steps within each phase. These phases are, in turn, separated by watersheds. Another distinction is that nouns name phases whereas gerunds identify stages to express action. Finally the watershed between the phases or stages is called here a *step* to reinforce the character of necessity from one phase to the next one. These terms will be used consistently throughout this dissertation.

It should be added that an intuitive phase that follows the infusion phase is maintenance. This phase has been considered in earlier research as well. For example Swanson (1999) describes maintenance as the corrective, adaptive and perfective activities after the installation of an information system (ibid p.66). We will discuss some maintenance aspects in relation to the renewal phase described later. However there have been few discussions of these issues during the data gathering process and as this phase is less central to the notion of innovation it will not be in focus for this study. Though, this does not mean that this phase is less important.

Phase	Stage	Description
I. Initiation	Agenda Setting	Organizational problems or technological opportunities increase the pressure for change. An awareness process develops that tries to contextualize opportunities of particular emerging technologies into the organizational setting.
	Matching	This step comprises some kind of match between an IT solution and its application in the organization. Negotiations to get organizational support and efforts to choose suppliers and system integrators are undertaken.
II. Investment Approval (watershed)		
III. Introduction	Redefining	A project structure is established. The organizational work practices are revised and the IT-application is developed and installed. Finally the IT application is put to work.
	Accepting	The IT application is available in the organization. Commitment to usage of the IT-application has to be achieved. Organizational members have to be trained in the new procedures.
	Routinizing	Usage is encouraged as a normal activity, and different types of evaluation are performed to check for achievements and new roles in the organization. Finally the artifact is no longer considered as something out of ordinary.
	Infusing	The application is squeezed and incremental improvements are made to fine tune the application. More integrated use within the organization is achieved leading to a higher potential of the IT application through different system-maintenance activities.

Table 10 General phases and stages of organizational innovation processes

Finally, I would like to point to a third group of more recently developed models strongly influenced by both forces described previously. These models cope directly with the implementation of Enterprise Resource Systems (ERP). See Parr and Shanks (2000), Markus, Tanis and van Fenema (2000), Hong and Kim (2002), Gefen (2004), etc. One difference compared with early life cycle models is that these models have tried to improve the quality of the development process instead of focusing on the improvement of the end systems. These systems often consist of standard packages and the modifications of the systems are therefore limited. Instead the efforts are orientated towards the implementation process itself.

Thus ERP systems, being a popular type of information system, have been object of study from a stage model perspective. Researchers have described ERP implementation with different models having three (Bhattacherjee 2000) to five (Ross and Vitale 2000) stages (cf. Appendix 2). Common for these models is that they recognize that firms have a planning stage, an implementation stage, a stabilization phase, and a stage in which new systems are maintained and improved, and old systems are retired. Worth noting is the description of the dip phenomenon in Ross and Vitale's (2000) model. It follows from their description that the implementation phase is likely to cause an initial dip in organizational performance (Hopwood 1979), that is, a temporary impairment of performance and reduction of output immediately after the change is introduced.

Concepts and relationships

Although adoption has been the central object of scrutiny in implementation studies and diffusion the main object of analysis in innovation studies, different researchers have focused on different stages of the process. These terms have in addition meant different things to different researchers (Wolfe 1994). For example, in a number of adoption studies, Daft and Becker (1978) studied the number of innovations adopted, Damanpour and Evan (1984) the number implemented and Zmud (1984) the extent of innovation implementation.

There is an ongoing debate about the very concepts of transfer, diffusion, implementation, etc. Several authors have signaled that technology diffusion is but an aspect of a broader process (Sullivan Jr 1985; Damsgaard, Rogaczewski and Lyytinen 1994; Heidtman 1994; Lien 1995; Veryard 1995). McMaster (1997) explains the innovation process as *technology transfer*. Lien (1995) describes the process of technology transfer as a part of a technology chain through which innovation moves. However, she makes a distinction between transfer and diffusion. According to her, technology transfer is considered a supply driven movement of technology whereas diffusion is driven in a complementary way on the demand side. Heidtman (1994) prefers to use the term technology transition instead of transfer when describing the process of institutionalizing new tools, techniques or approaches in organizations. Damsgaard et al. (1994) use another term to describe the process of information technology uptake through and in organizations, namely *penetration*. Veryard (1995) also describes the notion of penetration but critically points out that penetration only describes one-way influence. Thus he favors the concept of *adaptation*.

A general observation is that the multitude of concepts in the area shows a fruitful heterogeneity (Kautz 2000) but underscores the general opinion that the results are somehow fragmented (Kwon and Zmud 1987; Klein and Sorra 1996; Linton 2002). Within the International Federation for Information Processing (IFIP) WG 8.6 these concepts are often debated. Kautz (2002) writes in the foreword to the proceedings of the fifth international WG 8.6 working conference held in Sydney (Australia) that:

> *"The contributions to the conference triggered discussions about the very concepts of transfer and diffusion, adoption and implementation that are at the core of the group's work, both conceptually and empirically. Even after 9 years the group still has a lively, controversial debate with regard to these ideas" (Kautz 2002 p.vii).*

The same idea recurs in an interim review of the research performed within the group, through a literature analysis of all IFIP WG 8.6 conference contributions consisting of around 113 scientific papers between 1994 and 2003 in 7 different conferences (Kautz et al. 2005).

The ideal of finding a universally valid terminology is in my opinion unfeasible given the broad scope of the research area. It is therefore difficult to use general enough terms that describe such diverse phenomena precisely. Nevertheless, the risk for ambiguity may be reduced by proposing some preferred uses of the concepts. This represents the preferred strategy within this dissertation. The aim here is not to create internally consistent concepts but to increase the clarity of subsequent discussions.

According to the interim review in Kautz et al. (2005), the five most used terms in IFIP WG 8.6 are in order of frequency: adoption, diffusion, implementation, introduction and transfer. These terms were used significantly more often than the rest.

In this dissertation we use the term innovation as the most general one. It is worth noting that innovation is the result of a process (Rogers 1995), in this particular case the result of the implementation process. The successful implementation of information systems resulting in new work practices to support business processes in organizations represents the innovation. According to Wolfe's five criteria mentioned earlier the outcome of the process is conceptualized as successful and thereby as an innovation when it helps the organizations to develop sustainable advantages.

If innovation is the result of a process, the process itself was defined by Rogers (1995) as the diffusion process. For him diffusion is the process by which an innovation is communicated through channels over time and among members of a social system. However, as stated earlier, different authors prefer different concepts when addressing this process. This may be the case because the underlying process differs depending on the type of innovation and the potential context of it. For example the process of diffusion of an innovation is different if aimed at individual consumers or employees of a firm. Both the decision patterns to adopt, the mechanisms of spreading and the level of willingness to use differ.

It is just this distinction between the type of innovation and the people potentially involved that permits us to classify the most significant concepts mentioned earlier (cf. Figure 18). For example, the differences between product and process innovations highlights the important distinction introduced by Zaltman et al. (1973) between putting a technology into use (process innovation) rather than deciding to use it (product innovation). On the other hand we can distinguish between the micro-managed spread of technology within individuals or organizations and the macro-based process of diffusion within markets or industries as illustrated in Figure 18 below.

Potential Members of the Innovation System

Type of Innovation	Micro	Macro
Product Innovation	Adoption (e.g. cell phone)	Diffusion (e.g. access cards)
Process Innovation	Implementation (e.g. WIS)	Transfer (e.g. XML language protocol)

Figure 18 The process of realizing innovations

Adoption represents the initial decision to use a product innovation by individuals either within an organization (organizational user) or outside (consumer user). The typical example nowadays is the adoption of a new cell phone. In the case that occupies us, namely that of organizational users, this decision is often made by someone else.

In the case of process innovations it is more suitable to talk about the *implementation* of technology. Implementation has a more specific process character and keeps a reference to a particular organization. This is the particular case that occupies us in this dissertation, namely the implementation of information systems in organizations, a process labeled here the organizational innovation process (OIP). One important remark is that a process innovation can consist of several product innovations (an information system implementation including handheld terminals) in which case the usage of the term adoption is justified.

At the industry level (macro level), product innovations *diffuse*. This corresponds to the description given above of products that spread through channels over time and among members of a social system. We then could talk about the diffusion of cellular phones among different groups of society or the diffusion of access cards for security purposes among organizations. However process innovations are instead *transferred* at the macro-level. One such example of transfer efforts is for example the standardization of protocols that permits process innovations to spread within a market or industry like the XML language protocol.

The distinction above does not exclude the possibility of using these terms in other contexts. For example, there is a possibility for process innovations to diffuse to a market. However its use in this dissertation will be restricted to the description in the matrix to make the analysis consistent.

3.3.4 Organizational Innovation Process

Certainly, the different parts that comprise the OIP model described above represent only a general template of understanding – one that misses important complexities if it is extended too far or mechanistically. Nevertheless, the description above helps to make sense of the complex phenomenon of organizational innovation in terms of a process description, some critical factors, a number of central concepts and their relationships. Let us now sum up the overall model described so far by recapping the main aspects of the model and discussing some major critics.

Innovations inside organizations have been framed here as a process. We have seen that the development and usage of stage models is common to both implementation and innovation research. These models presented above aim mainly at clarity of exposition and help the participants in such a process to anticipate future challenges. However, the primary criticism of such an approach criticizes the linearity of the process. Another issue raised in a number of articles is the fact that stage models assume changes follow implementation and not the other way round (Markus et al. 2000). A third type of criticism is the issue of irreversibility due to prefigured programs and/or rules.

One possible solution to these limitations is suggested by Poole et al. (2000). They propose to complement life cycle descriptions with a teleological view in order to achieve descriptions of discontinuous sequences of change processes more consistent with how processes evolve inside organizations. Continuous action and evaluation of results along the process make changes more manageable.

In this type of model, several paths of activities influence each other and generate mutual feedbacks. This is the case in the "chain-linked model" formulated by Kline and Rosenberg (1986 p.290). Although developed to describe product innovations, the ideas of path dependence and reciprocity are interesting. Their description of the process of innovation focuses on the interdependency of the stages of the process, which are also called feedback paths. This is in line with Lundeberg's (1993) phases of operative process in the so-called V-model: (1) choose goals; (2) operate; (3) evaluate evidence (Lundeberg 1993 p.123). These three phases can also be tracked back to the TOTE (test-operate-test-exit) sequence model developed by Miller, Galanter and Pribram (1960), which describes a basic feedback loop to guide behavior.

An example of the application of teleological ideas is Clark's design-hierarchy theory from 1985 (Clark 1985). He analyzes the sequence of technological changes that underlie the development of industries. His focus when studying technical advances is on the refinements and extensions of established design concepts playing a central role. Applied to the implementation of technologies in organizations this means that knowledge about the project is developed until it is finished. Development processes evolve in small steps, where solutions are planned, introduced into organizations and then evaluated before proceeding to the next step. This represents a typical example of a teleological approach.

Summarizing the discussion so far, there is a greater interest today for process and stage models to understand organizational innovation issues. The organizational innovation process has been usually described as a sequential process with well-defined and separate phases. Although some scholars consider life-cycle models insufficient (Robey et al. 2002), one can argue that these models are adequate representations and good starting points for analysis. The problem is not the conceptualization of innovation processes based on the stage models because in a number of cases these methodologies have helped to divide projects into phases of manageable tasks thus helping to avoid the escalation of projects, but it is instead the use of prescriptions and guidelines that recognize particular methods or techniques as universally valid or applicable.

The factors that influence the organizational innovation process are summarized in Appendix 1. These factors are not comprehensive, but they are representative of the literature. They were divided into three main groups, namely organizational factors, technical factors and finally human factors. This is to reflect the intertwining of organizational and technical issues when dealing with organizational innovation processes.

It is interesting to highlight that the choice of factors influences the way successful implementation is framed. This is important because the choice of success factors that are too technical can influence a project negatively. A balanced mix between social, organizational and technical factors may contribute to a more positive outcome of the process. These factors will be used later in order to develop a number of challenges.

Finally a number of concepts and their relationships were clarified and sorted out as a part of my delimiting the organizational innovation process[21]. In this work we speak about implementing new technologies in organizations. This process is defined here as the organizational innovation process. The result of this process if successful is an innovation.

From what has been said, a platform consisting of conceptual relationships, definitions and earlier findings within the areas of capabilities and IS innovations among organizations has been developed. Let us now move on to consider the cases and the papers included in this dissertation.

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[21] These terms may not have always been used consistently with the description of the preferred use above in earlier sections of this dissertation nor the papers included. This is so because the more common and sometimes accepted usage of the terms has been preferred instead.

4 Summary of the Articles

This chapter provides with a summary of the articles included in Chapter 8 through 11. The aim is to build a link for the analysis to come in the subsequent chapters. Most of the information included in this section can be assimilated by reading the articles. However this section increases the independent character of the preamble of the dissertation (Chapter 1 through 7).

The chapter is structured as follows. First, I present the main findings from the articles. In addition to the findings, each section includes a brief overview of the case included in that article. The chapter concludes with supplementary empirical material collected for the additional analysis included in the preamble. This empirical material consists mainly of interview material, collected after three of the four papers were written. It comprises the empirical epilogue that closes the chapter. This epilogue should be read before the subsequent chapters even if the articles have been read separately because the descriptions there are not included in the papers.

4.1 First Article

The Value of Mobility for Business Process Performance: Evidence from Sweden and the Netherlands

This paper arose out of a cooperation project between the Stockholm School of Economics and Vrije Universitet in Amsterdam. Therefore, two of the cases used in the paper come from the Swedish industry (Taxi Stockholm and Graninge) and the third one (Mobile Parking) is from the Netherlands. The Graninge case however is introduced very succinctly in the paper because of space limitations.

This was the first paper that resulted from the cooperation project between Stockholm and Amsterdam. Out of this paper two subsequent papers were developed. One about a method to identify mobile business opportunities and another about mobile business processes with larger descriptions of the cases studied. These papers remain *work in progress* and therefore only the first is included in this dissertation because it is the more general.

In this paper we explore the linkages between wireless technologies and the potential improvements in business performance. We start from the position that the benefits of mobile technology are hard to quantify in isolation, and that the unit of analysis to identify value should be the business process. The underlying assumption in the paper is that business processes can be improved through the implementation of new technology.

An exploratory case study approach is used to explore the area. It describes the benefits of wireless technology when implemented in three particular business processes, namely a taxi dispatching process, a mobile parking process and the supply chain management of timber at Graninge.

Based on the findings, we conclude that a business process can benefit from mobile technology if coordination is required between difficult to locate actors. The value of mobility is contingent to the costs of not being able to coordinate during the period that the actors are difficult to reach. It is also related to the costs of available substitutes for mobile technology in a business process.

More specifically, this paper connects to the early stages of the innovation process, and the paper stresses the importance of frameworks that try to match the attributes of specific technologies to specific organizational problems or opportunities. This is in line with Earl's description of technology fitting frameworks (Earl 1989 p.46ff).

The analysis of the benefits of new technological investments is usually carried out during the initiation phase. The identification of benefits is important because different applications provide different types of benefits. This study shows how benefits are not only of a cost-reduction character but organizational enhancement also. Moreover, the identification of coordination dependencies may help to increase the value of the solutions implemented.

Next we briefly introduce some highlights from the Taxi Stockholm's case. This summary of the case describes some of the empirical material used in the analysis included in subsequent chapters. Article 4 also includes additional descriptions about this case.

4.1.1 Taxi Stockholm

Taxi Stockholm AB is a taxi company owned by *Taxi Trafikförening*, a 107-year-old Swedish cabdriver cooperative with a membership of about 1,000 taxi owners. Operating in a deregulated market since 1991, Taxi Stockholm runs by far the largest taxi circuit in Sweden with over 1,500 vehicles and a total capacity of around 50,000 transport requests per day. Taxi Stockholm is responsible for the development, marketing and administration of the transport services offered to customers. They build the brand for the cooperative owners and provide drivers with work. In return membership requires acceptance of the company's policies regarding brand, uniforms, cab appearance, dispatch system, etc.

Taxi Stockholm's heart is located in downtown Stockholm where the dispatch system matches around 25,000 transport requests per day with available cabs. Reservations pass through the customer-service centre and are relayed on to drivers via the taxi dispatch system.

The allocation of available cabs is critical for the company. *Taxi load* and *distance to customers* are usual parameters guiding the allocation process. Allocation, at Taxi Stockholm, also takes into account fairness to drivers to balance customer and employee satisfaction index. These two metrics, together with profitability per cab and hour, define the overall corporate goals. Complex algorithms are therefore needed to allocate resources, especially regarding the fact that customer need for cabs is highest when few drivers are available, i.e. early morning on weekdays and late at night on weekends.

Today 75% of dispatch work goes through the call centre and 40% is completed via the Interactive Voice Response System (IVR) i.e. routed automatically. This percentage is high compared to other European countries where taxi cabs are allocated directly on the street. For example, southern European countries have a 25-75% ratio for reservations through call-centre versus hailing a taxi on the street.

Taxi Stockholm is therefore highly dependent on its technological platform to be able to run its business on a daily basis. For example, the notification of dispatched taxi customers is carried out today without taxi drivers needing to approach a taxi stand, but directly to the cabs wherever they are. This technological dependency has steadily increased due to the deregulation of the industry that has led to a fierce competition.

Taxi Stockholm's technological platform is built upon four different systems where the dispatch system is one of these four components. The telecom system is the interface used when the customer makes a taxi reservation. Once the booking has been registered, the dispatch system matches the requirement with an available cab. This system represents the heart of the taxi business. The next component of the platform is the radio system keeping track of Taxi Stockholm's entire taxi fleet. Finally, the wireless-equipment component constitutes technology located in each particular cab and represents the driver's toolset for her daily work.

Taxi Stockholm computerized its dispatch system in 1984. The company used a combination of Ericsson and Volvo systems called Taxi80. It lasted until 1991 when the company migrated to a Motorola system. The migration was performed according to a forklift method (also known as Big Bang) through which the old system was replaced all at once. The migration was problematic and resulted in extensive downtime periods.

Due to obsolete terminals in cabs, better load balance, automatized check-in process and future customer information requests, the company realized that their technology platform had to be modernized to meet future customer demand. Taxi Stockholm's vision was to become a first mover regarding automatic and GPS-based dispatch process. The process started in 1998. A group was established then to revise the dispatch, radio and wireless systems. One consequence of this process was that the IT-department was outsourced in a timely hope to develop a competent buying centre instead of developing a system development competence in-house.

Market research was carried out, and around ten different companies were evaluated. Taxi Stockholm decided to abandon the Motorola platform and to install a solution provided by a Canadian company called Digital Dispatch. Digital Dispatch System (DDS), the company's flagship product, would provide Taxi Stockholm with a complete solution for the dispatch, radio, and wireless terminals at the cabs[22]. The company abandoned the Motorola system for two reasons: Motorola's waning interest for the taxi industry and the fact that the terminal equipment offered by the company was based on thin clients, without processing capacity. Taxi Stockholm's fleet needs processor capacity at the terminals to decrease traffic-load.

The upgrading of the system was to be performed during a three-year period. The migration strategy was agreed to be a seamless upgrade instead of the forklift method used previously. At the time the first paper was written Taxi Stockholm was half way through the implementation.

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[22] Both the system and the company have similar names. Therefore we will use Digital Dispatch when referring to the company; Digital Dispatch System (DDS) when referring to the whole system comprising the telecom, radio and dispatch system and the wireless equipment in the cabs; and finally Pathfinder refers to the dispatch application included in DDS.

4.2 Second Article

Bringing the Enterprise System to the Front Line: Intertwining Computerised and Conventional Communication at BT Europe

This second article describes how the implementation process of new technology is a risky venture. In part this is so due to the fact that implementation of new technology is an ambiguous process. IT is a general-purpose technology, and its implementation is related to different types of uncertainties.

This paper describes the process of how BT Industries, a leading supplier of forklift trucks, in cooperation with technology suppliers has proceeded in order to make wireless technology less uncertain and both useful and used. This is therefore a study about change management that studies uncertainty reduction activities at three different levels, i.e. what technology can do; will technology work; and will users adopt it.

Results from the paper show how different types of changes, both planned and emergent or opportunity based, must be dealt with during the innovation process. In technology-related change process literature the focus has been on planning, thereby trying to overcome obstacles and reduce uncertainty, while other authors have focused the emergent nature of change. In the analysis presented in the paper an attempt to combine these ideas has been illustrated through the uncertainties of providing mobile service technicians access to a central ERP system and how these uncertainties have been resolved over time.

The paper shows how these levels interact and how the computerized parts of the information system are complemented by mindfully intertwining with the non-computerized communication and manual data processing, in order for the information system to work as intended.

Previous versions of the paper have been presented at two different conferences. It was presented at the Austin Mobility Roundtable 2004. Then a revised version was published in the proceedings of the 12th European Conference on Information Systems in Finland. Finally the paper has been published at "*Unwired Business: Cases in Mobile Business*" as a book chapter.

Let me now give a brief description of the BT Europe case to serve as background information of the up-coming analysis.

4.2.1 BT Europe[23]

BT Industries, part of the Toyota group, is a leading supplier of forklift trucks, with a world market share of more than 20%, annual sales of €1.3bn and 8,300 employees. The company offers a wide range of forklift trucks plus servicing facilities. The case analyzes the implementation of a wireless information system, EASY (Engineer Administration SYstem), providing the service technicians from the European division, BT Europe, with an interface to structured data through handheld terminals in order to rationalize the entire service-order process.

Let me start by providing some background information about related IT-projects at BT to improve the understanding of EASY (cf. Westelius 2006). From the middle of the 1990s onwards, BT Europe embarked on an ambitious computerization venture. A business process reengineering (BPR) project to explore IT-enabled business change was carried out. An earlier attempt to use a new German ERP System (BPS that stands for Business Process System) failed as the system was evaluated insufficient for a European implementation especially in respect to country-specific functionality in Sweden and U.K. Thus, in August 1995, the Sales Support Project (SSP) was launched, consisting of the evaluation of alternative packages of new ERP systems. It was considered the largest project in the company's lifetime. Although Baan's Triton had been informally selected, an ERP system called Movex from a Swedish supplier (Intentia) was chosen. Movex was chosen because of Intentia's closeness and future commitment. The ERP system was rolled out across Europe in a strategic partnership with Intentia.

The basic idea for the roll-out was that the BT employees should learn enough about the system to be able to conduct the implementation with a minimum of support from Intentia. However a number of problems delayed the implementation. The middleware necessary to integrate the system with other BT Europe specific applications showed deficiencies. The application, called *configurator,* that translates between customer agreements and production terminology turned out to be deficient. Therefore the delivery estimates provided were inaccurate. The application had to be revised and updated after the installation in four different divisions.

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[23] We will use BT Industries to refer to the company (although formally it was the European division that implemented EASY) and BT Europe when referring to the case.

Finally, in the summer year 2000, the close down and clean-out of remaining activities from the SSP project was initiated. Internally, it was called the SSP Post implementation project.

Having installed a shared information platform, new ideas related to technology-enabled projects started to appear in the organization. In 2001, BT Europe decided to further improve quality in its customer offering through rationalization of its service order process. Moreover, the common ERP platform could enable a pan-European project, making the exchange of ideas between different local market units possible.

The idea to make BT Europe's 1150 mobile service technicians more effective was therefore discussed at an annual brainstorming meeting of market and service development held centrally in 2001. Wireless technology was by that time often debated in the media, and it was framed with visions about cost reductions and improved efficiency. However earlier attempts by competitors to implement similar systems based on laptops installed in the service vans convinced BT Europe that careful analysis of the final solution was required.

Many people at BT regarded the project as a prestigious one. EASY could profile the organization as a company on the cutting edge of new technology. After identifying possibilities for service-order rationalizations the local companies were asked to develop a business case to identify payback for the project. The project itself was kicked-off, and Sogeti, a consultancy specializing in local professional IT services and a member of the global Cap Gemini Group, was chosen as the preferred consulting partner to develop the final solution in cooperation with BT.

The group identified a number of administration-related cost reductions. Yet, revenue drivers for EASY were more difficult to identify. BT Europe's field service engineers were processing 5,000 assignments daily. Annually, 1.2 million hand-written work orders were delivered on paper to the administrative offices, and fed into BT Europe's back-office ERP system. This was a costly and time-consuming process. BT Europe's service managers decided to implement an automated solution, which extended the back-office system to the field service force by providing them with handheld wireless devices for access to the job, contract, or product information required.

A project group with approximately a dozen participants was formed. The members had different backgrounds, coming from local operations, central staff personnel and technology consultants. The process model from Sogeti was chosen. It is basically based on the analysis of the current and intended future situation out of which a number of *use cases* are developed.

In the summer of 2002 the first working prototype was presented and approved by BT Europe for pilot tests. Three local companies in Sweden, the U.K., and Belgium were chosen for the pilot. The Swedish division in Stockholm tested the system during the summer until October. Field technicians had some suggestions such as the difficulty of using black and white terminals. Therefore an action point for the project consisted in finding new terminals with color functionality. Another problem was the scarcity of impact resistant-devices. Most of mobile handheld devices were fancy terminals for business men. This led to the choice of Pocket PC-based solutions with offline synchronization update methods using GSM networks. Tests had shown that connectivity was often a problem and that GSM was the only type of radio network that offered relatively extensive coverage in the dozen European countries where the application would be implemented. Technicians often work in areas with bad network connectivity, such as in rural areas and inside industrial buildings with massive concrete walls.

The decision to go ahead with the project was then taken and the roll-out was started one country at a time with evaluation after each implementation. Regarding the back-office personnel, the strategy was to cut the number of staff at the beginning of the implementation. Although a decrease in errors from service technicians would reduce the workload for back-office personnel, the workload on the (reduced) back-office staff was highest during the implementation process, which resulted in difficulties in giving adequate support to the service technicians. Nevertheless, the rollout progressed according to plan, and by March 2004, all the mobile service technicians were using EASY.

4.3 Third Article

The Role of End-Users for Wireless Information Systems Usage

The third paper is about innovation processes studied in the light of user involvement during the stages of the implementation of wireless information systems in organizations. At the organizational level, one of the most central challenges when innovating organizational processes with new technology are not usually the technological problems that need to be solved. A more frustrating part of the process is to understand what the end users of the system really need, i.e. their expressed, unexpressed, uncertain and unidentified needs (Leonard-Barton 1995 p.183ff.). The paper analyses such an adaptation process at Graninge Skog & Trä AB.

The article investigates how different users are involved in the development of wireless applications for enterprise customers, and how suppliers learn from user involvement in terms of improved abilities and reduced uncertainties. Theoretically, the paper provides an overview of the development within the research area about user involvement. One distinction developed in the paper is that between user as a consumer or as an employee. Consumers often pay for the usage of a product whereas employees get paid. In addition, consumers decide on the adoption of a product by themselves whereas employees are supposed to adopt new technology based on someone else's decision. This distinction helps us to understand better the idiosyncrasy of enterprise employees (the real users of the wireless information systems).

The paper was presented at the Fourteenth International Conference on Information Systems Development (ISD 2005) in Karlstad (Sweden) and selected for publication in the conference proceedings "Advances in Information Systems Development: Bridging the Gap between Academia & Industry", published by Springer US.

The third case about Graninge is succinctly introduced below.

4.3.1 Graninge

Scaninge timber AB is a forestry and sawmill company located in the northern part of Sweden. At the time of the study the company's name was Graninge, today an energy supply company that sold the forestry and sawmill line of business summer 2000. Scaninge was, at the time of the first study, owned by Graninge AB (40%) and Svenska Cellulosa AB (60%)[24]. Operations were based at four sawmills located in Sweden. The turnover in 2001 was SEK 1,800 million.

The Swedish Forestry Research Institute (Skogforsk) and Telia, the Swedish incumbent telephone operator, approached Graninge, in the early 1990s proposing the implementation of a wireless information system to improve the flow of timber. The company launched the SKINFO project to improve the coordination of their supply chain through radio-technology. Smoother operations were needed between the units operating in the forest (harvesters and forwarders) and the main office of transports at Bollstabruk.

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[24] We will use the name Graninge throughout this work even though the company was re-named when Svenska Cellulosa AB (SCA) acquired a part of Graninge.

Due to demands on quality and timely delivery of fresher pulp, the company experienced a number of problems that led to the implementation of a company wide wireless solution. Some problems were timber wasted when it was left too long in the forest or when the dimensions requested by customers did not make the best use of the timber in stock in the mill, timber in-flow to keep the mill going on, etc. The idea behind the implementation of wireless data technology was to integrate the process from harvest to delivery.

Graninge's woodland region was divided into five different districts. An inspector responsible for timber production managed each district. At each particular forest area, a number of machine operators harvested and forwarded timber. Trucks collected timber dispersed over the whole harvest area and transported the logs to the sawmills.

There existed a number of geographical constraints to carrying out the process. The administrative unit, where data was registered, was far from the forest units. Moreover the operating land was 245,000 ha. productive woodland, and there existed a need for regular information exchange between units at the different locations both on the move (such as the transport units, i.e. trucks, harvesters and forwarders) and on different locations (inspectors that supervised the different forests districts). At the districts, production was carried out according to monthly delivery plans. In order to get the right diversity of wood products, information about type of wood, dimension and length was collected in matrices with best-case distributions. These, so called, *price lists* had to be forwarded to the foremen in each forest area. Before the implementation of SKINFO re-arrangements of timber production required the inspectors to make regular visits to the different areas to communicate changes in the production plans included in the updated price lists.

SKINFO was carried out by Graninge in cooperation with Telia and Skogforsk. Later on, the system integrator Telesoft Uppsala was also added to the team to provide computing competence to the group. Once having secured the budget (Telia Demotel 50%, Graninge 40%, Skogforsk 10%) a project steering committee and a project team was established. The company decided to install a system for the radio communication based on Mobitex, a pan-national network developed for business applications based on voice, data and alarm services, and Telesofts' MobiBase-module for communication with the central information system. Prototypes were installed in a number of mobile units based in the forest so that machine operators could give their comments on the interface during the introduction phase.

Once the operators realized they could manage the system, their appetite grew and an intense period of learning by using started. After the first pilot project a press-conference was held in Vilhelmina for project marketing purposes. A video presentation was also prepared with some of the results from the pilot.

A number of benefits were realized through the implementation of SKINFO such as increased detail level of delivery plans, volume reports from harvesters and forwarders on a daily basis, relevant progress and status reports from production and roadside stocks, and better computer based planning opportunities.

As a result of SKINFO new ideas started to appear about what to do with wireless data communication (good example of problem finding). This resulted in a follow-up project called TIMPG (timber on demand). TIMPG was not as successful as SKINFO. The vision of this project was to bring forest districts closer to the sawmills in order to achieve better control and follow-up. However this vision of harvesting on demand was never realized. Instead the company was bought by SCA and future IT plans were postponed.

4.4 Fourth Article

Understanding Migration Strategies by Decoupling Application Roles and Technology Generations

Starting from the technology life cycle, this article discusses how sequential technology generations fulfill an application role in a company. This is illustrated in the paper by showing how Taxi Stockholm has renewed its customer-dispatching application through three different technology generations. Finally, an analytical model that describes the process of technology switching in organizations is presented.

The paper focuses on technology renewal efforts. The analysis of information technology abandonment is described through the study of market based technological and organizational factors. The discussion aims at increasing the understanding for the application development through successive technology-generation renewals.

Organizational innovation studies have traditionally focused on the early stages of the implementation life cycle namely initiation and design of technology applications. However, the mechanism of innovation and technical change can be explained by not only the implementation of new technology or the imitation of existing technology, but also by the removal of an obsolete technology. Thus, this research expands the innovation model covering not only initiation and introduction of new technology, but also renewal of obsolete technology.

Earlier research on technology switching has focused on this type of issue. However, the approach has been to study it from a market or technology-system perspective. In this case we intend to approach the problem from an organizational point of view, i.e. to study technological change from a company perspective.

This paper was presented at the 12th European Conference on Information Systems in Finland, and it has been published at the International Journal of Technological Innovation, Entrepreneurship and Technology Management (Technovation) in March 2006.

4.5 Case Epilogues

This section presents additional interview and written material collected after most of the papers were finalized. It gives a more comprehensive view of the cases and provides processual data used in the analysis described in the preamble of the dissertation.

4.5.1 Taxi Stockholm

So what has happen with Taxi Stockholm since 2003? A series of interviews carried out during the fall of 2005 revealed interesting issues both positive for the company and less so. A press article in the Financial Times commented:

> *"Taxi Stockholm should be the benchmark for cab companies around the world. Their easy-to-remember number, GPS navigation system, spotless cars, estimated time of arrival announcements when booking and gleeful acceptance of credit cards make it the only way to go around Stockholm when a bike or public transport won't quite do" (Brûlé 2004).*

Despite glamorous articles in newspapers such as the one above, the early years of the new millennium affected Taxi Stockholm severely because of a growth depression due to economic recession. One additional problem was the roll-out of Pathfinder, the last upgraded part of the company's dispatch system.

The original deadline for the project introduction was January 2003. However the implementation deadline was postponed due to integration problems and software execution faults. It is from that point onward that Taxi Stockholm unintentionally assumes a co-developer role of the Pathfinder software together with Digital Dispatch in order to make the application bug-free. Several requests for correction are sent back and forth between Sweden and Canada before proceeding with the roll-out. When additional tests are performed new bugs appear. In addition, during this time the call-centre dispatches customer requests in two different systems, namely the old Motorola TaxiPak and the new Pathfinder. This increases the stress factor.

In early fall 2003, the supplier exerts pressure about starting the migration of cabs. The initial idea of migrating cabs in small groups of 20 is abandoned. The migration path is redesign for three different phases with groups of 50, 500 and all the cabs. The migration starts on December 2003.

In January 2004, after having added around 700 cabs, the system experienced performance problems. The radio became overloaded and reservation queues overflowed when almost all the cabs had been added to it. After three days running the system, it went down, causing a major halt. Although the error was identified by the supplier that tried to fix it effortless during the weekend, Taxi Stockholm decided to go back to the old Motorola's TaxiPak system. The switch over from the DDS system took just one hour thanks to Taxi Stockholm's earlier requirement to run parallel systems. In early February a SWAT team of technicians from Digital Dispatch traveled to Stockholm to solve the problems in situ. After almost two weeks intensive work they managed to bring the system up.

In April 2005, after more than a year and a half, all taxi cabs were migrated to Pathfinder. It took three weeks to finalize the migration. During a year and a half the call centre had to work in two different systems simultaneously. Even though a new version of the software is available, Taxi Stockholm does not dare to proceed with the upgrade and prefers to help TAXA 4x35 (Copenhagen's oldest and largest taxi company) to install this new version called 3.0 to learn from the experience without being involved.

In retrospection, Taxi Stockholm's upgrading of their dispatch platform has been a sweaty work indeed. However, when you go around and ask the managers for their opinion about Pathfinder and the implementation process they have been through, the answer is unanimous: it was worthwhile!

4.5.2 BT Europe

Interviews performed during the spring of 2006 revealed interesting facts about the organizational innovation process after the installation of EASY. A number of improvements were realized soon after the implementation. Profitability increased because of a more accurate assignment of spare parts to specific trucks serviced. On average, service technicians also performed more jobs. A probable explanation for this is that the service technicians' awareness of other customers waiting for service became more acute when they appeared on the screen of the PDA. The increased level of stress is closely monitored by the company and the labor union, and so far, no general adverse effects have been detected.

Another improvement was the reduction from six administrative back offices to only two offices in Sweden. Telephone calls from service technicians to the back office have also decreased. Finally, there are positive signs about the adoption of the new handheld terminals among service technicians. They appreciate being the focus of attention and are proud to be modern as part of the IT era.

The roll-out of EASY was almost problem-free. In Sweden, only one out of 276 technicians had to quit because of EASY. Outside Sweden, there were two small companies where the implementation of EASY did not succeed. The reason was that the back office personnel did not really understand the logic of the existing ERP system. In the implementation of the Movex system that preceded EASY, small countries were happy to accept the assistance from the implementation team rather than challenge the way the system was set up and demand modifications to fit previous work routines. However, these two divisions had difficulties following this pattern, and the implementation of EASY was therefore delayed.

Soon after the initial rollout, the project team started to work on the next version of EASY, version number two (EASY 2.0). The goals with this new version were to improve execution efficiency, decrease response time and improve the platform stability.

Although no major additions of functionality for service technicians were developed, a new application, the spare parts catalogue (QP that stands for Quality Parts), was added to EASY. A time-consuming adaptation of QP was necessary because of the interface differences between the existing application, developed for full-size computer screens, and the small screens used in EASY. This application enabled service technicians to have access to the entire range of trucks and their spare parts without needing to download drawings and catalogue data over the slow wireless connections.

The service-order process has become more and more technology dependent. It is now clear that service technicians would not be able to manage the process without EASY. BT became aware of this fact and its negative consequences when the application ground to a halt because the servers could not handle the large number of simultaneous synchronization requests after upgrading to EASY 2.0.

Finally, new functionality and suggestions stay up to a thorough evaluation. BT takes advantage of a core team of key users to test new functionality. Minor additions to the existing application can be incorporated in upgrade versions of the software. Such new versions are implemented easily in the back-office applications. The same is not true for the PDAs. The standard procedure for updating the application involves collecting the terminals from the service technicians, switching chips and redistributing the terminals. Considering that this is a disruptive process to the service technicians' work, the project team has refrained from small PDA updates. Version 3.0 will improve this update capability, but it will still require lengthy data transfer at considerable cost to the company.

4.5.3 Graninge

On December 19, 2003 SCA exercised the right to acquire 41% of the share capital in Scaninge from Graninge AB. In accordance with the terms of the purchase option, the exercise price for the entire block of shares was SEK 4.9M. This was the announcement of the final acquisition of Scaninge, where SCA secured the full and long-term strategic control of the company.

The acquisition of Graninge by SCA presented a number of challenges. There existed substantial differences between the two companies. Old Graninge had to install a new ERP system based on SAP/R3 to comply to SCA standards. The descriptions of the forest stocks were very different although one may think that they should be somehow standardized. For example, the management of maps was different in Graninge and SCA. Other differences had to do with time-reports. SCA works with contractors and Graninge with own employees. Thus salary was handled differently as well.

In 2001 the machine-data project was initialized which consisted of the installation of PC computers at the machines in both Graninge and SCA. Graninge machines were updated first, new harvesters were already equipped with the computers and finally the rest of SCA forwarders were equipped with the Sunit D10 computer. During the implementation of the project, reports were produced the old way through a spot market category in the SCAs computer system. This was done until the new PCs were installed in all the machines.

The roll-out of PCs started year 2002. It was led by the different forest districts. Today the company has 210 machines (25 machines from Graninge and 185 from SCA) that report via the system. This includes around 440 operators in two different shifts. Although all the machines are equipped with a PC, the process was not problem-free. SCA experienced problems with bandwidth in the system. In addition there were users with limited PC experience.

The next step was to perform a number of tests to include the trucks in the information system. The tests started with 6 trucks. Transport orders were presented in html pages that drivers could download to check new orders. The tests were very positive. However, the maps, required for positioning purposes, could not be downloaded directly to the trucks. Therefore, the updating of geographical information was carried out through updates once per day. The result was less successful as one update per day gave obsolete information about return-transport opportunities. One update per day was not sufficient and Mobigate, the communication server, was not fast enough.

During this time the Forest Industry Data Centre (SDC), a joint-venture organization established to store and provide the forestry sector with business-related information, developed a data warehouse solution. Their initiative consisted in the promotion and follow-up of timber fell in the forest. The main idea was very similar to Skogforsk's earlier vision of TIMPG, namely to connect the sawmills and the forest through automatic data transfer. Bollstabruk was again chosen because of personal contacts with one service manager at SCA. What turned out to be most critical was the training in the new system because data quality was not satisfactory due to negligence with data reporting activities. The real volumes of felled trees did not always exclude missed trees that are not felled.

SCA is now rolling out the pilot project from Bollstabruk called *Timmer Prognos* to the rest of their sawmills. This will enable increased control of the timber flow.

It is time to conclude the empirical section of this dissertation and move on to the analysis. The next chapter investigates what these different implementations of wireless information systems have to say about the organizational innovation process.

5 Organizational Challenges

This chapter presents a revisited conception of the organizational innovation process, a conceptualization based upon earlier research described in Chapter 3 and upon the findings of the articles included in this dissertation. That description makes it possible for me to identify and analyze a number of challenges observed in the cases. The analysis proceeds case by case even though the research design of this study reflects its more explorative nature and does not therefore foreground variation per se. There are nevertheless differences among the cases, and the insights that arise from these differences do so most clearly in a case by case exposition.

This part of the dissertation targets research question one regarding the challenges that the organizations encountered when they implemented wireless information systems to support mobile workforces.

5.1 Organizational Innovation Process

I discussed a number of issues from different theoretical perspectives in Chapter 3 above. This included a comparative review of earlier research about IS implementation and innovation theories. This section develops the main findings presented there in light of the cases studied.

A first attempt to conceptualize the organizational innovation process was introduced in Table 10 in Chapter 3 (cf. Figure 19 below).

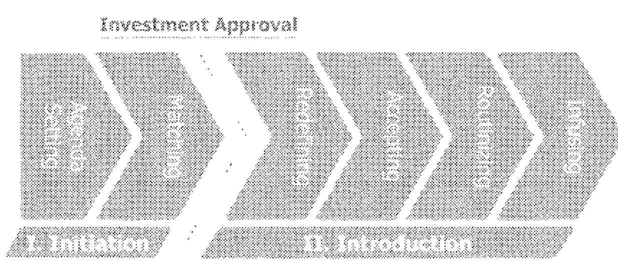

Figure 19 Process innovations in organizations[25]

[25] Adapted from Rogers (1995) and earlier discussions

Although simple this conceptualization provides us with a picture of organizational innovation mainly framed as a development process. It has in addition guided the selection of research areas for the papers included in the dissertation. It depicts two phases (initiation and introduction) derived from Thompson (1965) and six stages within these phases (agenda setting, matching, redefining, accepting, routinizing and infusing)[26].

It should be highlighted that, the combination of innovation research and implementation theories provides an alternative view of the organizational innovation process. This is so because innovation research focuses on the early initiation steps whereas implementation theories analyze more specifically the installation and usage of the system during the introduction phase. Another reason for seeing these two approaches as complementary is that innovation underscores creative aspects of the process while implementation highlights analytical and problem solving aspects.

Worth mentioning is that the adoption phase according to Thompson (1965), can be interpreted as an investment approval, i.e. a go/no go investment decision. This is depicted in the figure above as a bridge between the initiation and the introduction phases (cf. Figure 19). Therefore, it was suggested to change the name of this label from acceptance to investment approval. Westelius and Valiente (Article 2) describe how in the BT Europe case formal approval from the management group was required before proceeding with the EASY project. The way chosen by BT Industries was to prepare a *business case* for the management group, and then the EASY project received a go ahead. This step is thus considered here as some kind of tollgate for the project. Another form of crossing the investment decision watershed is illustrated at Graninge. In this case securing the budget for the SKINFO project led to the go ahead decision. Later, additional funds for another Telia-Demotel project called TIMPG provides an additional example of watershed through budget guarantee. This does not mean that negotiations to get such an approval cannot be a long and cumbersome process. But without a go-ahead decision the project could hardly continue.

As a form of guideline and to understand how the articles included in this dissertation relate to each other, it should be noted that the first three of the four articles included in this dissertation can be mapped onto the model in Figure 19 above. The fourth article discusses renewal issues that have

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[26] The term *phases* refers to the more general steps of the organizational innovation process and *stages* to the steps within each phase.

emerged during the research process. These issues are not covered in Thompson's (1965) description.

Article 1 covers primarily the initiation phase whereas Article 2 and 3 address the introduction phase. The difference is that Article 2 covers the early stages of the introduction phase whereas Article 3 covers the later stages. This distinction indicates the emphasis of the articles although it should be noted that discussions about other parts of the process may be found elsewhere also.

So far these articles can be mapped against the model presented above (see Figure 19). This model is both linear and one-dimensional. The fourth paper of this dissertation, by applying a company perspective on technological change, gives the model above a second dimension, i.e. the breadth of the development process. This is carried out by contrasting it to the traditional product life cycle (cf. Article 4). For this purpose, the concept of the *application life cycle* was introduced in the paper. The application life cycle however differs from the product life cycle since it deals with a company applying some technology to create a value proposition rather than a product itself. This second dimension or breadth is represented in the model by the utility contribution of the technology implemented to the organizational performance as illustrated in Figure 20 below (cf. y-axis).

We should notice that, traditionally, the area under the life cycle function is given by the level of penetration of a certain product or technology among the members of a social system. When applying a micro organizational perspective on this process, penetration is no longer useful as successful introductions of IS are not dependent on how many users applications reach, but on how utile they become to their users and ultimately to the company implementing them. Obviously the utility level is a vague concept and dependent on a number of organizational internal and external factors. In the taxi Stockholm case two indicators were chosen to define the utility level of the final introduction, namely the reduction of the distance between vehicles and customers and the increased taxi load.

5.1.1 The Renewal Phase

Not surprisingly, much of the research carried out in relation to organizational innovation processes has focused on the implementation of technologies. However this conceptualization of the process does not take into account the process of abandoning old technologies. Although the implementation has been central for IT-innovation studies, as illustrated in Klein and Sorra (1996), the fact that the innovation process within an organization is very much dependent on the existing technological platform confirms the insight that new technological implementations are often dependent on old technologies.

In addition, traditional implementation research often assumes the introduction of a new technology to be clean slate projects with few or no preexisting applications to be considered (cf. Appendix 2 where a majority of the models included show at most one life cycle of a technology's implementation). However, the cases showed that the process of abandoning old technologies is closely intertwined with the introduction process. Some examples from the cases illustrate this fact. Taxi Stockholm's dependence on Volvo's Taxi80 and Motorola's TaxiPak when migrating to Pathfinder has already been covered in Mårtensson and Valiente (Article 4). Another example was BT Europe's ability to introduce EASY thanks to the earlier installation of the ERP system, Movex. Interdependence between old and new, although illustrated in the cases above, has not received similar attention as other parts of the innovation process, such as the development or the introduction phase.

This interdependence is manifested in the fact that companies, at least in the cases presented in this dissertation, have trouble when migrating or upgrading to new technologies. The abandonment of obsolete technologies represented a big challenge for this type of organizational customers. Abandonment implies high costs due to path dependencies arising from the applications introduced earlier.

Based on this discussion the following revision of the process depicted in Figure 19 above is proposed. The new conceptualization adds a third phase called renewal (cf. Figure 20 below).

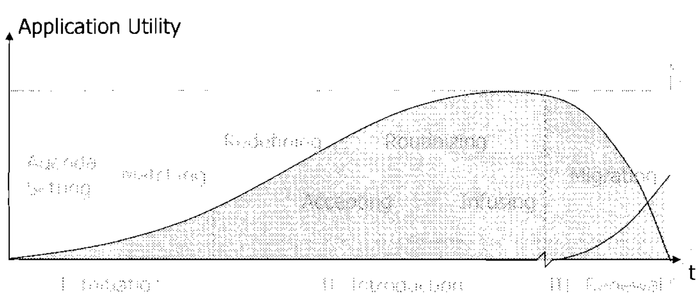

Figure 20 The OIP over time

This phase includes a stage which we have chosen to denominate migrating. Strictly speaking migrating is just one example of what the renewal phase *can* consist of, namely the installation of updated versions of the existing application. The renewal phase can also result in the abandoning of obsolete technology (in which case the term renewal is less correct but it will be kept to simplify the model). As an example, Taxi Stockholm's renewal of technology resulted in a migration of the existing application with the help of a new supplier; in the Graninge case SKINFO enabled TIMPG in a similar way as Movex enabled EASY in the BT Europe case.

Let us now move on to analyze what happens when we put different generations or application life cycles together (cf. Figure 21). As observed in earlier pictures, the volume of the innovation process is determined by the utility potential of a certain application. The dotted lines inserted in the figure represent the life cycles of different technologies, in this case two different generations. At a certain point in time a specific technology, when applied by the company, manages to meet the application's role to some extent, until next generation comes through and a new renewal process starts. This is due to a shift in the point of intersection between the value proposition of the company, the customer requirements and the opportunities of technology as illustrated in the CCT-model (see Article 4).

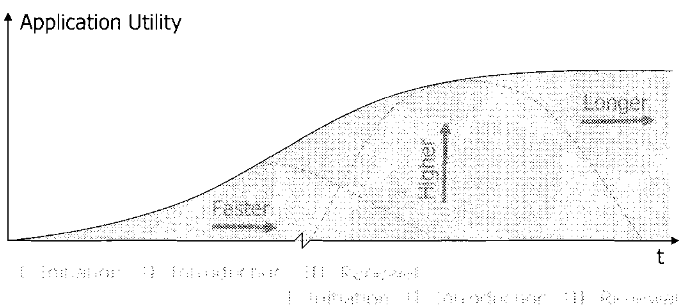

Figure 21 Development efforts applied to the application life cycle

It should be noted also that a large part of the innovation and implementation research efforts applied to the traditional application life cycle have been focused on three directions namely, making a faster implementation, achieving higher utility levels and enlarging the period of use and revenue generation after the introduction phase (see arrows in Figure 21).

However, faster implementation efforts often collide with the dip phenomenon mentioned in Chapter 3. At the later stages of the introduction phase there occurs a dip effect similar to what Ross and Vitale (2000) explain during the installation of systems. The realization of planned benefits is delayed until the system is well routinized and infused into the organization. During this time the utility level of the system may decrease influencing the total benefit of the system negatively. It is when the utility function suffers some kind of diving phenomenon that it puts pressure on innovation projects and can create frustration.

Next, higher utility levels (see second arrow in Figure 21) are often increased by technological opportunities. The development of IT and information systems puts few limits on what is feasible. However the cost/benefit ratio may raise a number of concerns. Thus an important issue in this regard is to find an optimal utility-payback function that balances costs and benefits as there exists an inverse proportionality between the utility function and the investment costs of an implementation venture.

Finally, the maximization of benefits advocates longer usage periods; however as life cycles become shorter the renewal process becomes more central, and the benefits must be squeezed earlier. This is for example the case with the Windows OS-platform where new versions of the operating system are developed and launched every other year forcing companies to draw as much benefits as possible during shorter life cycles.

Generational intersection

We will now look in greater detail at the intersection in the renewal phase between the old and the new applications by focusing the discussion on alternative renewal strategies. After the experience of earlier implementation ventures via a big bang approach, Taxi Stockholm opted for a migration strategy based on a smoother phased introduction. However not even this time was the migration painless. After a couple of crashes early in 2004 and system-instability signals, the organization was forced to re-launch the old Motorola system (TaxiPak). One explicit requirement from Taxi Stockholm to the supplier was to have TaxiPak ready in case the new Pathfinder could not meet expectations. Taxi Stockholm ended up with a parallel introduction with back-up alternatives. At BT Europe a number of implementation strategies were available but a trial and dissemination approach with small-scale implementations was used before going global.

As discussed in Chapter 3, earlier research has identified a number of implementation strategies. Out of Eason's (1988) five implementation strategies (cf. Table 9), three alternatives are more relevant than the others for the discussion here. The reason is that the big-bang approach, parallel running and phased introduction makes explicit reference to existing systems and are therefore more suitable for consideration when analyzing the intersection in the renewal phase between the old and the new applications.

The two other alternatives that will not be considered here are trials and dissemination, and infrastructure application. Trials and dissemination will be considered later in this chapter in connection to the linearity of the process as part of the system testing during the introduction phase. Infrastructure application as proposed by Eason (1988) relates mainly to user involvement and this also fits later in connection to the challenges section. Remember also that the distinction between whether a strategy relates to the introduction or to the renewal phase has to do with the pre-existence of related systems or not.

These different implementation alternatives (cf. Figure 22 below) impact the three strategies mentioned earlier about faster introduction, higher utility levels and longer usage periods. We will now explain this relationship.

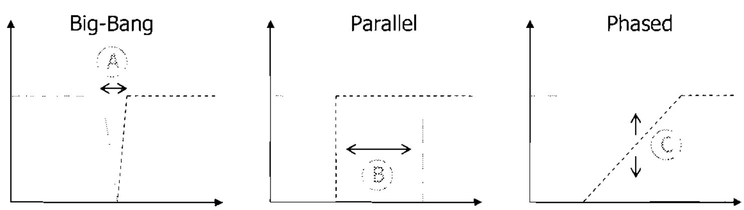

Figure 22 Alternative migrating strategies

The first implementation alternative is the big-bang approach that advocates instant changeover. This strategy is often considered when the benefits of a system require a critical mass of functionality or users. A well known example is the overnight switch of the London Stock Market to electronic trading in 1986 (Clemons and Weber 1990). However this strategy assumes some downtime for the system as illustrated by the (A)-arrow in Figure 22. The shorter the downtime the more meticulous planning is required.

Nowadays, technology dependent organizations suffer great losses from IT system's downtime, which makes this alternative more and more unrealistic. For example, back in the 1980s, Taxi Stockholm could manage dispatching without the IT platform. Today the losses due to some hours of dispatch system downtime can be catastrophic. Connecting back to Figure 21, big-bang approach poses a trade-off between making a faster implementation and achieving a higher introduction utility.

The parallel strategy (second example in Figure 22) builds upon the co-existence or duplication of systems. The effort in this case is to minimize the period requiring the maintenance of two different systems (minimize (B)-arrow in Figure 22). This was also clear in the case of Taxi Stockholm as they dispatched on both TaxiPak and Pathfinder for several months until Pathfinder, the new dispatch system from *Digital Dispatch*, was stable. Dispatching with two different systems was considerably harder and put pressure on the call-centre staff. The objective is thus to minimize the duplication time without going over to big-bang.

Finally, the phased strategy makes an implementation over a period of time. This is possible especially if the system consists of independent parts that can be introduced separately. This strategy works well with complex systems that require a smoother transition. In addition this phased strategy explains some types of dip phenomenon that occur late in the process when renewal is about to happen. Depending on the slopes of the introductory and abandonment processes, the risk for a dip phenomenon exists.

From the figure above one sort of dilemma arises[27]. As new technologies come about faster, the development and installation of these technologies also needs to be performed more quickly to keep up the development pace. However as the systems get more complex, the difficulties and problems that arise before, during and after installations make them more cumbersome. These two observations are therefore mutually exclusive and if, from a timing point of view, big-bang should be preferred, the complexity advocates alternative renewal strategies. The only hopeful answer to how to reconcile these two apparently contradictory viewpoints is by evaluations of each particular case.

Although the renewal phase is general enough to be applied to any technology-based innovation process, a clear connection to wireless information systems exists. Due to the nature on wireless information systems, physical characteristics pose constraints to the methodology for development of such systems to ensure organizational feedback as indicated by Krogstie et al. (2004). In addition, the application life cycles become shorter because the technology itself is still emerging and developing rapidly. Renewal aspects become thus more central.

Prototyping and versioning represent two approaches to cope with this issue. However, new versions of software are already available when implemen-

[27] A number of dilemmas are discussed in the text and summarized in Chapter 7 through a number of paradoxes (cf. Section 7.1).

tation just finished. As systems increase in complexity the implementation phase gets longer, the usage or infusion stage shortens and the abandonment or migration comes earlier. This was the case in Taxi Stockholm. When they finalized the implementation project, a new version of Pathfinder was available and the supplier pushed them to migrate to the newer version.

5.1.2 Process-based Modifications of the OIP

From what has been said, a bi-dimensional organizational innovation-process conceptualization including the renewal phase has emerged. Next, we shall look at another closely related issue in relation to the model's linear character. Thus, additional insights more directly related to the temporal aspect of the process are discussed below. The linearity of the model is discussed from the perspectives of trial and error based adaptation, the versioning-development approach and finally the iterations in a spiral. An alternative conceptualization of the process is proposed on the basis of the way the phases unfold.

So far, the organizational innovation process has been depicted linearly implying that phases and, within phases, stages develop in a neat and orderly way. This model revealed, among other things, the interdependencies between the stages and highlighted the less well researched phase described earlier as the renewal phase of the process.

However the position shared in this research is that this conceptualization should not be confused with a belief about a process where stages neatly follow each other. In practice, these stages are much more interdependent and linked to each other in a non-linear manner.

Although this insight originates from research discussions and ordinary life observations, a number of passages from the cases studied support this idea.

As illustrated by Westelius and Valiente (Article 2) technology-related change processes demand attention to the interplay between planning, i.e. trying to overcome obstacles and reduce uncertainty, and the more unplanned consequences of change. These unplanned change activities question the conceptual linearity of the organizational innovation process.

One such example from the cases was the discovery of bugs, defects in software or hardware that caused the wireless systems to malfunction. At Taxi Stockholm software bugs were encountered both during and after the installation of Pathfinder as more and more cabs were migrated to the new system. These bugs required fixes distributed to the company through patch images added to different versions of the system. Some patches required the revision of work practices before re-launching Pathfinder. This example illustrates how loops between the redefining and the accepting stages were a fact during the introduction of Pathfinder.

At BT Europe different prototypes were developed and tested before the final version of the application was delivered to the service technicians (Article 2). Moreover a small-scale system introduction at two different local divisions (U.K. and Sweden) to test the system for live working before launching it globally required iterations within the redefining, accepting and routinizing stages.

Iterations between the abandoning and migrating stages were also present at Taxi Stockholm. As explained in the section about renewal strategies above, Taxi Stockholm had to dispatch both on TaxiPak and Pathfinder for several months. When most cabs were migrated to Pathfinder and TaxiPak was set to be abandoned, a server halt obliged the company to revert to the old Motorola's TaxiPak until Pathfinder was fixed.

From what has been said, the iterations described question the linearity of the model introduced earlier. It is however worth noting that iterations exist *within*, but are less common *between* the phases. Thus we would like to argue for loops within the stages of a particular phase (cf. Figure 23).

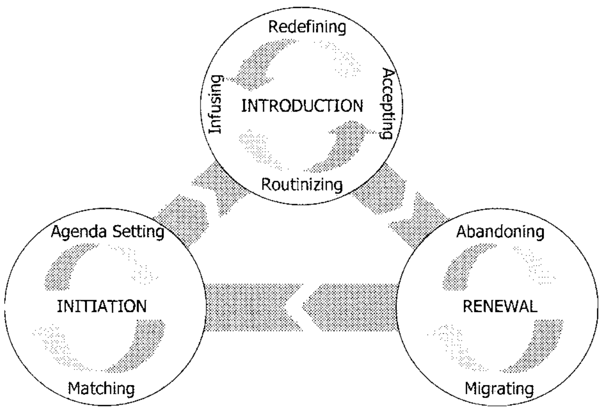

Figure 23 Iterations of stages within particular phases of the OIP

The watersheds mentioned earlier, such as the investment approval, provide check points before proceeding to the next phase. It may be suitable to mention that the second watershed between the introduction and the renewal phase will be labeled here as *support discontinuance*. This step represents the decision to stop maintaining a particular system in order to retire it or replace it because it is no longer needed, superior software has been developed, the hardware needs to be replaced, etc. (cf. Zvegintzov 1984).

This conceptualization is consistent with the teleological school of change processes based on the assumption that development proceeds according to recurrent, discontinuous sequences of goal setting, implementation and evaluation of achieved goals in order to proceed through the change process.

Taxi Stockholm illustrates this type of development. The teleological development stresses the importance of iterative loops as illustrated above. Taxi Stockholm's migration of the different systems in a phased manner highlights the importance of iterative loops of manageable size. The radio, telecom, dispatch and car equipment were upgraded and evaluated before proceeding to the next phase in a good teleological spirit.

The model above is a combination of the teleological and life cycle theories. At the stage level, teleological interpretations explain the way the organizational innovation process unfolds. Within each stage, event progression consists of constructing an envisioned end state, taking action to reach it and monitoring its progress. Further, the progression at the phase level in the model can be interpreted with life cycle theories characterized by a sequence of phases that unfold more or less linearly.

In this sense, it could be particularly appropriate to discuss the sequences not considered in Figure 23 above. The counter clockwise path includes three different development cases that are not considered in the model, namely (a) introduction to initiation, (b) initiation to renewal and (c) renewal to introduction.

The first one represents the case when the introduction of a new technology fails, and a fresh re-start is required. Such abandonment of a technological venture before it is finalized is present both in earlier research and in practice. However, although minimal, the re-start requires an abandonment strategy even if it is not even formulated. In addition, the new venture is then considered in the model as a new organizational innovation process and the experience is brought into the new process.

The second case, initiation to renewal, is less common and therefore it has been excluded from the model. There is a hypothetical case of organizations, during the technology matching stage, becoming aware of the need for abandonment and skipping directly to the renewal phase without any new introduction. This case is more speculative, and it is therefore not considered.

Finally renewal to introduction represents the third case also beyond the scope here. The stance defended in this research is that, although sometimes minimal, there are often time and efforts devoted to planning and initiating the introduction of new technologies in organizations. Thus, this case is also less relevant for our purposes.

In order to avoid the linearity of the phase development, a limitation that puts too much focus on the extreme points of the process, we propose a process that unfolds in a loop-like manner without necessarily a clear end point. The discussion about the need of renewal above stresses this fact. In addition an observation from the cases is that continuous improvements of installed systems are common among organizations, which therefore indicates that innovation efforts push development forward similar to the way loops progress.

This is a consequence of the organizational innovation process being path dependent. This process is not exactly the same along each iteration because each iteration influences the process either positively or negatively. Each of the phases advances one or more aspects of earlier accomplishments. Sometimes these advancements represent deteriorations but in the long-term some improvements are usually achieved.

Thus, we propose a framework based on a helix path that develops in time and rises as it turns. The helix path lies on the surface of an elliptic paraboloid or circular cone as depicted in Figure 24.

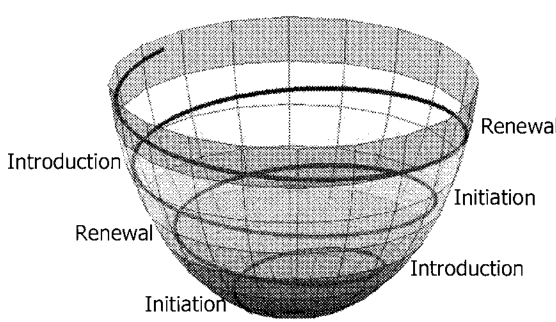

Figure 24 Helical-based model of OIP

This conceptualization is in line with Smith et al's (2002) business use of wireless technology in different stages that improve each other. They mention five stages that can be understood as evolutions along the helix curve. Other similar models have been proposed earlier (cf. Boehm 1988; Boehm and Hansen 2001). However, one main difference is that their model is based on the spiral metaphor on a two-dimensional surface. The tri-dimensional model proposed here helps to visualize the development by including the time dimension along the perpendicular axis[28].

The radial dimension in Figure 24, i.e. the distance from the origin, represents the cumulative level of utility of the underlying business process studied. The angular dimension (angle of the ray and the polar axis) represents the intervals between the phases in the model. Finally, as already mentioned, the perpendicular dimension represents the time aspects of the OIP indicating its development. These three elements (r, φ, t) describe the helix model. They are normally called the cylindrical coordinates.

In Figure 24 above, the helix path lies on the surface of a circular cone. However, other geometric figures could develop. Generally they are called quadratic surfaces consisting of cylinders, cones, spheres, ellipsoids, etc. These quadratic surfaces depend on the characteristics of the underlying organizational innovation process described by the helix path, and they can help us to understand different dynamics that influence the organizational innovation process, at least in theory.

These quadratic surfaces depend on the shape of the exterior helix curve. This curve is normally determined by two main characteristics, namely its curvature (κ) and the torsion of the curve (τ). The curvature represents the rate of turning of the curve and the torsion is its degree of twist, i.e. the extent to which it fails to be planar. A large curvature represents a largely utile process (large radial dimension r) whereas a large torsion characterizes a fast-developing process. According to these characteristics a hypothesis about the OIPs shape can be developed. One can identify two extreme positions, namely an OIP with large curvature and torsion represents a *lean OIP* whereas a process with a small torsion and a small curvature determines a *sluggish OIP*. This is so because technological change can take many different forms. These two types of innovation have different dynamics and represent the extremes of a continuum, in between which other alternatives are possible.

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[28] A tri-dimensional spiral is normally called a helix. Therefore the term helical is preferred to spiral when referring to the development of the OIP.

5.1.3 Contextual Aspects of the Organizational Innovation Process

Additional changes to the base model will be presented here. These are however related more to the contextual aspects of the model, i.e. relationships to other players and the external influences on the process.

When studying the process of technical development and especially innovations it is important to emphasize the search behavior on the technology developer's and the technology intensive's side. Some technology-push efforts arise from the developer's side. Earlier research has framed the innovation process as networks that permit inter-organizational interactions of exchange (including exchange of knowledge) between technology developers and the users (Robertson, Swan and Newell 1996). Their theory looks at the needs and activities of the different groups involved – from the supply side, to the innovation pool and the users. The supply side shapes the availability of technology to the users. The innovation pool is the sum of technology used to provide an answer to the user's problem. The end result is the co-modification of knowledge and its selective transfer between the participants and groups comprising a network. Such an example in this investigation is the pressure to change that motivated BT Europe to invest in new wireless technology due to the media and operator's roll-out of third generation wireless communication.

The role of third-party system integrators has been central in the cases studied. One related example can be taken from the 3G industry. Telephone operators seek new identities as providers of everything wireless through partnerships and alliances. When technological innovations are introduced in an industry, such as wireless data communication, increased choice is created (Normann and Ramírez 1994) due to the removal of entry barriers. This process magnetizes new actors to the industry, a well-known economic phenomenon called contestability (Clemons, Croson and Weber 1996). This in turn results in an unbundling process according to functional disaggregation (Hirschhorn 1984). As increased choice within the industry means that operators no longer can dominate the whole value chain, they look for alliances that could provide a total solution profile. As Clark (1985 p.238) states, emerging industries are often populated by many producers, most of whom are relatively small.

As the complexity of the solutions grow the role of system integrators becomes more and more central. This phenomenon is observed in the Taxi Stockholm case but especially in the BT Europe case, as described in Westelius and Valiente (Article 2). Development of the applications in question is performed in cooperation with system integrators, or even operators as in the Graninge case. This leads to an increased number of technology developers, in terms of new players that are attracted to the industry.

5.1.4 Summarizing the Conceptual Framework

Some facets of the organizational innovation process recognized so far include the presence of recursive stages, the sequential character of the innovation phases along a helix path that helped us to distinguish between lean and sluggish processes; the importance of the renewal of technology, especially when it is followed by upgrading the existing technology; and the fact that these processes are externally influenced by technology suppliers, management consultants and/or system integrators.

These findings both contrast with and complement earlier findings described in Chapter 3 above. Table 11 shows some of these differences organized along three dimensions: *Learned* aspects from earlier research are contrasted with *observed* phenomena in the cases studied. Finally the *conclusions* indicate how these dissonances were taken care of here.

Learned	*Observed*	*Conclusions*
Earlier models of innovation and implementation have focused on different process phases. Representative of these are initiation-adoption-implementation.	Less attention has been paid to the phase after the introduction of technology deemed important in the cases studied.	The renewal phase was included in the organizational innovation model to reinforce its importance.
Some of these earlier models consider implementation of new technology as clean slate projects with little or no pre-existing applications.	Implementations of different applications were intertwined and dependent on each other.	The organizational innovation process was depicted as a helical model where different technology generations follow each other.
The life cycle metaphor used in some of these models influences the conceptualization of new technology implementation as a linear process.	The reiteration of some of the stages within the phases was a salient phenomenon in several cases.	Iterative loops were used to explain the teleological development process within each particular phase.

Table 11 Learned-about process innovations

This conceptualization is one of the results of my research and offers a slightly different description of the implementation process than what is commonly found in earlier literature. More common are descriptions of linear processes, studies that only take into consideration the design and installation of the systems and where implementations are considered as an investment approval instead of a development and change process.

5.2 Organizational Challenges

So, what are all the articles included in this work and the discussion so far really about? One possible interpretation, based on a number of recurring themes such as the renewal of obsolete technology, mutual adaptation requirements, unplanned changes, etc., is that it is all about challenges!

Despite the extensive use of challenges in earlier studies, there is no clear definition of what challenges really mean as it often depends on who you ask and the evaluation criteria used (cf. Lundeberg's discussion in 1993 p.91ff. about deletion, distortion and generalization based in Bandler and Grinder 1975).

Simply put, a challenge is a threat or a problem. However, all problems are not challenges according to the use of the term in this dissertation. The term challenge in this dissertation differs from the term problem in that challenges are considered as *demanding* and *stimulating* situations whereas problems do not always need to be stimulating.

Challenges are considered here as triggers of the process of going from a current situation to a future desired state. This view is inspired by the Y-model (Lundeberg 1993, 2003) that describes and helps us to analyze the different alternatives associated to a particular change process. Challenges are the antecedents in some change processes labeled *need for changes* in the Y-model (cf. Figure 25). Worth noting is that not all challenges lead to changes. More often than not, the identification of challenges is a framing issue. A problem can be framed as a challenge when described in positive and stimulating terms.

It is also worth revisiting the difference between resources and challenges because both represent antecedents to the change process. In this dissertation resources are considered factors of production such as capital, technology, labor, etc. However challenges are demanding situations that trigger change. For example, the IT infrastructure platform of a company is a resource, whereas obsolete hardware represents a problem and the upgrading of the technological platform to meet future customer demands a challenge.

Equipped with these distinctions and the organizational innovation process introduced above, we are now prepared to review the challenges present in the cases studied.

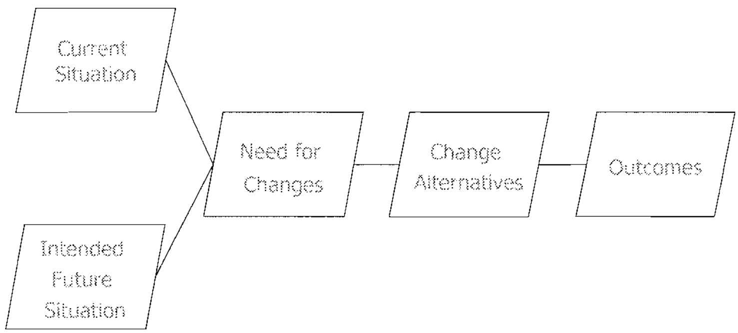

Figure 25 Different types of process focus in a change process: The Y model[29]

5.2.1 Challenges in Practice

In the following section the challenges from the case studies are discussed through the different phases of the organizational innovation process introduced previously (cf. Figure 23). Each section includes the challenges from a particular phase and it ends with a table that summarizes the discussion to increase the clarity of the exposition. The tables include both examples from the cases and the patterns that these examples represent. Although some of these challenges have already been discussed in the papers separately, in this section I would like to address them in more detail and segment them through a case by case analysis following the different stages of the innovation process.

The list of challenges discussed below is not exhaustive. They represent a small subset of challenges described during the interviews in the organizations studied. The classification is nevertheless based on my own personal interpretation of the situations described. The value lies not in the list per se, but in connection to the capability discussion in the next chapter.

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[29] The interpretation of the figure goes like this. The Y-model helps to sort out different process focuses related to change processes. Information about a particular situation can be sorted according to its relation to either a current situation or an intended future situation. Using this distinction, it may be easier to analyze the needs for change, and different alternatives that may be relevant in closing the gap. A plan for the future actions can be finally developed.

A. Initiation phase

The initiation phase is important for project sponsors and managers because one aim is to take the investment proposal across the watershed of investment approval if the case is sound. This is done by scanning organizational needs and evaluating IT solutions. Project sponsors search for a match between organizational opportunities and the IT solutions as the pressure to change increases from either organizational needs (pull), technological innovation (push) or both. This phase has been called also by others the exploration phase (Clark and Wheelwright 1993).

A.1 Agenda setting

During the early stages of the innovation process we come to observe some struggling to become aware of technology's opportunities. The opportunity awareness process was often distorted by the newness of wireless technologies (cf. Table 12 that summarizes this section's discussion). This process is made even more challenging by the fact that the properties of emerging technologies, which typically evolve quite rapidly, are affected by early organizational users.

This was for example the case as the opportunities of wireless technologies were exaggerated, especially in newspapers and promotional material. This media hype or sensational promotion of technology is exemplified in the following examples from articles in newspapers.

In the October 2000 print edition of Red Herring, a media company whose mission is to cover innovation, technology, financing and entrepreneurial activity, a closer look at the state-of-the-art broadband wireless technology was reported in the following terms:

> *"Now we're in the midst of a turbulent communication boom that would unnerve even Marconi*[30]*. Fiber-optic cables are being laid at a frenetic rate to carry terabytes of Internet traffic for businesses and consumers. Wireless transmission towers are being deployed throughout cities and countries to keep pace with the snowballing information glut, and so people can keep abreast of the latest stock market rally or plunge. Across Europe and Japan, wireless tech-*

[30] Guglielmo Marconi, the Nobel Prize winner in physics 1909, was an Italian inventor who experimented with wireless telegraph technology already back in the late 19th Century.

> *nologies have rapidly become part of the social culture and business environment. There's no turning back." (Bruno 2000 p.280).*

Three excerpts from different articles about the cases included in this dissertation published in periodicals show how expectations about these cases were also somehow unrealistic. Fast Company published an article about Taxi Stockholm in May 2001 that described future developments for the system in the following terms:

> "*In the works is the addition of new technology that will allow Taxi Stockholm to home in on mobile handsets. By this summer, Malmqvist plans to offer customers a precise taxi ETA every time they call for a cab – estimates that will take into account congestion and other traffic snarls – and an automatic call-back function that will confirm each reservation. And by the end of the year, Malmqvist plans to have PCs with Internet connections installed in each cab to give the drivers access to route maps and other information from headquarters.*" *(Wylie 2001 p.53).*

ETA stands for estimated time of arrival, and the offering of Anders Malmqvist, the CEO of Taxi Stockholm between the years 1996-2001, is not available yet. Customers have demanded neither information about estimated time of arrival nor the automatic call-back function for confirmation of reservation. The vision of PCs with Internet connection is also somehow unrealistic as the bandwidth of the wireless connection in the cabs is only 9,600 bps[31].

The BT Europe case was described by a Microsoft Case Study titled "BT Industries drives down costs with a Microsoft mobile workplace solution". One of the benefits mentioned in the case was "*Any time, anywhere access of business-critical information for field staff*" (Microsoft 2004). This was obviously not the case as the solution was built upon synchronization (cf. Article 2). Still today, service technicians in Sweden experience problems when synchronizing the devices early in the morning due to congestion problems because most of the technicians want to know the status of reserved spare parts at the same time.

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[31] As a comparison a GSM cell phone has a data-rate of 9,600 bps, a computer modem around 56,000 bps (56 Kbps) and broadband access may vary between 500 Kbps and 10,000 Kbps (10Mbps).

Finally, the case of Graninge was described at an article in Telia Mobitel AB, an internal periodical of Telia AB, in the following terms:

> *"Machine operators should in the near future be able to download even more information from the central office. We are considering transferring geographical information and maps to delimit the harvesting areas."*[32] *(Telia Mobitel AB 1996).*

This was also overestimated functionality for the application.

Despite these success stories in the media, the implementation of wireless applications in all three organizations was far from painless, especially as they were pioneers and limited experience could be transferred from similar implementations. One example was the use of geographical information like maps for harvest delimiting purposes at Graninge. The company tried to use one such application but because of the rudimentary maps and capacity problems in the connection, the idea had to be abandoned.

A.2 Matching

The next stage within the initiation phase is the matching process. Two different types of challenges emerged in the cases studied, namely the provider interests and the requirements complexity (cf. Table 12). One important goal during this stage is to get organizational support for the introduction of the application.

Provider interests represent the challenge posed by the application vendors when approaching or being approached by the implementing organizations. The choice of application provider was challenging because of the difficulty in finding both an experienced and committed provider.

In the cases studied, the providers were either experienced or committed. Large solution providers often possess experience built up during many years of work. However, if this competence does not fit with the company's overall strategy, there is a risk for limiting the further development of applications. This was the case of Motorola, the solution provider for Taxi Stockholm. Motorola reduced their support of the transportation industry because of focus shift towards other operational areas.

Sometimes, smaller players with less experience take this as an opportunity and commit themselves to these particular areas offering more focused

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[32] My own translation from Swedish.

solutions. This phenomena was explained earlier through the implementation of technological innovations that increased commercial choice because of the removal of entry barriers (Normann and Ramírez 1994). This process magnetizes new actors to the industry. In this context, a large and experienced supplier may not always be the preferred option as small new entrants may show larger commitment to the application offered. However these new entrants usually have limited resources.

In the cases, Taxi Stockholm opted for a committed player (Digital Dispatch) and abandoned Motorola whereas BT Industries chose Sogeti, an experienced system integrator. Graninge did not actively select a provider as it was approached by Skogforsk and Telia to collaborate in an already existing project.

The other challenge in this stage is the requirements complexity. Actually, the requirement analysis performed at the implementing organization can be considered as laying the ground for going from the as-is to the to-be environments (Evans 2002 p.153).

This specification of the application envisioned influences the adaptation of the developer's application to a specific market. In Taxi Stockholm the fact that a large part of dispatching is carried out via the call-centre and not on the street put pressure on Digital Dispatch, which was obliged to modify their product accordingly.

Another challenge connected to the specification of requirements is the fact that many of the change drivers associated with wireless solutions cannot be expressed in monetary terms. BT had problems identifying the revenue drivers associated with the EASY application. However a number of cost reductions were more easily identified. There were a number of other non-monetary drivers that were also important. In the Graninge case the central issue was to secure the budget of the project through grants and R&D allocated funds. These were two different paths for securing the organizational support.

The discussion above from the *agenda setting* and *matching* stages within the *initiation* phase is summarized in the table below.

Stage	*Challenges*	*TS*	*Graninge*	*BT*
Agenda Setting Organizational problems or technological opportunities increase the pressure for change. An awareness process develops that tries to contextualize opportunities of particular emerging technologies into the organizational setting.	Newness of emerging technologies	Internet PC and route maps	Rudimentary harvesting maps	Synchronization congestions
	Media hype	Fast Company: All Hail Taxi Stockholm	Telia Mobitex Forward-looking at Graninge sawmills	Microsoft Case Study – BT Industries
	Opportunity awareness	Taxi ETA and automatic call-back	GIS (geographical information system)	Anytime, anywhere access
Matching This step comprises some kind of match between an IT solution and its application in the organization. Negotiations to get organizational support and efforts to choose suppliers and system integrators are undertaken.	Provider interests	Digital Dispatch – a committed vendor	Skogforsk and Telia	Sogeti – an experienced vendor
	Requirements complexity	Call-centre dispatching	Secure budget	Revenue drivers of EASY

Table 12 Initiation challenges

Summarizing, the combination of challenges presented in Table 12 above builds up what I choose to label the *technology assessment* challenge. The challenge represented by the newness of emerging technologies, media hype, managing technology provider interests, etc., ultimately deals with the issue of contextualizing emerging technologies. Thus, technology assessment connects to the first uncertainty described in Earl (2003), the enabling uncertainty (cf. Table 4), and it confronts companies with the question: what can technology do for us?

A comparison of this challenge with the implementation factors discussed earlier reveals a similarity with Feeny and Willcocks' (1998) first risk about how to address a two-way strategic alignment between business and technology. They write: *"Business and IT vision requires insightful assessments of the myriad claims about what technology can do and how to use it"* (Feeny and Willcocks 1998 p.10).

The question what technology can do for us is linked to the problems managers find trying to identify the real scope of technology. The answer depends on, among other things, two important dimensions. These are the level of maturity of the technology analyzed and the level of experience (or newness) in the adopting organization. The combination of these two dimensions provides us with a number of roles assumed in the organizations that implement the technology as illustrated in Figure 26 below.

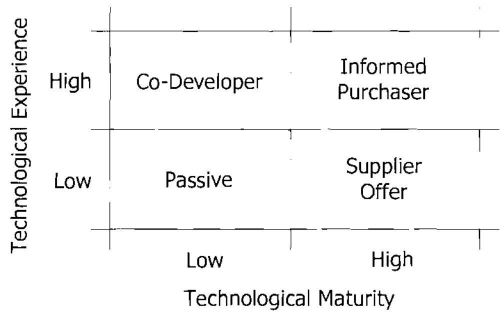

Figure 26 Roles of implementing organizations

One example from the cases studied is the role of Taxi Stockholm as co-developer of Pathfinder. Taxi Stockholm's experience with radio dispatching technology was extensive as they had dispatched via radio since the 1970s. Pathfinder was incomplete at the time Taxi Stockholm decided to implement it. They became a product co-developer as their experience about automatic dispatching was extensive, something that the company was not fully aware of at the project start point. This is illustrated in Figure 27 below where BT Industries and Graninge have been positioned closer to the passive role as their experience with wireless technology was more limited than Taxi Stockholm's.

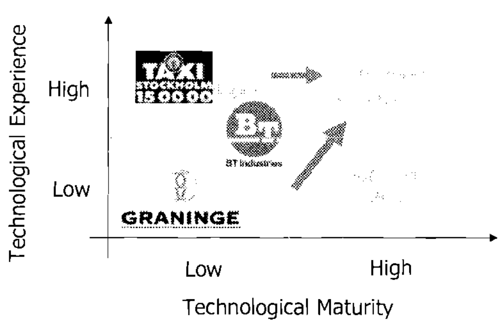

Figure 27 Dynamic view on technology assessment

One insight is that neither the technology experience nor its maturity is static. As already pointed out in Mårtensson and Valiente (Article 4), the

CCT model introduces a dynamic view of how technology experience influences requirements for what technology can provide as the organization's offering matures. The same phenomenon can be observed within the initiation phase. This matching process between experience and maturity is a moving target (illustrated through the arrows of Figure 27 above), where firms try to become informed purchasers and not supplier offers. The efforts of Skogforsk to improve Graninge's capability to implement emerging technologies illustrate the evolution of technology-assessment roles in one of the companies.

A consequence of this evolution of roles is the trade-off between freezing configurations in order to meet deadlines (managing technological maturity) and handling continuous change requirements that appear (nurturing technological experience). This represents one additional dilemma.

B. Introduction phase

The introduction phase includes activities such as the development, installation and usage of new technology. Let us now proceed to see what type of challenges appeared in the cases during the four different stages included in this phase, namely redefining, accepting, routinizing and infusing (see Table 13).

B.3 Redefining

A major challenge connected to this particular stage relates to the uncertainty whether technology will work alongside existing work practices. More often than not, technology and work practices need to be re-aligned. Old work practices do not fit with the new technology and the new technology enables new work practices not available earlier. Thus, during the introduction phase an important challenge of the redefining stage is the revision of organizational work practices.

A good illustration taken from Article 1 is the installation of GPS equipment in the taxi cabs that allowed for automatic checking process into a zone. With the previous system, drivers used to check into a zone manually. This process was inefficient and the reason for reduced cab load. For example, drivers were aware of the high demand on the route Kista – Arlanda (route joining a dense industrial suburb with the Airport). Many drivers on their way to Arlanda checked in the Kista zone, even though they were still at the airport. Available cabs arriving to Kista were allocated high queue numbers on check-in at the area. A large number of available taxis therefore left the zone, discouraged of getting any customer even though no free cabs in fact were available at Kista because they had not arrived yet.

Another revised work practice at Graninge was the price lists distribution. Price lists were made at the head office and sent out to the harvesters automatically. When pricelists were distributed through the work leaders instead, local foremen lost control over the distribution process and complained. On the other side, an unexpected benefit of using text messages for communication was that a lot of small talk was avoided. When work leaders can send messages instead of calling they save a lot of time.

At BT Europe, EASY enabled a more accurate assignment of spare parts to specific trucks serviced. Previously, parts could be assigned mistakenly to recurrent service orders where BT had a service contract with the customer that did not include spare parts. As these spare parts were not assigned to a new work order they would not be charged to the customer. EASY impedes this practice, and technicians are required to charge all spare parts used.

This revision of work practices is also challenging as it brings about large uncertainty among employees. Revision of work practices may directly affect the personnel through layoffs because of system automations. The increment of efficiency within the organizations leads to the need of fewer people. At Taxi Stockholm the IT department was outsourced, whereas Graninge had no need to release personnel. By contrast BT Industries utilized the situation to reduce the personnel at the back office. This was badly timed as it was done at the beginning of the process when most people were needed. The layoffs were necessary, but the timing can be questioned.

B.4 Accepting

In this stage, we include the commitment to use the IT-application. There is a risk that systems that have been installed become only partially used. Additional challenges thus appeared in the cases studied to get the systems used. In this stage the main challenge observed was the IT-assimilation challenge (cf. Table 13).

The fact that we study blue collar workers makes IT assimilation especially important as a result of some of their distinctive characteristics. For example, blue collar workers do not usually have extensive experience of information technologies. One of the project leaders at Graninge explained how difficult it was to make people understand the concept of data transfer. They had never used a PC before and they had not heard of e-mail back then. They were totally unfamiliar with the new tools, and they had difficulties seeing the benefits before they had the opportunity to use the system. He mentioned that people working as machine operators in the forest industry are hardly computer geeks.

Another example is moonlighting at Taxi Stockholm that, although limited, it has been difficult to control because of the cooperative character of the company with independent taxi owners. The installation of GPS and the automatic allocation of queuing numbers hinder this practice as the call-centre can nowadays monitor the taxi cabs. Although monitoring of moonlighting has not been practiced actively and thus has not been a real obstacle to the assimilation of the IT application, the automatic allocation of queuing numbers is a challenge to drivers that develop their own ways of working, often learned on the field.

Blue collar workers are often trained on the job and they learn while working. For example, lunch breaks entail disruptions for the taxi drivers that are allocated a queue number automatically. These breaks often mean higher queuing numbers when returning to work. The waiting periods after the lunch are larger because most drivers take the break at similar times. A workaround devised to keep the queuing number while having lunch was to disconnect the antenna from the GPS sender.

Blue collar workers are employees who perform manual or technical labor in field environments in contrast to white-collar workers who do non-manual work, generally at a desk. This description occasionally carries a stereotype based on the historical development of the concept. However, though challenging it was very rarely considered as a negative by the project managers in the cases studied.

As work is often performed out in the field, targeting the real needs and problems these workers find most annoying is another aspect of this challenge. Often blue collar workers are afraid of admitting that they do not understand something. Instead they keep silent. For example, a number of less IT-acquainted technicians at BT had problems using EASY as some customer data was missing on the screen presented to them. This was not because data was missing but because columns were too narrow for them and therefore it seemed like data was missing. By dragging from the border of the columns more information could be showed. This obvious functionality for a standard Microsoft office user was not so obvious for some members of this user group, and it took some time for the back office at BT to understand the problem they were experiencing as support had to be carried out remotely.

B.5 Routinizing

Next, usage is encouraged as a normal activity and the observed challenges were the need to disseminate know-how practices and the personalization of the solutions (cf. Table 13). The mobility of the blue collar workers studied represents both strengths and weaknesses. Wireless technologies target the dynamic, flexible and often urgent nature of the users' work very well. At the same time the mobility of the workers over large geographical areas makes coordination harder.

A good illustration of this is BT Europe and their upgrade process of the software in the handheld terminals. The standard procedure for updating the application involves collecting the terminals from the service technicians, switching chips, and redistributing the terminals. The collection and the distribution of new terminals is carried out by post which represents both an expensive and time-consuming activity. Taking into account that this is a disruptive process to the service technicians' work, the project team has refrained from smaller PDA updates.

Once the system is installed one optimal dissemination process among blue collar workers is through word of mouth where users train themselves. However this is impeded by the location uncertainty of the mobile work-forces. Thus, the lack of socialization opportunities represents another challenge for the project managers as best practices are not so easily communicated to colleagues. At Graninge it was for example important to remember that someone out in the forest, unlike an office worker, does not have anyone to ask in case of trouble. Out in the forest you are completely alone. Similarly taxi drivers used to socialize at taxi stands which are nowadays almost completely removed.

The blue collar workers studied have solved their socialization problems through the use of the cell phone. In contrast to the fact that blue collar workers do not usually have extensive PC experience, they are regular users of cell phones and even early adopters. Among these people coordinating lunch is considered as an important socialization activity and it is mainly carried out through the cell phone.

Their experience of how cell phones work increased expectations on the EASY terminal. As technicians became more acquainted with the EASY tool, waiting for the next screen to load was experienced as highly annoying, and gave the impression that filling out electronic forms was more cumbersome and took more time than filling out the paper based version. However, measurements have shown that the computerized process seems to be no worse, and perhaps even faster overall than the paper based process, but the stress of not being able to control the progress yourself leads to a subjective evaluation that differs from the measurements. This is one consequence of the exploration based usage in comparison with how their instant feedback experience of tools such as the phone worked for them.

Finally, I would like to mention that wireless terminals are very personal devices. This represents a challenge for organizations as a balance between private and work life has to be reached. Otherwise the mobile terminals may very well end up being used for other purposes than intended. BT found out that the system terminals had a number of built-in applications not necessary for the tasks of the workforces. They enforced a lock-out of non-wished functionalities. Another example is the use of taxi cabs during vacations when some immigrant drivers return to their countries of origin. The use of GPS positioning system hinders this practice nowadays.

B.6 Infusing

Once the IT-application has been developed and installed and its usage becomes a normal activity of the organization, there comes another period called the infusing stage. It is during this time when the application really is squeezed to the maximum and incremental improvements are done, often directly after the dip phenomenon has occurred, to fine tune the application. Different maintenance activities to keep the information systems operational are also launched. The main challenge in this stage was to maximize the benefits.

Taxi Stockholm is aware of the potential gains of the new system but they have been unable to take full advantage of them. Pathfinder can be tailored in many different ways, but until now they have not been able to start 'playing' with the system functionality due to instability problems and implementation uncertainties. Taxi Stockholm prioritizes system stability before testing new work practices. For example, it is possible for drivers to make reservations for particular pre-booked customers. A driver can check if there are any booked customers in the area where he plans to start the following day and make a reservation for that customer. However the applet has not been activated yet.

Another example that shows how Graninge tries to squeeze the application to make further improvement is SKINFO. As new ideas started to appear about what to do with wireless data communication, a follow-up project called TIMPG (timber on demand) was launched. TIMPG was not as successful as SKINFO. The vision of this project was to bring forest districts closer to the sawmills in order to achieve better control and follow-up. However this vision of harvesting on demand was never realized. Instead the company was bought by SCA and future plans for IT were postponed.

At BT Europe a new application, the spare parts catalogue (QP), was added to EASY. Each service technician thus had access to the entire range of trucks and their spare parts without needing to downloading drawings and catalogue data over the slow, wireless connection.

Moreover during this phase, older applications that earlier had to be mindfully intertwined with the new systems, can be definitely phased out. This was the case with the withdrawal of TaxiPak as the servers were locked in a closet and the operation terminated. In a near future this can also be the case with BT as the phone calls to the back office are not longer needed, and data communication channels are the only ones used. However, when and how to abandon existing systems are challenges that will be discussed in the next phase.

The discussion above from the *redefining, accepting, routinizing* and *infusing* stages within the *introduction* phase is summarized in the table below.

Stage	*Challenges*	*TS*	*Graninge*	*BT*
Redefining A project structure is established. The organizational work practices are revised and the IT-application is developed and installed. Finally the IT application is put to work.	New work practices	Manual check-in of taxi cabs	Price lists distribution	Spare parts
	Layoffs	IT department	n/a	Back office
Accepting The IT application is available in the organization. Commitment to usage of the IT-application has to be achieved.	IT assimilation	Automatic queuing numbers	Unfamiliarity with the concept of data transfer	Keep-silent behavior
Routinizing Usage is encouraged as a normal activity, and different types of evaluation are performed to check for achievements and new roles in the organization.	Know-how dissemination	Socialization taxi stands	Loneliness of forest work	Software updates in terminals
	Personalization	Vacation usage of cabs		Lock-out of unwanted functionality
Infusing The application is squeezed and incremental improvements are made to fine tune the application.	Benefit realization	Application fine-tuning	TIMPG	Quality Parts

Table 13 Introduction challenges

In order to choose an appropriate label for the aggregation of all these challenges, the remaining two uncertainties described in Earl (2003) also appear useful (cf. Table 4). These uncertainties, the commissioning and the impact uncertainty, were linked to the following questions: Will technology work? Will users adopt it?

The challenge label chosen in connection to the first question is *work system alignment*. Often technology does not work or fit into an organization because the work practices differ from the functionality imposed by technology. Work-system alignment comprises the challenges included in the first and last stage, namely the redefining and the infusing stage. It refers to the revision of current work practices to align them to the new opportunities provided by the technology. Challenges such as new work practices, layoffs and benefit realization are included here.

This challenge also connects to the earlier discussion about implementation factors. Work-system alignment was discussed as the first key assumption in the socio-technical approach. Often emerging technologies change the entire work system of an organization. The challenge consists of being able to align the new work system and the design of the technological system. It also connects to work flow integration described in Linton (2002) and the challenge of identifying benefits both during and after the re-alignment of practices discussed in Eason (1988).

Next, the label proposed for the second question above about whether users will adopt the technology or not is *blue collar worker adaptation*. It comprises the challenges in the accepting and routinizing stages, such as the IT assimilation, know-how dissemination and personalization.

These challenges particularly connect to the discussion of Robey et al. (2002) about knowledge barriers, especially relevant when studying blue collar workers. Kwon and Zmud (1987) discuss role involvement as a factor that creates a positive attitude towards change also discussed in Summer (2000). This challenge concerns user adaptation, which is similar to people's resistance to change discussed by Markus (1983).

Finally, there is an argument based both on the commissioning and the impact uncertainties that connect the users with wireless technologies. The argument links different occupational communities (Gerstl 1961) with boundary objects (Star and Griesemer 1989) as follows.

In the theoretical section (see Chapter 3, Section 3.3.2) we described blue collar workers as members of the same occupational community. They represent groups of individuals who belong to the community because they share the same occupation. They are contextually bound, and they do apply a common competence in the pursuit of the same enterprise. Both machine operators at Graninge and service technicians at BT develop their identity from their work. In addition there is a power struggle between management and occupational communities. The taxi example of automatic queuing numbers in response to the high demand on the route Kista – Arlanda illustrates this.

In the examples above, the taxi drivers, machine operators and service technicians are clearly delimited examples of occupational communities that do a certain type of work, talk to each other about their work and derive their identity from that work. These occupational communities interact with other groups within their respective organizations when coming together to solve a particular problem of common concern (cf. discussion included in Article 1 about coordinating and operating actors). For example, taxi drivers interact with members of the call centre in order to dispatch customers with transportation needs. Table 14 below summarizes these interactions.

	Blue Collar Workers	*Coordinating Actors*	*Interactions*
Taxi Stockholm	Drivers	Call-Centre	Customer Dispatching
Graninge	Machine Operators	Operations Office	Updating Harvest Data
BT Europe	Service Technicians	Back Office	Reporting Work Orders

Table 14 Interactions between occupational communities

When different occupational communities come together with different interests they face more communication problems in their interactions than do members of the same occupational community. This was illustrated above through the keep-silent example and the lack of familiarity with Excel sheets. Communication across occupational boundaries is especially challenging because different backgrounds and work expectations are present. Members of different occupational communities need to communicate with and learn from others who have a different perspective and perhaps a different vocabulary for describing their problems or challenges. Machine operators at Graninge had difficulties understanding the concept of data transfer but it became more concrete when the operators got the wireless terminals.

In this regard, the wireless terminals used in the different cases can be conceptualized as boundary objects (Star and Griesemer 1989). The dispatch terminals in taxi cabs, the handheld devices at BT and the wireless computers in harvesting machines represent boundary objects that facilitated communication between the different occupational communities. For example, while visiting the call-centre at Taxi Stockholm one could observe DDS-terminals similar to the ones installed in the cars at the operators work spaces to support the drivers with any problems encountered.

These objects were used across-practice by both operating and coordinating actors. They could also mobilize action as in the case of BT Europe where terminal synchronization could result in new work orders requiring immediate action.

The role of boundary objects working with mobile workforces is even more important. Earlier studies have investigated technical drawings (Bechky 2003), prototype assemblies (Carlile 2002) and document archives (Briers and Chua 2001) that bring together the different communities. However wireless terminals have the capacity to keep the communities apart, yet facilitate interactions by establishing a shared language for individuals and helping individuals to learn about the differences and dependencies across a given boundary.

Finally, the role played by boundary objects in organizational innovation processes is that of facilitators of the sharing of knowledge that is situated in local practice.

C. Renewal phase

One of the contributions of this study is the highlighted OIP phase *renewal of technology*. Mårtensson and Valiente (Article 4) discuss the role of existing applications when introducing new applications or renewing old systems. As the use of information technology in companies matures, adopting new technologies increasingly means abandoning old technologies. This phase closes the loop and connects with the next innovation process. It can therefore be considered as the final or the first phase of the innovation process.

The discussion in this section is organized in two stages namely abandoning and migrating (cf. Table 15), even though for simplification purposes only the migrating stage was depicted in Figure 20 as a constituent part of the renewal phase.

C.7 Abandoning

The abandonment of obsolete technology represented a challenge for some of the organizations studied. The difficulty consisted in determining the life length of the technical systems. Organizations always have the possibility of postponing the abandonment of systems. However, large resources are often spent on maintenance of outdated systems (Swanson and Beath 1989).

The exact point in time for phasing out hardware and/or software is not a given one, but depends on a myriad of factors. The particular moment of abandonment, the form of withdrawal and the reasons behind the decision were taken seriously and considered challenging in the organizations studied.

At Taxi Stockholm the old dispatch terminals in the cabs were worn-out, too complex, requiring special training of new drivers and incompatible with modern radio-dispatching technology. Their replacement kicked off the idea of the renewal of the complete IT platform in the cabs, which in turn affected the decision to select a new dispatch system supplier. The internal CB-radio at Graninge needed a renewal back in the early 1990s. This process kicked off the idea about linking a forestry district together with the harvesting areas through data communication links.

These are two examples of how the obsolete technology triggered change towards new innovation processes.

C.8 Migrating

Finally, the migrating stage is similar to the abandoning stage with the difference that the applications are just upgraded. Two challenges were found in the cases included in the dissertation: downtime and application versioning. These are discussed below.

The challenge, or in this case we may refer to the risk, of downtime during this phase was apparent during the switching of technologies and most clearly so in these technology-intensive organizations. Bringing systems down is increasingly a non-affordable disruption and a consequence of the different migrating strategies discussed earlier in Section 5.1.1 *The Renewal Phase*.

In January 2004, Pathfinder became overloaded when all the cabs had been added to it. After three days running the system, it went down causing a major halt. Although the error was identified by the supplier, who tried to fix it effortlessly over the weekend, Taxi Stockholm decided to go back to the old Motorola's TaxiPak system. The switch from Pathfinder took just one hour thanks to the earlier requirement by Taxi Stockholm of running parallel systems. In early February, Taxi Stockholm required a SWAT team of technicians to fly from Canada to take charge of problems in situ. After almost two weeks intensive work they managed to bring the system up.

BT Europe experienced a system halt of EASY 2.0 during the migrating stage. The service-order process had become more and more technology dependent. BT became aware of this fact and its negative consequences when the application ground to a halt as the servers could not handle a large number of simultaneous synchronization requests after upgrading to the new version.

For a number of days, chaos reigned while everyone was trying to invent coping strategies and the project team was searching for the bug. During that period, business could not be conducted "as usual". Once the project team had identified the bug, a workaround was devised, according to which the service technicians were divided into groups and assigned time slots for synchronizing. This scheme had to remain in place for a couple of weeks while the program was being rewritten. Then all the terminals had to be collected, updated and redistributed again.

Finally, the management of the different versions of the installed information systems became more than a challenge in some of the cases. Often, innovation processes take time, and insights from a certain system introduction are used by the suppliers to prepare new versions of their software package. BT Industries had to cope with different versions of their ERP system, Movex, in order to standardize communication between service technicians' terminals and the ERP database. Taxi Stockholm also found that when the implementation of Pathfinder came to an end, a new package version was already available and the supplier pushed the company to migrate to the next version.

The discussion above from the *abandoning* and *migrating* stages within the *renewal* phase is summarized in the table below.

Stage	*Challenges*	*TS*	*Graninge*	*BT*
Abandoning When technology becomes obsolete the decision to abandon old systems becomes necessary. Plans for how it should be done are made.	Obsolete technologies	Dispatch terminals in taxi cabs	Internal CB-radio	
Migrating Upgrading the existing technology is driven by new versions of software and hardware. Implementation of such upgrades thus becomes necessary.	Downtime	SWAT team		System halt of EASY 2.0
	Application versioning	Pathfinder version 3.0		Movex upgrades

Table 15 Renewal challenges

The last group of challenges can also be grouped along one dimension that has to do with timing. Being confronted with obsolete technologies, the risk of downtime and different versions of applications can be summarized as the challenge of *renewal timing*. Deciding when to abandon obsolete technologies or upgrade the existing technology is a challenging decision and requires good timing.

This challenge represents a window of opportunity: too early can be as bad as too late. Choosing the best moment to migrate or abandon particular systems highlights the fleeting nature of opportunities, attractive during a time of period during which they must be seized or lost.

Because implementation factors deal mainly with the introduction of systems into organizations it is more difficult to link this challenge to earlier factor research (cf. Appendix 1). The renewal of systems lies outside the scope influenced by the decision to introduce a new system and therefore the timing aspect is a non-issue in this type of research. Thus, there is limited relationship between this particular challenge and the implementation factors described earlier.

It is worth mentioning here that timing the renewal of systems is not a clean slate decision. The introduction of new systems and even more the renewal of old systems is path dependent. Earlier choices very much influence this renewal timing challenge. A company's system portfolio both inhibits and enables future organizational innovation processes. It is like a chain where each decision is interlinked.

For example, the BT Europe case is a good illustration of this. The existing ERP system, Movex, facilitated the implementation of the EASY application and Movex was implemented as a result of a business process re-engineering (BPR) activity at BT Industries. The concept of local tinkering (Ciborra 1994) and centrally placed imaginators (cf. Article 2) explains the development of new ideas based on existing systems and future opportunities.

In the Graninge case the interlinked chains are even clearer. As a result of SKINFO new ideas started to appear about what to do with mobile data communication in a good 'problem finding' spirit. The completion of the SKINFO project started off discussions about the opportunity to implement new ways of bringing forest districts and sawmills closer to each other. This was later launched as the TIMPG project. Before this, the installation of Mobitex Units in harvesters at the Vilhelmina district attracted the attention of Skogforsk, which approached the company for discussions about the SKINFO project. A timeline of these different projects including Taxi Stockholm is presented in the figure below.

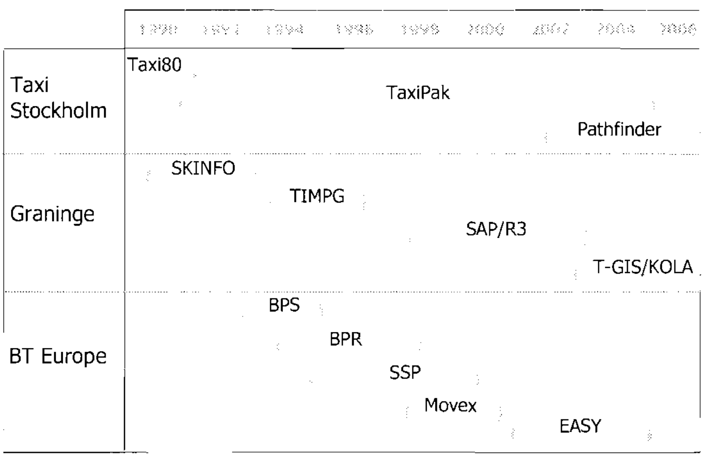

Figure 28 Timeline of the different projects in the cases

Finally, the challenge of timing the renewal of technologies applies to both installed and future systems. One insight provided by the cases studied is that the consideration of the consequences of renewal at the beginning of the organizational innovation process could have facilitated the transition in terms of lock-in effects. Thus one suggestion proposed in this study is that the consequences of this challenge should be considered not only at the end of the life cycle of a system but also at the beginning of the innovation process.

5.2.2 Final Discussion

How does this discussion relate to the original research question? The research question presented in the introductory chapter referred to the challenges that companies encounter when managing wireless information systems. In summary it can be pointed out that this investigation has identified four main challenges that are related to the management of wireless technology when involved in organizational innovation processes (see Figure 29).

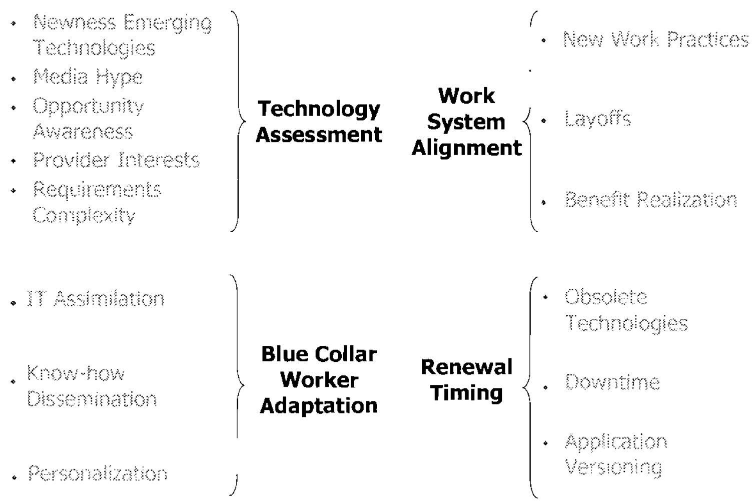

Figure 29 Challenge topics and themes

The assessment of technology opportunities represents the first challenge identified in this investigation. As we have seen this is especially important in relation to the management of emerging technologies. Second, the work-system alignment represented a challenge because the innovation process was framed as an open mode of change that generates new forms of both planned and unplanned end states. Third, the tailoring of the systems to the characteristics of the users and training them on the new systems represents an important challenge. This is especially important when dealing with blue collar workers and therefore the third challenge was labeled blue-collar-worker adaptation. This adaptation was discussed along the lines of personalization, IT assimilation and dissemination of know-how. Finally, the renewal of obsolete technology becomes a challenge to be taken care of. The timing when to phase-out old technology and implement new versions of systems were among the topics discussed. Moreover the renewal alternatives need to be discussed not only when it is time to phase out obsolete technology but even at the initiation phase of a new innovation process in order to e.g. minimize future switching costs.

Lastly, it would be interesting to consider the actual choice of challenges and compare them to results in earlier research. These challenges are related and sometimes overlap since they depend on each other. For example, the IT assimilation challenge when working with the adaptation of blue collar workers is strongly influenced by the definition of new work practices explained in the work-system-alignment challenge above.

There are other challenges apart from those presented above that are less likely to become apparent due to the approach of studying phases from the adopting organization's perspective. For example environmental challenges may very well gain in strength especially if radio waves are proven to be harmful for human beings. However, they are part of another type of research, and they have not been directly observed nor discussed in the cases studied.

Similar types of challenges connected to wireless information systems have been presented elsewhere. Belloti and Bly (1996) present a number of problems due to the mobility of workers such as lack of awareness and problems locating people. Technically related challenges in Smith et al. (2002); usage challenges in Krogstie et al. (2004), such as culture or age of adopters; or organizational challenges in Leonard-Barton (1995), have also been identified and described. However there are a number of differences with the approach taken in this research.

Many of these challenges represent challenges for research (cf. Krogstie et al. 2004). This is for example the case in Smith et al. (2002), who mention lack of standards and security as two research-specific challenges. For the purpose of this work, it is important to make clear the distinction between challenges for management and research challenges. Most of research challenges are not managed directly by technology intensive organizations. These are handled by technology based firms, sometimes also called technology developers. Therefore the focus in this work is upon management challenges rather than research challenges. Nevertheless these have inspired the argumentation in this section, and especially the description about capabilities presented in the next chapter.

In addition these research challenges refer specifically to one phase before the organizational innovation process namely the development of the systems themselves. For example, Turisco (2000) mentions slow transfer speeds, high initial infrastructure costs, limited memory and few graphical capabilities as important challenges to take care of. More than challenges these often represent limitations posed by technology. In this dissertation the focus however is more broadly on analyzing different stages and phases and not on any design issues before the implementation process.

Varshney (2003) describes a number of challenges that are more closely related to this work. These challenges are described at a more general level such as support for group communication; inter-working and integration of different technologies; and introduction of wireless technologies in business and organizations.

Another closer example is Leonard-Barton (1995) who has written on similar terms. She describes four challenges which she calls key innovation activities. These are problem solving, implementation and integration, experimentation and finally knowledge acquisition. Although her work has influenced this dissertation, her choice of challenges is different and her challenges are mostly derived from individual capabilities. Instead, this study applies an intra-organizational approach.

These factors have also a connection to the implementation factors elaborated in Chapter 3 above. The three main clusters of factors presented in Appendix 1 are also represented in the list of challenges developed in this chapter. There, organizational, technological and human factors were described. Here, work-system alignment can be interpreted as an organizational type of challenge; technology assessment as a technological challenge; Blue collar worker adaptation a human challenge; and renewal timing a combination of an organizational and a technological challenge.

Finally, I would like to mention that the value of these challenges as a research result is not derived from the particular enumeration of certain challenges. Instead, these challenges presented here intertwine with the discussion about capabilities in the next chapter. As we will see in the capability development section these challenges represent the problems experienced at the organizations studied that increased the pressure for change.

Another important issue is that while these challenges are not new when studied in isolation, their combination increases their importance as each challenge is amplified when studied in relation to the others and to change-management projects where emerging technologies are present. These are sometimes combined in ways that are not yet understood.

We may now proceed to discuss capabilities in the next chapter. The following picture (cf. Figure 30) shows the link between challenges and capabilities using the y-model (Lundeberg 1993). It moreover connects current and the intended future situations according to the resource-based view of the firm.

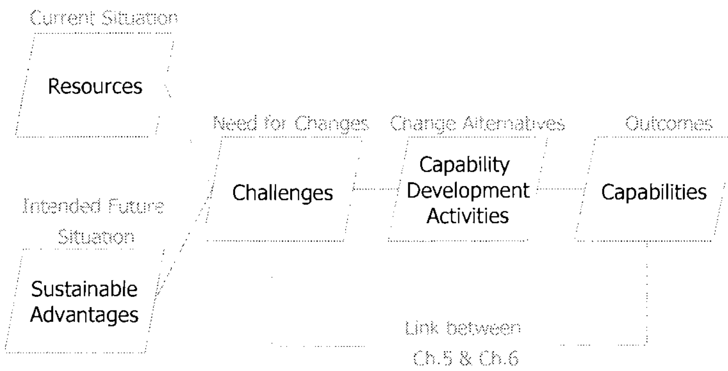

Figure 30 Organizational innovation process according to Y-model[33]

This figure is a footprint pulling together the different concepts discussed so far. It is moreover a roadmap for the analysis to come and describes the relationship between resources, challenges and capabilities as part of the organizational innovation process.

[33] Adapted from Lundeberg (1993).

6 Developing Capabilities

One natural question that follows the earlier discussion about challenges is how the organizations studied addressed technology assessment, work system alignment, blue collar worker adaptation and renewal timing. I have chosen to focus the discussion on capabilities. As explained earlier in the theoretical section, a resource-based view of the firm justifies the choice. The concept of organizational capability can help us to understand how these challenges were managed at the different organizations. The analysis of organizational capabilities underscores how managers confronted with challenges can asses whether their organizations are capable of tackling them or not.

This chapter discusses the second and third research questions introduced earlier. The section describes the capability development activities that were carried out to meet these challenges and the capabilities developed.

6.1 Linking Challenges and Capabilities

How are capabilities docked into the earlier discussion about challenges? It is through improvement capabilities that challenges can be connected to the capability discussion. Challenges, among other factors, represent demanding situations that increase the change pressure. It is however important to remember that challenges are but one change pressure factor. Other factors include market contacts, experimentation, weakness discovery, etc., all of which Miller (2003) refers to as discovery paths.

This pressure for change may or may not have an effect in the particular organization. If it leads to change, the development of sustainable benefits can be achieved. The existence of improvement capabilities, defined as the ability to develop operational capabilities, may then facilitate the change process leading to sustainable benefits.

Let me give an example to illustrate this argument (cf. Figure 31). We can consider the *technology assessment* challenge. This challenge represents a trigger of a number of change activities that help organizations to develop capabilities. If these activities lead to sustainable benefits, the ability to evaluate new technology becomes an improvement capability that can be used in different situations.

More specifically, one aspect of technology assessment introduced in the previous chapter was the selection of provider discussed in the *provider* *interests* challenge section. As long as the organization has a competent IT department, the selection of providers remains a challenge. The firm does not need to interact with external providers because it can develop information systems in-house. But the next time the IT department fails to develop the solution in-house, the organization will lack the ability to handle provider interests. This is a consequence of capabilities being path dependent.

The improvement capability corresponding to the technology assessment challenge is described here as the ability to assess and evaluate the impact of emerging technologies. This improvement capability helps the organization to develop a number of operational capabilities when applied to a specific business process with a particular technology such as emerging wireless technologies. For instance, the operational wireless capability represented by the ability to use time-variable geospatial information (spatiotemporal capability) helps the organization that posses it to increase the visibility of its business processes.

So we have a challenge, technology assessment, that triggers a number of activities developing into an improvement capability, namely the ability to evaluate technology. Finally, thanks to this improvement capability, the organization develops a spatiotemporal operational capability (cf. Figure 31). Although analytically the division helps us to clarify the relationship between the concepts, the process is in reality neither linear nor easily separated into its basic components. It is still argued however that separating the interwoven complex process that typically occurs in reality is helpful in order to understand the underlying process.

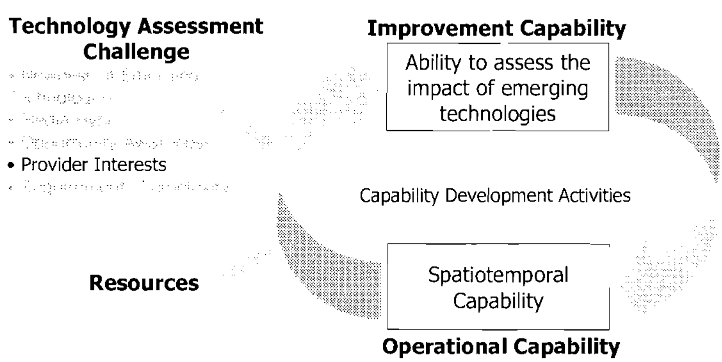

Figure 31 Linking challenges and capabilities, an illustration

This figure also illustrates the outline of the discussion included in this chapter. First we will cover a number of capability development activities that helped the organizations to develop corresponding improvement capabilities. Then the operational capabilities, specific for wireless information systems, and the benefits provided by these are discussed in the light of the cases studied.

6.2 Developing Improvement Capabilities

The three operational capabilities for wireless information systems identified in Chapter 3, namely spatiotemporal, radio-engineering and connectivity capability, are the result of some change processes initiated by a number of challenges. These change processes helped the organizations to develop several improvement capabilities through a number of capability development activities that will be discussed in this section in more detail. For example, the organizations studied performed a number of activities to overcome the challenge of blue collar worker adaptation in order to develop the corresponding improvement capability. The position taken here is that these abilities' importance is based on the fact that they provide benefits that continue to exist even after the activities have been performed, mainly because of the learning process associated with them.

In this section a number of capability development activities carried out at the organizations studied will be discussed. The outline of this section follows the challenges identified in the previous chapter. This is so because these challenges are considered initiators of the change process, and thus they started a number of activities that resulted into improvement capabilities. Challenges are considered here as demanding situations before the change process, and they trigger activities that develop into improvement capabilities after the change process if these abilities provide sustainable advantages to the organizations.

Each section includes the description of one or more illustrations from one organization that has developed the corresponding improvement capability before a number of activities from all three cases are discussed. The focus of attention in this section is illustrated in Figure 32 below.

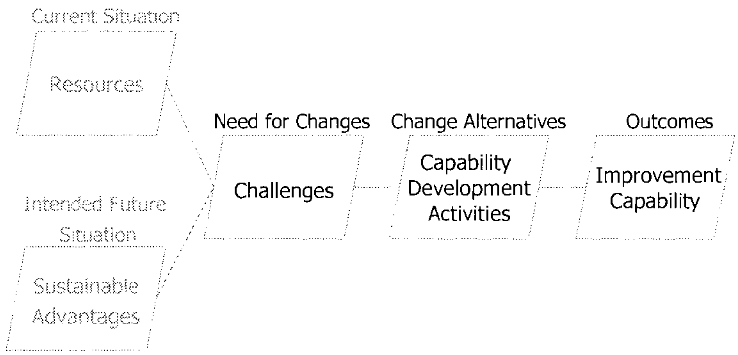

Figure 32 Capability development activities in context

Before entering the discussion, I would like to mention that other challenges than those discussed here trigger the development of some operational capabilities and the chain from challenges through capability development activities and improvement capabilities to become more wireless capability enabled is not a linear and a straight forward process. For analytical purposes the process has been dissected and presented in an orderly way. A number of activities did not provide the organizations with any benefits. The activities described below represent a small subset of all the activities that the firms carried out. The aim of this section is not to present a comprehensive list of activities but to illustrate the capability development process. In addition some activities were relevant to a number of firms but not to others as we will see below.

6.2.1 Technology Assessment

The improvement capability associated with this challenge is the ability to assess and evaluate the impact of emerging technologies. This ability means both envisioning technology in use and its business benefits. The discussion in this section is summarized in Table 16 later in this chapter.

Out of the experience working with the BPR, ERP and EASY projects, BT Europe has developed a technology assessment capability.

Nowadays, BT Europe discusses suggestions about new technological improvements with key users from the service companies, and these are studied in terms of business benefits, pay back, resources and time. The different technological opportunities are prioritized on the basis of such evaluations, and the service-market business developer checks the assumptions with the service companies before decisions to proceed are taken. After implementation, the business developer checks with the companies that the intended effects were actually achieved. Compared to the earlier ERP implementation, this is a more bottom up process, where BT has become less dependent of technology suppliers and their interests.

For example, wireless RFID (radio frequency identification) technology was mentioned as a suggestion of future technological improvements in our earlier interviews with representatives from BT Industries. However, the idea of equipping the forklift trucks with such electronic tags was not even mentioned in later interviews and when asked about it, bar codes were mentioned as both a cheaper and more realistic alternative.

BT's technology assessment capability has developed from what can be interpreted as a strategy of jumping on bandwagons more or less blindly towards a more critical stance and analysis of technological opportunities. If the Business Process Reengineering (BPR) project during the early 1990s represents an example of mimicking other companies' behavior, the later versions of EASY show a stronger ability to translate emerging technologies into business benefits.

Let us now extend the analysis of the technology assessment improvement capability by examining the activities that the case organizations performed to develop this capability. They illustrate different paths for how the organizations developed advantages derived from the ability to evaluate and asses the impact of emerging technologies.

Capability development activities

In the three cases studied, the organizations developed strategic alliances with different types of external actors, such as a software developer (Digital Dispatch in the Taxi Stockholm case), a consultant firm (Sogeti that helped BT Europe) and a telecom operator (Telia supporting Graninge), more or less deliberately.

The original initiative to develop a wireless information system was not taken internally in all the three cases. Graninge was approached by Skogforsk and Telia with ideas of using wireless information systems in forestry operations. A large part of the search activities in this case consisted in finding the adequate partners for carrying out the implementation. For example, Telesoft Uppsala provided programming competence for the integration of the different parts of the system at Graninge.

In addition SKINFO was launched as a Demotel project. Telia Promotor in cooperation with other partners in the Swedish industry launched Demotel projects to serve as showcases of how IT can be put to productive use. The clients contributed with their problems and Telia provided problem-solving expertise and project leadership. The partners split the project funding but the client was responsible for investing whatever resources were necessary for its own operations. Being a part of the Demotel project could also provide Graninge with additional publicity.

In the other two cases, the company itself was the project initiator. Taxi Stockholm evaluated several suppliers of software development for taxi-dispatching operations. They decided to contract Digital Dispatch and their product DDS for their expressed long-term commitment to the taxi industry. One result of this strategic alliance was that the Canadian company opened a sales and customer-support office in Stockholm.

BT is also an example of strategic alliance making. BT managers met with five or six different suppliers of middleware applications out of which two were selected and finally Sogeti, a consultancy specializing in local professional IT services and a member of the global Cap Gemini Group, was chosen.

Sogeti issued a press release on September 24, 2003 to announce the establishment of a partnership alliance with Intentia's R&D division (the earlier supplier of Movex to BT Industries) for the development of joint mobile solutions. The cooperation was to be carried out at Sogeti's Mobile Solutions Center in Linköping (Sweden). The press release mentioned the co-development of EASY at BT Europe as the main reason for the alliance. The solution developed by these organizations, called Service InMotion, was to be sold by Intentia and customer tailored and further developed by Sogeti. This is another example of alliance making in the cases studied.

BT Europe also exploited the possibility of learning from others. This benchmarking activity affected the technology assessment ability. Although no competitor had tried earlier to standardize the service-order process in several countries at the same time, BT could learn from a competitor that had tried to equip field technicians with wireless technologies to improve their service-order process. This system was implemented using laptops and printers installed in the service vans. However, the company experienced low system adoption because of mistaken work practices. Service technicians often require means of assistance at the point of data entry, often away from the service vans.

However, benchmarking is not always possible. Taxi Stockholm was a first mover regarding the installation of GPS-based dispatch system for large cab fleets allocated through call-centers. The lessons from being a first mover have been assimilated and it seems as if the migration to the next version of Pathfinder (the first commercial version of the DDS software) will follow a *wait and see* strategy. Even though the new version is already available, Taxi Stockholm prefers to benchmark other implementations. Consequently the company has volunteered to help TAXA 4x35 (Copenhagen's oldest and largest taxi company) to install Pathfinder 3.0 to learn from the experience of others.

Regarding Taxi Stockholm's improvement capability of technology assessment, the company has become more aware of the technological development within the industry thanks to the selection process of dispatch providers. The scanning of suppliers and their offerings provided the company with awareness of similarities and differences in relation to other taxi companies in other parts of the world, a piece of knowledge certainly less necessary during the period of regulation in the Swedish taxi industry.

The discussion about the development of this improvement capability in the cases studied is summarized in the figure below.

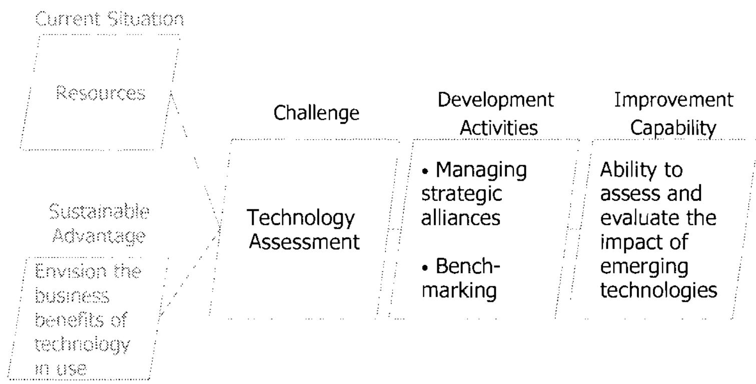

Figure 33 Technology assessment improvement capability

The sustainable benefit derived from this improvement capability is the envisioning of the business benefits of technology in use. This benefit enables the organizations to make informed choices about emerging technologies. Sometimes it means that the organization becomes a technology leader, other times a follower or maybe just a borrower. A firm may even let the technological development just pass by. But in all these cases the decision is a voluntary and explicit choice.

6.2.2 Work System Alignment

The improvement capability associated with this challenge is defined as the ability to align work practices and the functionality of technology so that the benefits from the OIP can be maximized.

BT Europe is once more a good example of an organization that has developed work system alignment capability. Misalignments of work systems often occur because of the escalation of possible improvements during the implementation process. The EASY project has kept a strict versioning policy from the start because of the problems of constant additions to the functionality of new systems that was learned the hard way during the large ERP project back in the 1990s. One such problem back then was the lack of agreement on the negotiations required to standardize new definitions and work practices which resulted in the project leader stepping aside. In addition, one of the project managers acknowledged that "*the pilot installation of new key processes in the Swedish division represented the time when we invented darkness.*"[34] (Gäre 2003).

However, work system alignment during EASY was approached differently. New functionality and suggestions stood up to a thorough evaluation. Good ideas that were generated during the system implementation would not be incorporated in the present version unless they were absolutely essential. The managers of EASY succeeded in stopping change, getting people to adhere faithfully to the carefully designed service administration process, while not stifling initiative by channeling it into a "versioning" system. Change ideas were submitted to the process owner, evaluated, prioritized and, if accepted, sorted into the next or a future version of the service process. BT has thus learned to manage the dilemma, already mentioned above, of the trade-off between continuous system development and meeting deadlines by freezing system configurations.

Let us now move on to discuss the activities that helped the firms to develop this improvement capability selected from the cases studied.

Capability development activities

In the cases studied one important activity carried out to develop the ability to align work practices and technology was the gap analysis. Basically, this activity consists of analyzing how current work practices differ from

[34] My own translation from Swedish.

envisioned business processes to establish the differences that need to be introduced in the organization to achieve some desired future state. This activity is closely connected to the requirement analysis challenge described in the matching phase and labeled requirements complexity.

There is a striking similarity among the cases as regards the difficulty that the organizations experienced defining current work practices before they were able to describe the desired future operations. Underestimates occurred in all three cases regarding the effort that mapping current operations would take.

Inspired by Sogeti's consultants, BT Europe worked with *use cases* (Article 2). The project team at BT spent close to a year on mapping the present processes in three countries, devising a redesigned process, and then requiring the service managers in the other countries to perform a gap analysis between the redesigned process and their existing ones. They were required to state what needed to be changed in the current process to implement the new one and whether there were aspects of the existing process that were essential to keep and would require modification of the new process.

In the case of Taxi Stockholm, Digital Dispatch (the Canadian provider) was responsible for the development of the requirement list, which posed some difficulties regarding what to develop and not. Taxi Stockholm's main requirement was to maintain same functionality as before with increased flexibility for dispatch operations through software configurations. Although some especial applications were specified in more detail, the rest of the new system was not documented in advance.

Next, we found a number of activities carried out mainly at Taxi Stockholm that have helped the company to develop the ability to align work practices. Product sequencing consists of pulling the development of capabilities by pushing the development of products (Grant 2005). The case of Taxi Stockholm was clearly one of product sequencing or, as has been earlier mentioned, product co-developer. Taxi Stockholm reduced uncertainty by becoming a co-developer of the dispatch system together with the supplier. However, this product-sequencing ability also brought headaches.

So, the mechanism of organizational innovation as far as work system alignment is concerned can be explained by the analysis of gaps and product sequencing.

Figure 34 summarizes the discussion about the development of the improvement capability originating from the work system alignment challenge according to the cases studied.

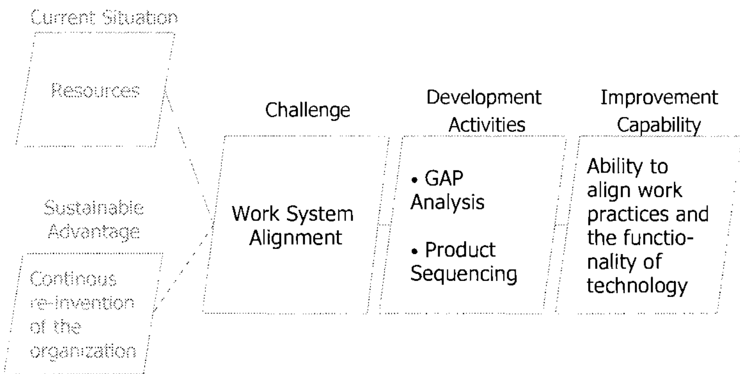

Figure 34 Work system alignment improvement capability

The organizational innovation process consists both of planned (e.g. gap-analysis) and unplanned (e.g. product co-development) change activities that emerge during the process. The alignment of work practices and technology is therefore an uncertain process, and the benefits from this improvement capability are described here as a continuous organizational re-innovation process.

6.2.3 Blue-Collar-Worker Adaptation

The improvement capability associated with this challenge is the ability to deliver technology in a way the users, in general, and more specifically blue collar workers feel comfortable with and are able to operate. This ability of the users to adapt to the new organizational circumstances can considerably reduce the total time of the organizational innovation process. In this context, the importance of ease of use and user friendliness has been highlighted in earlier research for example within the Technology Acceptance Model (Davis 1989). However, an at least equally important consideration appeared to be ease of learning. But before discussing the activities that helped the organizations to develop this ability we will illustrate this improvement capability with an example from the cases.

Graninge is a good example of blue collar worker adaptation capability. Article 3 in this dissertation discusses user involvement from the Graninge case. The distinction between involvement and participation raised in the paper may also be useful here. Involvement represents the subjective psychological state of users whereas participation can be defined as the activities that users or their representatives perform in the system-development process. The combination of both involvement and participation is described as user engagement (cf. Article 3).

This user engagement is what drives blue collar worker adaptation and can be illustrated with some examples from the Graninge case. A key user at the Vilhelmina's district could take the computers home to test functionality even during the weekends. He was then nearly 60 years old but very active, and he was clearly an enthusiastic person. He was described as a deep and actively involved person.

Once the harvesting operators realized they could manage SKINFO, after it had been installed in the machines, appetites grew and an intense period of learning by using started. This gave the operators better self confidence. The longer effect of this process was a positive attitude of the users towards technology-generated change enabling better and easier implementations in the future.

What probably raised their user engagement most was the fact that the workers became part of the IT era. This was a phenomenon experienced in all the cases. The project leader at Graninge tells with pleasure one story from a machine operator who commented for one of his colleagues that now he felt himself a part of the IT-society. This obviously increased his involvement which led to increased participation. This is an ability that can be re-used in future developments. Less fear for technological change enables faster implementations.

As already discussed, before SKINFO, most harvest operators at Graninge had no experience of ICT tools such as PCs or e-mail. They were totally unfamiliar with the new applications, and they had difficulties seeing the benefits before they had the opportunity to use the system. Nowadays, Graninge's machine operators feel more comfortable with the IT-tools.

Consequently, as with earlier discussions, we will now describe some activities that the case organizations carried out to develop this capability.

Capability development activities

Blue collar worker adaptation and learning occurs mostly through interactions with colleagues. Although training courses were arranged in all three cases, the identification of lead users and the use of mentors were far more effective than indoor courses. Mobile workforces are often on the move and training courses can be cumbersome for some of them.

The search for different lead users in the cases was both case-specific and different. The common characteristic to all cases was driven by the insight that positive experiences from first users lead to faster dissemination. For example, BT Europe has used a group of key users to test new functionality. This core team of key users was not available at the project start time, but has been developed, and they act as ambassadors for the new versions of the system.

One important thing for blue collar worker adaptation is the issue of status. This is important to this particular group of workforces. Service technicians at BT appreciated being the focus of attention, and they were happy to be brought into the IT era and to be modern. A service technician told the service manager in one of the pilot companies "*My son plays with my PDA when he can*." He was proud to have a tool that caught his son's interest and gave him esteem at home. The service manager was not so pleased with this use of the PDA, but recognized the importance of the status effect.

Although the Taxi Stockholm case does not present any special activity towards the search of lead users, the project leader for the upgrading of the system was once a taxi driver himself. Taxi Stockholm preferred more formal training courses.

The amount of training also varied from case to case. The training activities could range from one day courses, or even no training at all as in the case of the new EASY spare parts application (QP was just upgraded into the terminals), up to training courses of several days.

At Graninge, work-leaders in each district were responsible for roll-out and acted as ambassadors for the project. They were responsible for helping with the roll-out and took care of problems that developed in the field. This was another way of facilitating user adaptation to the new system.

The discussion about the development of this third improvement capability is also summarized through an illustration (cf. Figure 35).

The long-term benefit of this ability is probably the positive attitude of users towards technology-generated change if experience with gadgets is positive. This is especially interesting when upgrading to the next version or even to a totally different system.

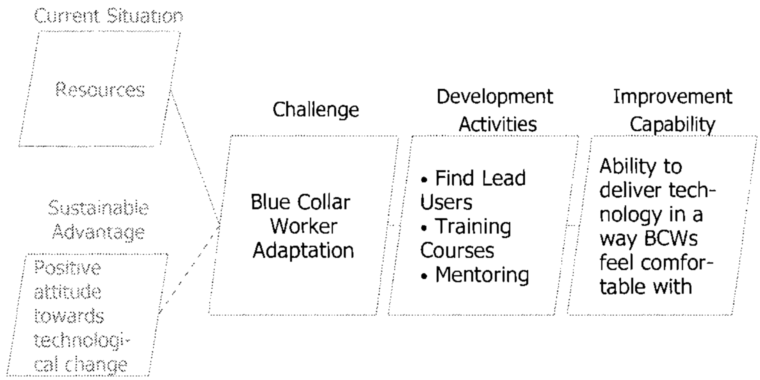

Figure 35 Blue-collar-worker-adaptation improvement capability

6.2.4 Renewal Timing

Finally, the improvement capability associated with this challenge is the ability to seize the renewal window of opportunity. This challenge, described earlier in Chapter 5, represents the trigger of renewal activities.

It is difficult to say whether the companies studied have developed any stable improvement capability based on the challenge of renewal timing or not. Most of the activities triggered by this challenge can be described as fire-fighting operations (cf. discussion below), and there have not been clear signs that neither BT nor Graninge have developed a renewal-timing ability that provides them with long term benefits. This does not mean that the organizations necessarily lack this ability. I simply have not been able to find clear cut indications of it.

Nevertheless, there are a couple of illustrations from Taxi Stockholm that shows how different system-introduction strategies were applied fruit of experience. Taxi Stockholm has learned the risks of being a first mover. As already mentioned in the discussion about technology-assessment capability the company will follow a *wait and see* strategy instead of being a first mover when implementing Pathfinder 3.0. Taxi Stockholm prefers to benchmark other implementations and the company has volunteered to help TAXA 4x35 to install the new version of Pathfinder to learn from the experience of others. The choice of wait and see strategy can be interpreted as a fruit of the organization's renewal-timing capability.

In addition, as explained in Article 4 and earlier in this chapter, back in the early 1990s the increased consultant fees incurred when upgrading the Taxi80 system made it quickly obsolete. The migration from Taxi80 to TaxiPak was performed by a forklift, or rather big bang, process where the old system was replaced all at once. The migration was problematic and resulted in extensive downtime. Because of this experience, upgrading to DDS (including Pathfinder) was to be performed during a 3-year period. The migration strategy agreed upon was a seamless upgrade instead of the forklift approach used previously. This example refers less to the timing aspects of the capability but rather it illustrates the improved renewal ability.

These examples show Taxi Stockholm's improved ability when renewing technology. However, it is also fair to say that the choices of renewal strategy have been influenced by a number of contingent factors. Among others, the demands of a deregulated industry and the impact of system downtime have influenced the choices of renewal strategies and its timing.

Let us now proceed to analyze the activities associated with this improvement capability from all the three cases studied.

Capability development activities

The renewal timing challenge triggered maintenance activities of different character at the three organizations studied. These could be described as replacements, adjustments, repairs, etc. and were intended to restore or retain a functional unit in a specified state in which the information system could perform its required functions (cf. Swanson 1999).

Some limitations experienced with Taxi80 represent an example of maintenance activity with an adjustment character at Taxi Stockholm back in the 1990s. Taxi80 caused delays in the polling process (asking the status of each cab) when the radio channel was used for voice communication simultaneously. The polling delay resulted in inaccurate information about the status of early polled cabs. This information caused the dispatching of occupied cabs to customers. The company opted for restricting the use of the voice channel to extraordinary occasions such as emergency calls.

Another type of maintenance activity was the reparation of existing systems to keep them up and running. Graninge experienced problems with the CB-radio installed in the machines. It was obsolete and the number of fixes in the harvesters increased all the time. Similarly Taxi Stockholm built up an IT department which worked to develop bridges and interfaces in order to get the different systems comprising the technological platform up and running. As a Taxi Stockholm manager told us: "*They became heroes but also firemen*."

An example of fixes from the BT Europe case was the application called *configurator*, the middleware necessary to integrate the system with other BT Europe specific applications in the late 1990s. This application basically translates customer agreements to production based terminology to be able to provide delivery estimations. The application already installed in four divisions turned out to be deficient and had to be revised and updated.

Many of the activities described in this section have a clear fire-fighting character. Constraining voice communication at Taxi Stockholm had negative effects on the drivers. Continuous fixes of the CB-radio at Graninge implied disruptions in the work of the machine operators, etc. It is though intuitive that activities triggered by the renewal-timing challenge result in emergency allocation of resources. However these fire-fighting activities can hardly build up any long-term ability in an organization. One can thus question how developing these activities have been for the organizations studied.

The discussion about the development of this improvement capability in the cases studied is summarized in the figure below.

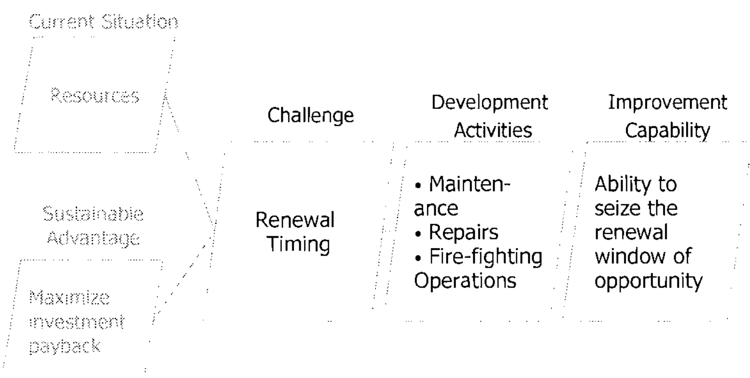

Figure 36 Renewal timing improvement capability

It has been difficult to identify proactive initiatives by the organizations studied to promote the development of this improvement capability. Hypothetically, the benefits of such a capability could be the maximization of the investment payback. The improvement capability defined as the ability to seize the renewal window of opportunity results in maximizing the value from earlier investments, a long-term advantage that follows from this capability.

The capability development activities described here are summarized in Table 16 below alongside the advantages created.

Challenge	*Improvement Capability*	*Development Activities*	*Sustainable Advantages*
Technology Assessment	Ability to assess and evaluate the impact of emerging technologies	• Managing strategic alliances • Benchmarking	Envision the business benefits of technology in use
Work System Alignment	Ability to align work practices and the functionality of technology	• GAP Analysis • Product sequencing	Continuous re-invention of the organization
Blue Collar Worker Adaptation	Ability to deliver techno-logy in a way BCW feel comfortable with	• Find lead users • Training courses • Mentoring	Positive attitude towards technological change
Renewal Timing	Ability to seize the renewal window of opportunity	• Maintenance • Repairs • Fire-fighting operations	Maximize investment payback

Table 16 Developing sustainable advantages

These improvement capabilities can be contrasted with the dynamic capabilities discussed in earlier literature (cf. the discussion about Static and Dynamic Capabilities in Section 3.2.1 *Organizational IS Capability*). Dynamic capabilities have been described earlier as an organization's adaptability to change. Some of these were product development, strategic decision making, alliance making, innovative R&D, etc. to mention but a few. There exist both similarities and differences between the improvement capabilities as described in this work and the dynamic capabilities discussed in earlier literature.

The improvement capabilities described here are a bit more concrete and at the same time a blend of different dynamic capabilities. Work system alignment can be understood as a combination of organizational restructuring and change management, technology assessment consists both of some process innovation and strategic decision making, etc. However, one difference between them is that improvement capabilities are driven by challenges, and therefore they represent better candidates for true change in line with Klein (2004) that discusses how challenges represent true pull for changes.

One link between capabilities and capability development activities goes through the *integration character* of capabilities discussed earlier. From what has been said, it can be seen that the improvement capabilities and the activities performed can be divided on the basis of their integration character as supplementary or complementary capabilities (Sen and Egelhoff 2000). This relationship between capabilities and integration may have an impact on the capability development process. In the first case (vertical integration i.e. complementary capabilities), organizations may be more motivated to seek new abilities through in-house development tools such as product sequencing, finding lead-users or mentoring. In the latter (horizontal integration i.e. supplementary capabilities), external means such as strategic alliances or benchmarking may be preferred instead.

From all this, there follow a number of characteristics of improvement capabilities worth being discussed here. First, these capabilities are relatively independent of specific technologies. This means that improvement capabilities are not derived from the characteristics of any particular technology. The improvement capabilities derived from technology assessment, work system alignment, blue collar worker adaptation and renewal timing are as useful in wireless information systems as in the implementation of e-commerce applications, bio-fuel-engine technologies, unmanned single-grip harvesters, etc. However, the benefits of the improvement capabilities very much depend on the level of impact of the technology on a company's operations.

Another characteristic, a consequence of improvement capabilities being independent of specific technologies, is that the abilities developed can be re-used. Future technological implementation can also benefit from the abilities developed earlier, especially as the improvement capabilities described represent types of organizational abilities that can be maintained even after the activities are finalized. For example, blue collar worker adaptation can be applicable for communication technologies, transportation technologies, environmental technologies, etc. The positive experience developed thanks to wireless technology implementation predisposes the users to test additional innovations even from other technological areas.

A new technology under revision at Taxi Stockholm is the payment system in the cabs. The company wants to install a new fare meter with credit card payment functionality. An assumption is that the installation of the new fare meter will benefit from the earlier implementation of the dispatch system as far as improvement capabilities are concerned. Another example from the renewal timing capability is illustrated by fewer fire-fighting operations when satisfactorily developed. The renewal timing capability can for example help organizations to better monitor the life-expectancy of systems through 'health checks' where managers assess the life length of systems continuously (cf. Swanson 1999; Swanson and Dans 2000).

In addition, improvement capabilities are not digital in the sense that organizations have them or not. They may be better understood in a gradual or incremental manner. A consequence of this is that capabilities can always be improved and further developed. The question therefore is not whether a particular organization has a certain capability or not but how much and how it can be improved. Improvement capabilities are moreover good examples of path dependency in the sense that their actual status highly depends on earlier activities.

All these characteristics of improvement capabilities (reusability, technology independency and path dependency) make the benefits derived longer lasting, i.e. sustainable benefits.

Surprisingly enough, the organizations studied seldom described the benefits derived from the improvement capabilities first. Sometimes they were not even identified as consequences from the implementation process or at most they were mentioned as indirect consequences of the organizational innovation process. What is remarkable in this respect is that organizations did not actively seek improvement capabilities, but the more direct benefits from wireless technology, namely the operational capabilities that will be discussed now.

6.3 WIS-specific Operational Capabilities

Next, this section discusses the abilities derived from the characteristics of wireless information systems and the benefits thereof. These benefits are linked directly to the technology in focus and they were eagerly discussed when asked about them during the interviews. Although they were not always easily quantifiable (in terms of both increased efficiency and effectiveness), they are more tangible than the benefits derived from improvement capabilities and certainly more easily identifiable.

Thus, this section discusses how the organizations studied realized the three WIS-specific operational capabilities. These three operational capabilities, namely spatiotemporal, radio-engineering and connectivity, will be discussed through a case by case analysis. The section closes with some comments about the benefits derived from these capabilities.

6.3.1 Spatiotemporal Capability

According to earlier discussion, the spatiotemporal capability was defined as the ability to use time-variable geospatial information to meet spatiotemporal challenges through the use of wireless technologies. This operational capability creates advantages drawn from the increased openness of the business processes described as visibility advantages.

How was this spatiotemporal capability realized in the cases studied? Taxi Stockholm strived to increase visibility throughout the dispatch process by provisioning updated data about the cab's position. Graninge's efforts consisted in bringing the forest districts closer to the sawmills through the exchange of harvesting information. Finally, BT Europe enabled direct access to the ERP database to provide service technicians with better and more reliable information in their meeting with the firm's customers. All these are examples of opening up the business processes to increase the visibility of the underlying activities.

The analysis of the visibility advantages starts with the study of the coordination patterns in the processes mentioned above. First we need to consider the interdependencies that arise in the different processes. Let us look into three examples from the cases. All taxi transport members of Taxi Stockholm share the call-centre service facility. The call-centre represents an example of *pooled interdependence* where members share common resources but are otherwise independent. Graninge's supply chain represents an example of *sequential interdependence*. In the forest, harvest teams work in series in different forest districts where trees are felled, cut and piled prior to transportation to the sawmills. At BT Europe, interdependencies that arise between back office personnel and service technicians in the field are of *reciprocal* nature. Technicians upon completion of a service order synchronize their handheld devices. These order reports initiate the updating of service order lists and select the next service job that is sent to the technician's device. The service technicians feed their work back and forth between back-office and their handheld devices (cf. Figure 37).

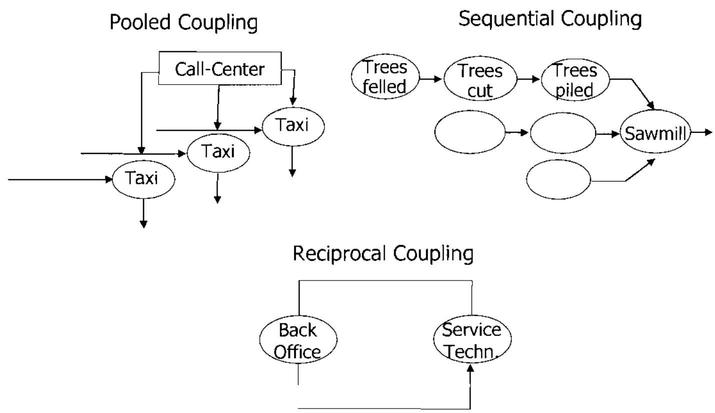

Figure 37 Interdependencies in the cases studied

Coordination patterns arise when interdependencies are controlled in a specific way. Three different control mechanisms were described in Chapter 3 earlier, namely standardization, plans and mutual agreements. These three mechanisms have been applied to the cases in focus.

First, *standardization* can be applicable to stable and repetitive situations. The use of standardized processes to control interdependencies can be illustrated by Taxi Stockholm's automatic dispatching of customers. This occurs when transportation requests originate from well-known addresses, i.e. stationary telephone subscriptions. The company's Interactive Voice Response System uses a *Caller ID-number* service to match the customer's telephone number and the corresponding address through its own database, which Taxi Stockholm developed itself to resemble the telephone catalogue. This is an example of standardized control mechanism and the presence of pooled interdependency.

Due to Taxi Stockholm's organizational structure as a taxi driver cooperative, visibility becomes extremely important. Taxi drivers compete for customers within the company. The allocation algorithm of cabs and customers needs to be transparent. In a traditional street hailing system the allocation is straightforward. However as the reservation process through the call-centre becomes more popular and the use of digital dispatch systems automates the allocation of customers to cabs, the process becomes more obscure. Drivers are now allocated queuing numbers and customers automatically. In this particular case we observe a lack of confidence steaming from a lack of visibility increased by technology automation.

Thus, it is not certain that location based information will increase the overall level of confidence in the process. Better location-based data increases visibility if the data can be correctly analyzed. Intervention requirements can only be satisfied if the data has been processed conveniently. A positive example of this relationship from the taxi case is the fact that the company used the logged data in the system to show drivers when more cabs were needed, i.e. early morning on weekdays and late at night on weekends. It is a fact that customer need for cabs is highest when few drivers are available. Drivers could be encouraged to have cabs available when most demanded by showing them statistics.

On the negative side, the fact that some drivers could not understand why other drivers got a particular job created frustration among them. The new system works with distance (radius) when searching alternative drivers if no cabs are available within the customer's zone. The allocation process is superior because it allows the reduction of customer-cab distance. However, the allocation is much less clear for drivers. Due to natural obstacles such as waterways, the shortest distance may not be always the nearest. Even people at the call-centre have difficulty understanding how the allocation algorithm works. Earlier log files could be searched for and understood if drivers had complaints. Today the amount of information in the logs reduces confidence as the data created can not be analyzed properly. Therefore the call-centre has developed a number of standard answers that take less time to deliver but do not always provide drivers with satisfactory information.

Second, plans are more appropriate for dynamic situations. The example in this case is taken from the forest harvesting activities. Graninge uses price lists to steer the bucking process[35]. Based on different pricing systems, the company produces price lists for determining bucking criteria for the harvesters. The work of foremen consists then of sending and receiving these price lists to and from the bucking computers on board harvesting machines. SKINFO enabled wireless transmission of data from the foremen's office to the on-board bucking computers. In this way, negative effects of the sequential interdependencies in the process were alleviated.

The next level of coordination was to use this information for increased monitoring of bucking to order. Graninge's visibility vision developed in the

[35] Bucking is the process of sawing a felled tree into sections called logs. Length of the log is dependent on the species of the tree and what type of product it will be made into.

TIMPG project consisted of matching particular bucking activities with customer orders, i.e. enabling sawmills to decide which tree to fell.

One issue raised in earlier interviews is to what extent such a vision can come true. The forest industry is strictly steered by volumes. A harvester costs around 70€ per hour and is capable of harvesting $10m^3$ per hour. Thus small volumes are costly to produce. In addition logs are delivered to different sawmills. Therefore limited optimization of the process is possible.

So the vision presented in a publicity video from the TIMPG project where a Japanese customer orders the required wood to build a temple being harvested directly on demand was at the moment of the collection of the empirical material too far from reality. For example, Graninge experienced problems such as the difficulty in establishing an efficient method for monitoring the bucking to order process. The existing reception and reporting procedures at the mill were inefficient and therefore follow-up activities were not possible.

Of course other benefits such as better time management and more accurate work-reporting schedules were achieved. In addition there were shorter deliveries and less spill-over out in the forest. However the vision of on-demand harvesting was too complex for the company.

Lastly, *mutual adjustment* involves the transmission of information during the process of action. This was the case in the interactions between back office and field technicians when unclear issues occurred. As explained in Westelius and Valiente (Article 2) this was the case with the intertwined modes of new and old communication. One such example is that error-free input by service technicians can not be achieved through programmed controls alone. To deal with this, a filtering function was built in the middleware, giving back office an opportunity to set filtering conditions on an individual level for manually scanning transactions before releasing them to the ERP system.

Another example is that due to the way the synchronization is initiated from the PDA, not from the ERP system or from back-office, efficient handling of rush orders includes the use of cellular telephones. The service technicians were already equipped with telephones, used them often, and will continue to use them. Calling the telephone or sending an SMS to it is thus a way to reach a specific technician. But informing a technician of the details of a new job by telephone, rather than via the PDA, would be an awkward duplication of the administrative process. Thus, the telephone is used to signal that it is time to synchronize the PDA.

Similarly, since the EASY application is not built to give online access to stock levels of spare parts, that feature is solved by telephone when deemed important by the service technician. The order for the spare part is placed via the PDA, but when it is important to know if an unusual spare part is actually in stock, the service technician calls someone with direct access to the ERP system.

These three examples are combined with interdependencies and control mechanisms in Figure 38 to show different coordination alternatives.

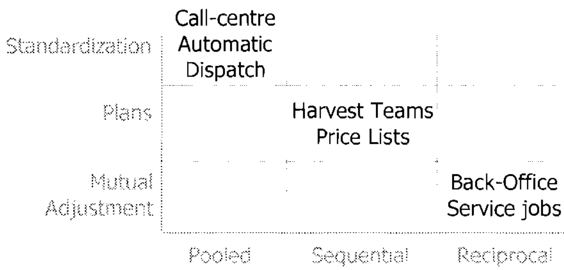

Figure 38 Coordination mechanisms with case examples

It is interesting to consider how the usage of wireless information systems increases the level of confidence in the business processes because there is a general impression that increased mobility leads to better visibility (e.g. Hanebeck and Tracey 2003). However, better support through wireless technologies increases only the amount of generated data from the process. This amount of data gives better opportunities for control. However, if the data is not processed adequately, the visibility in the system is not always directly increased. Just for once, let me take an example from SCA, the company that bought Graninge back in the end of the 1990s. SCA in 1989 had to employ 15 people whose only responsibility was to process data and analyze statistics generated by their new information system.

There is a dilemma here. Clearly valuable data generated by wireless systems requires analysis before being usable. The more data generated by the system the more complex the analysis becomes. This increased complexity reduces visibility leading to reduced confidence in the underlying process. Thus the wide spread assumption that wireless information systems increase confidence through better visibility may not always be the case. It increases the availability of information but increased information does not necessarily lead to increased visibility as we observed in the examples above.

Finally, one hypothesis is that there occurs an organizational decentralization process due to the fact that new activities are pushed down the organization to blue collar workers through automation. People change roles at the vertical level, for example technicians become more service oriented. New roles appear that are important to take into consideration and the users need to be trained in these roles.

6.3.2 Radio-engineering Capability

This capability refers to the ability to design wireless solutions to develop user-friendly applications. It was analyzed along two different dimensions namely a logical and a physical dimension. The benefits were drawn from the fact that a user-friendly application increases the probability of user acceptance.

At the logical level, the variety of available terminals represents an example of constraints posed by the need for separation between content and medium. The same content needs to be displayed in a multitude of different types of terminals such as pagers, cell phones, personal digital assistants or portable computers. BT could draw on the experience of the inappropriateness of using laptops. Nevertheless the application data had to be presented to back office personal working with desktop computers and field technicians using handheld terminals: same data, different media.

User friendliness was important because blue collar workers using the applications do not often pay for the solution and thus their adoption of the handheld terminals is more complex. This was solved at BT through prototyping as already described. However, some problems still appeared such as the earlier described anecdote about less IT-acquainted technicians having problems with some customer data that seemed to be missing on the display of their terminal. This was not because data was missing but because columns were too narrow for them and therefore it seemed like if data was missing. By dragging from the border of the columns more information could be displayed. This obvious functionality for a standard Microsoft office user was not obvious for some members in this user group.

At Taxi Stockholm, the drivers also experienced a number of problems with the new devices provided by Digital Dispatch because of the miniaturization of technology. Earlier terminals installed in the cabs had physical buttons to navigate through the different alternatives in the dispatch application. The new terminals use touch-screen technology which enables smaller displays and higher flexibility to configure navigational menus. The buttons are implemented in the software and can change appearance and function.

However, the new terminals require more attention than the old ones because the drivers cannot feel the buttons, and they need to direct attention to the display each time the dispatch system requires operation. According to one driver, it is easy to press the wrong button because they change function depending on the screen displayed. One unpopular mistake, easy to make, is using the *ID-send* button instead of the *Queue-send* button which logs the driver off the current zone and allocates a new queue number to the cab.

An excellent illustration of the miniaturization capability developed at BT Europe is the development of the spare parts catalogue (QP) as part of the EASY application. BT has a large range of different products including manual trucks, electric powered warehouse trucks and counterbalanced trucks with many product models and different articles. The spare parts catalogue enables service technicians to have access to information about the entire range of trucks and their spare parts. Paper catalogues have traditionally been generated from a database and they have been available in four different languages.

The adaptation of QP was necessary because of the interface differences between the existing application, developed for full-size computer screens, and the small screens used in EASY. Making the spare parts catalogue available on the PDA required converting the existing images to graphics that would be useable on small displays. This included panning functions and adding hotspots to the drawings that made it possible to quickly zoom in by clicking with the PDA pen. This application enabled service technicians to have access to the entire range of trucks and their spare parts without needing to download drawings and catalogue data over the slow wireless connection.

The users were pleased with the solution, especially with the visibility of the drawings on the screen. Most service engineers are familiar with the drawings and find it easy to navigate in the PDA. The application required no additional training and reduced the amount of consumed paper. However, the handling of updates is not optimal because it involves collecting the memory cards from the service technicians' devices, switching cards and redistributing them (in a similar fashion to the update of software versions in the terminals described in Chapter 5 earlier).

So, what about the benefits derived from this capability? Profitability at BT increased because of a more accurate recording of actual spare parts used and assignment to specific trucks serviced. Previously, parts could mistakenly be assigned to trucks where BT had a functionality contract, and thus would not be charged to the customer. The integration of QP and EASY enabled this benefit.

Another physical constraint already mentioned was the network management. A distinction between licensed and unlicensed spectrum-based technologies was introduced earlier. This is mainly based on the fact that frequency is a scarce resource, and licenses are often required to operate wireless systems. In my cases both types of examples are present. However, the older systems show a preference for own radio infrastructure. Taxi Stockholm is such a case. This has resulted in a number of problems such as Taxi Stockholm's bandwidth shortage that cannot be increased because the Swedish National Post and Telecom Agency has denied any additional licenses for upgrading the radio infrastructure.

Even though Graninge opted for an alternative way by using Mobitex, a pan-national network developed for business applications based on voice, data and alarm services, the out-phasing of this technology may set restrictions for future developments, especially regarding those coverage heavy applications. BT on the contrary opted for a commercial operator (AT&T) for GSM and GPRS operations which may be more future-proofed.

In relation to the discussion above about capability development, the frequency-management example shows different alternative ways for developing such a capability. This difference is illustrated across the cases. The difference between owning the required infrastructure vs. outsourcing this capability leads us to a difference in capability development processes. If Taxi Stockholm opted for utilizing its own resources to the fullest through the recycle of existing technologies, BT and Graninge opted for an accumulative strategy by borrowing experience from others. Through radio capacity rental, part of the technological capability was outsourced to others. Even within these two last mentioned cases there are differences. BT opted for a more open solution by contracting AT&T. This provided the company with a longer-term solution. According to this discussion a difference in the future-openness degree of the solution is present. A spectrum of alternatives ranging from one's network to global and more pan-European operator through a business based network operator such as Mobitex is present in the cases.

6.3.3 Connectivity Capability

This capability is treated here as the ability to interlink people in order to enhance collaboration between operating actors. This capability assures feedback functions between workforces and central units in the organizations.

It is possible to classify the workforces in the cases studied according to their mobility modalities. Graninge's forest operators can be classified as wanderers. This interpretation differs slightly from the original definition (cf. Kristoffersen and Ljungberg 2000) in that wanderers move inside a building whereas forest operators cover a large geographical area. However, the case is similar if we consider each harvesting area as a local workplace (equivalent to Kristoffersen and Ljungberg's (2000) definition of a local area). When finished, the operators *travel* to the next region. The information required for mobility purposes is similar to that in the office wanderer case. BT technicians are true visitors as they meet with customers at different locations. Finally taxi drivers travel inside a cab and require support while moving.

I will now confine myself to giving an account of how the connectivity capability was realized in each of the cases. It should be noted that the discussion that follows is organized by the mobility and the connectivity modalities. Apart from the mobility modalities recently discussed, three connectivity modalities were earlier presented in Chapter 3, namely disconnected, intermittent and connected connectivity. The discussion is summarized in Figure 39 below.

At Graninge before the implementation of SKINFO, machine operators were disconnected. Foremen at the different forest districts delivered different steering reports, such as price lists, manually to the operators. Interaction between operators and foremen took place through *face to face meetings*.

Mobitex and SKINFO provided the next level of connectivity at Graninge. Harvesting documentation and salary reports could now be delivered through *asynchronous modes of interaction*. The computers in the harvesters played the role of virtual post boxes where different types of reports could be sent to and collected from through radio communication technology. These computer-based text warehouses could be more generally described as virtual repositories supporting intermittent interactions.

Wanderers, either they are located inside a building or in a forest area, can benefit from always-connected solutions. This is the case when more *spontaneous interactions* are required between the organizational members. At Graninge, the CB-radio was used for such informal communication between operators in the forest. This type of interactions strengthened the social ties between the employees. This solution is less suitable for office workers. However people inside a building also use e-mail communication or chat applications to maintain these spontaneous interactions. Another difference is that forest operators usually work alone or in small groups whereas office workers are often surrounded by people.

At BT Europe, technicians visit different customers all over Europe. Although each local company is responsible for the corresponding market, field technicians have to travel long distances to serve different customers. Disconnected technicians have no possibility to interact with the back-office when at the customer's place.

BT Europe equipped its service force with cellular phones early. This level of connectivity enabled voice interactions with the personnel at the back office. However voice communication is only a part of the communication needs of field technicians.

The next level of connectivity is represented by the opportunity for data based interactions. This was the rationale behind the implementation of EASY. The opportunity of enhanced interactions with Movex improved collaboration between the back office and service technicians. The level of connectivity in the EASY application is intermittent as technicians are supposed to synchronize their terminals for updating service orders, repairs reports, customer information, etc. We call this type of interaction *virtual synchronization* as it is based on intermittent connectivity to support virtual, i.e. digital data transfer.

It can be observed that this modality is similar to asynchronous interactions in the wanderer case but differs in the underlying technical requirements to support this type of connectivity. Intermittent connectivity is easier to deliver in the wanderer case than in the person visiting different locations.

Due to periodic disconnections of the handheld devices, back office interacted with operators through their cell phones when offline. This is an example of combining different communication modes to improve the connectivity capability.

Obviously, a traveler always connected with unlimited bandwidth resources could become involved in *distributed collaborative* type of interactions. BT Europe technicians could engage in multi-service discussions through e.g. video conferencing. However BT Europe does not consider this capability as a critical need.

Finally at Taxi Stockholm connectivity was achieved early through taxi stands. Similar to the BT case above, the case of disconnected traveler makes little sense as the opportunities of interaction with other actors are nonexistent.

The case of taxi stands is however interesting as it represents a type of *nomadic communication*. Drivers gather around the stands to be dispatched. This case is comparable with the virtual synchronization at BT Europe. They are similar in the sense that both are based on asynchronous communication, however the technician case synchronizes in time, at a suitable point in time, whereas a taxi driver synchronizes in place, at a suitable location, that is the taxi stand.

Taxi Stockholm's digital dispatch implementation represented a higher level of connectivity. It enabled always connected modality. The GPS-based system sent position data about cabs' location to the call-centre. In such a way *real-time collaboration* between drivers and dispatchers could take place.

Out of this discussion a presence-management chart emerges (cf. Figure 39). This model is the result of combining the mobility and the connectivity modalities as described above. It represents different modes of interaction when working with mobile workforces. Worth noting is the fact that the dimensions presented in the chart combine the distinction between devices and their functionality, and the users of these devices.

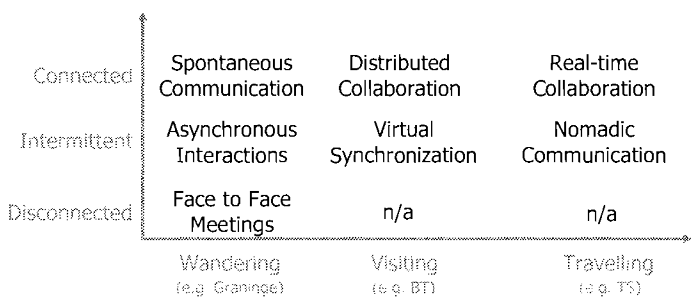

Figure 39 Presence-management chart

An illustrative analogy can help us to summarize the arguments so far. The difference between photographs and film sequences highlight the fact that different types of mobility were developed in the three treated cases. The former provides advantages through a number of snapshots while the latter does it sequentially. The case of service technicians at BT can be compared to the photography analogy whereas the taxi drivers with the film sequence. In the BT case no location based information was transmitted. Moreover the solution was basically built upon asynchronous information updating. On the other hand the taxi example can be compared to the film sequence. Real time and GPS positioning enabled the call-centre to have a more precise view about where cabs were located.

These different modes of interaction also present a trade-off between freedom and supervision, especially when working with mobile workforces. The cases showed examples of the collaboration modes being experienced as supervision by the blue collar workers studied. Taxi Stockholm's positioning system was one example. Although the call-centre does not use the information to track the drivers, the possibility exists, and privacy concerns have been mentioned in the conversation with the drivers. Another example from the BT Europe case (cf. Article 2) is that if the technician has not synchronized the PDA within a certain period of time, a follow-up mail is sent to back office, where further action to allocate the service task can then be undertaken.

This is a dilemma worth taking notice of. The dilemma consists of the fact that increased supervision and control reduces the level of freedom. It can easily become a source of conflict in organizations. This is an example of the connexity complexity mentioned earlier. Thus special attention should be drawn towards the users' experience of the wireless information systems.

As for the benefits of operational capabilities when implementing wireless technologies, we may refer to the discussion in Article 1 where we concluded that a business process can benefit from wireless technology if coordination is required, between difficult-to-locate actors. The value of mobility is contingent on the costs of not being able to coordinate during the period that the actors are difficult to reach. It is also related to the costs of available substitutes for wireless technology in a business process (Article 1). These benefits were presented in the form of three propositions and they relate directly to the operational capabilities described above. The spatio-temporal capability reduces the interdependencies that arise in the different business processes studied; the radio-engineering capability helps organizations to design wireless applications so that user-friendly applications can be developed; and the connexity capability links people in order to enhance collaboration between operating actors in the cases.

Summing up, this section has discussed both improvement and operational capabilities. The improvement capabilities were explained as a result of a development process of sustainable benefits. Three WIS-specific operational capabilities, namely spatiotemporal, radio-engineering and connectivity such were also discussed through a case-by-case analysis.

A number of differences between improvement and operational capabilities have also been discussed. Let us now summarize them here. Improvement capabilities were characterized as recyclable whereas operational capabilities were perishable because of the types of benefits derived from the organizational innovation process. The operational benefits, though important, are easier to copy and thus not as sustainable as the benefits derived from improvement capabilities. The second largest taxi company in Stockholm has now started to dispatch automatically with a simpler system than Pathfinder that provides similar operational benefits. However, the company did not undergo the sweeping implementation process described in this dissertation.

Capabilities were described earlier as path dependent. However improvement and operational capabilities also differ as to the level of path dependency. The re-usability of improvement capabilities makes them more path dependent than operational capabilities. For example the technology assessment capability is more history-dependent than the radio-engineering capability. It is nevertheless clear that capability development depends on learning and knowledge creation at the organization.

These differences can be summarized by stating that it is not always so important to possess the right operational capabilities: it is more important to posses the right improvement capabilities that help organizations to develop new capabilities.

What can we after all expect of such organizations that develop these capabilities? The combination of operational and improvement capabilities was described earlier as an organization's IS capability. The main benefits derived from such a process are to provide the ability to connect technology to its business performance.

IS capability differs from firm to firm in intensity when it comes to the ability to mobilize resources. A strong IS capability implies faster assimilation and agility in adopting and implementing changes whereas a weaker IS capability implies slower response when assimilating technology related strategic change. We can expect a more agile organization's adaptability to technology-based change than before.

Let me summarize the discussion above by stating that what matters is not the technology in itself, but how one uses it. Technology is but a tool, and what really matters is the business benefits achieved. Experience has shown over and over again that it is what a particular piece of technology can help you do in your business that matters, or put differently, the capabilities it helps you build. Therefore high performance firms are not those that are able to implement different breeds of technology but those that are able to learn from that process and develop long-term abilities from the challenges they are confronted with.

7 Conclusions

So what kind of piece of music did we create by orchestrating mobile workforces with wireless technologies? Retrospectively, BT Industries, Taxi Stockholm and Graninge all succeeded in getting their mobile workforces to play wirelessly both on the move and while moving. Yet the venture was painful and cumbersome, and the results both foreseen and unexpected. Revisiting the music analogy, the organizational innovation process, as described in this dissertation, presents a number of similarities with jazz music.

Jazz is often difficult to define, but improvisation is a key element of this style. Even when more traditional instruments are used, there are elements in the music consisting of free improvisation. The players can often improvise independent melodic lines simultaneously both individually and collectively. Apart from improvisation, jazz consists of a well-defined structure consisting of blue notes, syncopation, swing, call and response, and polyrhythms that produce a balanced sound – some instruments provide the rhythmic pulse, others harmonic foundation, still others melody and additional harmony.

The organizational innovation processes studied here consisted of both plans and improvisations as in jazz. For example, BT Europe's identified opportunity to reduce the back office personnel turned out according to plan. On the other hand, the company could not achieve error-free input by the service technicians through programmed controls alone. To deal with this, a filtering function was built in the middleware (cf. Article 2). The organizational innovation processes also included problem-based activities that were intertwined with the creative aspects of innovations. For example, the Taxi Stockholm's system halt, when all cabs were added to Pathfinder, required a SWAT team to operate from Stockholm to solve the problem. BT Industries creatively realized the potential to automatically attach marketing flyers to work-order notifications e-mailed to customers after the system launch. The organizational innovation processes are moreover not always predictable. Taxi Stockholm became a co-developer of Pathfinder, and both Graninge and BT Europe were surprised of the effect of blue collar workers becoming part of the IT era.

More about the organizational innovation process is included in this section where the main findings of this study will be summarized and the practical implications will be presented. This is done by linking back to the research questions and the purpose outlined in the introductory section. Finally a proposal for some future research avenues will close the chapter. But first let us present some of the dilemmas mentioned in the earlier chapters that came out of the analysis carried out. These dilemmas are summarized here as paradoxes representing some lessons from a number of unanswered questions. These paradoxes in combination with the discussion included in earlier chapters increase the understanding for organizational innovation processes when implementing wireless information systems for mobile workforces.

7.1 Embracing Paradox and Ambiguity

The descriptions in Chapter 5 and 6 contained a number of dilemmas. These dilemmas represented difficult problems or situations involving a choice between equally unsatisfactory alternatives[36]. This section puts these dilemmas together as statements that are apparently contradictory and yet perhaps true in fact. This is what a paradox really is: a sentiment or statement that is seemingly contradictory or opposed to common sense and yet perhaps true[37]. The choice of paradoxes represents lessons learned from a number of unanswered questions found in the cases, and the purpose is to reinforce the unplanned and ambiguous facet of the organizational innovation process alongside its solution-based character.

The four dilemmas identified earlier are summarized here and further developed into just as many paradoxes. I have chosen four labels to refer to these paradoxes, namely '*festina lente*', *moving the goalpost*, *myopic clarity* and *supervised freedom*. The first two paradoxes originate from the discussion of innovation processes in general and the other two paradoxes connect more directly to wireless specific technology[38]. I do not claim that these paradoxes are original nor complete. However, they reinforce the idea that organizational innovation processes are not always predictable.

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[36] *Merriam-Webster's New International Dictionary*, 3rd ed., s.v. "dilemma".

[37] *Merriam-Webster's New International Dictionary*, 3rd ed., s.v. "paradox".

[38] These can be compared with the paradoxes described in Jarvenpaa and Lang (2005) about mobile technology.

Festina lente

At the end of section 5.1.1, directly after the discussion of alternative migration strategies, a dilemma about new technologies being developed faster was described. Simultaneously, the implementation of these technologies takes more time as systems become more complex and intertwined with other systems. A paradox arises here, namely:

It requires much time and careful planning to implement new technologies, yet organizations with long implementation phases find themselves with obsolete applications at the end of this process.

The translation of '*festina lente*' is to hurry slowly or make haste slowly. This phrase, originally from Latin, is an old saying used by Caesar Augustus, the emperor of Rome. He used it when complex decisions needed to be made. On such occasions to hurry slowly meant to make decisions and act quickly after due consideration.

This paradox takes its origin in the fact that the development pace of new technologies is increasing. They come about faster, often in the form of different versions of the same application. As such, the implementation of these technologies needs to be performed more quickly to be able to keep up the development pace set by suppliers. Simultaneously, due to increased complexity of systems the difficulties and problems that arise before, during and after installations make the process more cumbersome.

This has a direct influence over the introduction strategy chosen. A trade-off between complexity and implementation time arises. For example if big-bang is preferred from a timing point of view, complexity advocates alternative renewal strategies.

Moving the goalpost

This dilemma was discussed at the end of the initiation phase in Section 5.2.1, in connection to Figure 27 *Dynamic view on technology assessment* and in the example from BT Europe about the improvement capability based on work system alignment (cf. Section 6.2.2). The discussion presented the organizational innovation process as a moving target. The trade-off between freezing configurations in order to meet deadlines and continuous change requirements constitutes another paradox that can be summarized as follows:

As the innovation process evolves it becomes necessary to freeze system configurations to meet deadlines even though the learning arising from early usage can provide valuable suggestions for modifications.

This paradox arises from the fact that no design can be completed if users keep changing the specification. Again we have a trade-off between the requirement specification and the window for user contribution to design. As the innovation process develops, fewer possibilities remain for users to change requirements.

Prototypes are a very efficient way to provide feedback. Yet, if prototypes are developed too early during the process some features may be too primitive. They prevent user's feedback instead of facilitating it. In contrast if prototypes are developed too late during the process, the configurations may already have been frozen and no changes are possible.

Timing issues of promoting suggestions and freezing configurations is clearly a challenge that stems from the paradox of finishing the application on time and at the same time taking care of users' suggestions.

Myopic clarity

The section 6.3.1 about the spatiotemporal capability closes with a discussion about the necessity of processing valuable data generated by wireless information systems in order to make it usable. The dilemma that arises here is that firms produce even more data, and often they do not know what to do with it. The following paradox evolves from this dilemma:

Wireless technologies help to generate a great deal of data on business processes; however the volume of this data creates interpretation problems that reduce the visibility of the overall process.

The idea I would like to transmit with this paradox is that too much automatically generated data does not resolve any problems. It just creates new ones. Nevertheless, these problems can be transformed into opportunities if treated correctly as we could observe in some of the cases earlier.

The label myopic clarity illustrates the apparently contradictory statement, and yet perhaps true, that too much data can blind us. It requires taking a step back to get the context into which certain data is embedded. Being too close to objects may result in clarity problems when taking pictures. Thus large amount of data represents a risk of not seeing the wood for the forest. This lack of focus is illustrated by the concept of myopia.

As explained earlier, this increased complexity may reduce visibility, which leads to reduced confidence in the underlying process. Thus, it may not always be the case that wireless information systems can increase confidence through better visibility as generally assumed. Ultimately, in the worst case scenario, it may confuse the managers in charge of the workforces.

Earlier chapters presented a number of examples where location-based data from wireless systems led to misunderstandings. These examples highlight how important the interpretation and presentation of the generated data becomes. This type of paradox was described already by the American librarian Rutherford D. Roger who once said that: "*We are drowning in information and starving for knowledge*".

Supervised freedom

Section 6.3.3 discusses the connectivity capability across the cases. The section develops, among others, an argument about the trade-off between freedom and supervision as a consequence of the implementation of wireless information systems. This trade-off represents a dilemma in that increased supervision and control reduce the level of freedom. The paradox associated with this dilemma can be stated as follows:

Wireless technologies increase the level of connectivity through better reach and control; nevertheless people's experience of such control, such as in negative concern about privacy issues, may lead to communication disruptions.

This paradox refers to the trade off between control and freedom. Geoff Mulgan (1997) introduced the term connexity to refer to the conflict between the level of connectedness and freedom. He illustrated this issue when he discussed whether interdependence and freedom are compatible. Increased supervision and control represents a source of conflict in organizations because it reduces the level of freedom, and conflict arises out of the growing range of interactions supported by wireless technologies.

This paradox does not indicate that supervision is always experienced negatively. Nor is it the case that the benefits of connectivity constantly overrun the integrity of the workforces. However, the balance between supervision and freedom is tricky, and the experience from the cases shows that transparent information to the workforces about privacy concerns make it worth the effort. This is even the case when deadlines and implementation problems endanger the planned activities to inform the users.

The main lesson of all these paradoxes is that organizational innovation processes are not always predictable. The only hopeful approach to reconciling these apparently contradictory viewpoints is by evaluating each particular case. There are few absolute answers. Each case of innovation through wireless technology has particularities in one or more dimensions.

7.2 Re-innovating the Existing

Despite the lack of predictability of organizational innovation processes a number of patterns across the different cases have emerged providing with a better understanding for how firms develop capabilities while managing the implementation of WIS to support mobile workforces. One way of summarizing how firms handle these implementations of wireless information systems is that a re-innovation process takes place.

The mechanism of organizational innovation can be explained not only by the introduction of new technology but also by the improvement of existing technology framed here as a re-innovating process. The assumption of organizational innovation processes based on the implementation of new technology seen as clean slate projects with few or no pre-existing applications has been shown to be insufficient. The cases illustrated how the process of implementing new technologies is closely intertwined with the abandoning of old technologies.

The requirement for re-innovating existing processes becomes more critical, especially as the technological park of firms grows and gets older. In addition, shorter technology life cycles put greater emphasis on renewal processes, which does not mean that the early stages are thereby less relevant.

7.2.1 Understanding the Organizational Innovation Process

The conceptualization provided here provides a picture of information systems implementation mainly framed as a development process rather than a formal investment decision. Some facets recognized in the model are that these processes are not linear; they comprise the development, installation, use and abandonment of technologies; and they should take into consideration the future renewal of technological platforms already at the initiation phase. Some earlier models have considered implementation of new technology as clean slate projects with little or no pre-existing applications. Our observations from the cases illustrated how implementations of different applications were intertwined and dependent on each other.

The organizational innovation model described in this dissertation follows Wolfe's (1994) recommendation of five criteria that should be addressed by organizational innovation researchers, namely (1) the preferred research stream; (2) the stages in focus in the study; (3) the types of organizations studied; (4) the conceptualization of the innovation outcome; and (5) the attributes of the innovation (cf. Section 3.3.1).

First, this dissertation applies a preferred research stream for studying innovation processes inside organizations. Process-based research with both life cycle and teleological theories has been used. As a consequence, recurrent stages and sequential phases describe the development of innovations in the organizations studied. Iterative loops were used to explain the teleological development process within a particular phase (cf. Figure 23). Further, the organizational innovation process was depicted as a helical model with different phases following each other along subsequent technology generations (cf. Figure 24). This reinforces the idea of continuous re-innovation processes.

Second, the OIP model consists of a number of phases and stages within the phases that both simplify and increase the understanding for how the model develops. Although no focus is preferred for any phase in particular, the division helps us to identify a number of challenges that are used later in connection to understanding how the organizations developed sustainable advantages. The special attention to the intersection of different cycles provides with a discussion about different migration strategies.

Third, three different technology-intensive organizations were studied. The characterization of the organizations as technology consumers and dependent presented their common denominator. In our particular case, Taxi Stockholm, Graninge and BT Industries are organizations outside the telecom industry that to a large extent depend on technology for their business but have limited insight about the possibilities of technology. An important insight in this particular respect was the severity of system downtime. Otherwise, a more common approach consists of the analysis of technology based organizations (e.g. technology developers).

Fourth, an important issue that should be discussed is what constitutes innovation. In the case of product innovations this criterion is easier to assess. A new and successfully commercialized product represents an innovation. However, process innovations present different equally satisfactory alternatives depending on whom you ask. The innovation can be a satisfactory designed system, a successfully introduced information system or an operational and user-accepted such. The position held here is that the successful introduction of technology will do. This means that at least one watershed has been cleared. The information system has been installed and usage constitutes a normal activity of the organization. This implies new work practices and clearly defined improvements. Conceptually, organizational innovation occurs precisely before *support discontinuance*, the second watershed in the OIP model.

Finally, the attributes of innovation were discussed through the combination of both process/product innovations and the critical factors for implementing technologies in organizations.

7.2.2 Wireless IS Capabilities

We can sum up the distinctive features of the wireless information systems studied by stating that these systems represented cases of both multi-layered and multi-user technologies. The systems involved different organizational layers and were used by different occupational communities within the same organization from service to administration and management. Therefore, the impact and the implementation difficulties were larger. Moreover these technologies needed to be intertwined with existing ways of communication because of their multi-user condition. The intertwining required integration between old and new ways of communication in sometimes innovative ways. This represents another case of re-innovating the existing.

The distinction between operational and improvement capabilities provides with a dynamic view of resource management inside organizations that help us to distinguish between abilities that are longer-lasting than others.

In the cases studied three operational capabilities were identified. These were directly connected to the technology in focus for this dissertation, namely wireless information systems. These wireless-specific capabilities provided the organizations with a number of benefits. The spatiotemporal capability reduced the interdependencies that arise in the different business processes studied; the radio-engineering capability helps organizations to design wireless applications so that user-friendly applications can be developed; and the connexity capability links people to enhance collaboration between operating actors in the cases.

These three WIS capabilities were contrasted with improvement capabilities, and the conclusion was reached that it is not always so important to possess the right operational capabilities, it is more important to posses the right improvement capabilities that help organizations to develop new capabilities. Surprisingly enough, the organizations described in the first place the implementation benefits in terms of operational capabilities. The improvement capabilities were not even actively sought but were considered indirect consequences of the organizational innovation process.

This distinction between improvement and operational capabilities can be compared to Argyris' (1977) concept of single and double-loop learning. Single-loop learning refers to learning within a given system and operational capabilities fall into this classification. On the other hand double-loop learning refers to situations in which a particular system is questioned and thus improvement capabilities can be useful. This can involve challenging underlying assumptions, norms and objectives.

The issue that remains is what body of knowledge does IS capability provide. We described IS capability as the combination of operational and improvement capabilities (cf. Figure 13). IS capability is the ability to connect technology to its business performance. Although all organizations have an IS capability, they differ in their ability to mobilize resources. A strong IS capability implies faster assimilation and agility in implementing changes whereas a weaker IS capability implies a slower response when assimilating technology-related change. Therefore, the IS capability provides the ability to manage innovation processes in relation to IT technologies and consists of both long-term and shorter abilities.

7.2.3 Supporting Blue Collar Workers

How was the support of blue collar workers realized? This was discussed along the line of wireless terminals representing boundary objects earlier in this dissertation. The new technology, manifest in some touch-screen terminals, handheld devices and machine computers, represented both a strength and a weakness. If blue collar workers are normally less acquainted with information technology, these terminals facilitated the data sharing process that is situated in local practice.

An interesting consequence of boundary objects as technological artifacts is that these objects may impact the initiative-cooperation trade-off, a classical problem of organizational design research (cf. Salaman 1974; Roberts 2004). The provision of incentives promoting initiative, i.e. honest and diligent pursuit of individual goals and responsibilities, can negatively affect the cooperation disposition understood as the promotion of other's well being and common goals. This is because own goals make people more focused on these and less willing to devote time to help other people.

However, the boundary objects explained above can influence this trade-off by making it possible to have more initiative and more cooperation simultaneously. Finer performance measurements facilitate getting more initiative by lowering the cost of providing incentives and more cooperation by making coordination easier and by increasing contact between communities. In our cases for example the mobile workforces experienced greater status after workers became part of the IT era, which led to increased initiative. In addition the possibility of tighter links was also an example of increased cooperation that often happened in more formal ways than earlier.

To sum up, as we discussed earlier, blue collar workers became the great heroes of the process: both empowered and more involved. Similar to the way jazz-instruments empowered the musical expression of American black culture and America's outstanding contribution to the art of music, wireless terminals impacted the status of our blue collar workers.

7.2.4 Answering the Questions

An important part of one's own research maturation process consists in being able to identify the weaknesses of one's work. In this sense it could be interesting to discuss a number of issues that this dissertation fails to answer. However, before discussing these shortcomings I will contrast the main findings above with the original research questions. I will do so by linking back to the outset.

The overarching goal of this dissertation was to explore how technology intensive firms develop capabilities while managing the implementation of wireless information systems to support mobile workforces.

Four challenges were identified in connection to the first research question about what challenges the organizations studied encountered when managing wireless information systems. At a general level of analysis, these were technology assessment, work system alignment, blue collar worker adaptation and renewal timing. These challenges were compared to the risks factors described in earlier implementation research. It is worth noting that renewal factors have been considered less in earlier research. However, as observed in the cases studied, they are becoming more important due to, among other factors, shortened technology life cycles. This insight led to an extended description of the organizational innovation process, including the renewal phase. The extended description included several renewal strategies such as big-bang, parallel and phased approach discussed in the light of consecutive life-cycles of applications.

This first research question was addressed mainly in the articles included in the dissertation. These findings were complemented with additional empirical material and presented through a case-by-case analysis described in Chapter 5. Finally, in Section 5.2.2, the main four challenges were summarized and discussed in the light of earlier research.

Next, the second research question dealt with the capability development activities that were carried out to meet the organizational challenges identified above. These challenges were thus analyzed to identify a number of capability development activities leading to sustainable advantages. The development activities discussed in Section 6.2 were summarized in Table

16, and included activities such as managing strategic alliances, benchmarking, performing gap analysis, product sequencing, mentoring, etc. It is important to notice that the chain from challenges through capabilities and on to the development of organizational advantages is neither linear nor predictable.

Finally, the third and last research question raised the issue of which capabilities the organizations studied develop. Although the issue has already been discussed in Section 7.2.2 above, it should be added that in this regard Figure 14 is illustrative. The distinction between operational and improvement capabilities provides with a dynamic view of resource management. A number of wireless-specific capabilities and how they developed into advantages were also described in Chapter 6 earlier. These were developed from a number of research areas such as mobile communication, collaborative work, mobile commerce, etc. through a literature review and the insights developed in the papers included in the dissertation. These wireless-specific capabilities were the spatiotemporal, radio-engineering and connectivity capabilities that developed into temporary advantages.

But let us return to the issue of what could not be answered in this dissertation. The choice of studying one company from different industries has made it difficult to discuss the competitiveness of the benefits acquired by each organization. An inter-organizational study could have resulted in better insight into whether the advantages developed were not only sustainable but also competitive. More about this is included in Section 7.4 *Avenues for Future Research*.

Furthermore, the issue of unanswered questions in the dissertation has partly to do with the generalizability of results. Generalizability represents a challenge for researchers working in a qualitative manner and with case studies. Hopefully, the answers provided above have raised a number of issues general enough to be applicable to similar cases of innovations based on wireless information systems. Nevertheless generalizability should be analyzed along the two different lines presented earlier, namely generalizability beyond the domain and generalizability of observations to theory.

First, the generalizability beyond the domain studied raises an important question, whether the capabilities developed while managing the implementation of wireless information systems could be general enough to be applicable to other cases. The issue to discuss here is if it is always the case that when organizations set off to implement wireless information systems they in fact attain the benefits derived from capabilities as described above.

A first instinctive answer would be no. Such an argument would require accepting the uniformity-of-nature proposition[39]. In addition one important characteristic of capabilities described in this study is *path dependency.* Even apparently unimportant choices influence the organizational allocation of resources. This means that historical events are essential for the development of capabilities in firms. Dynamic processes such as the organizational innovation process described here exhibits sensitive dependence on past conditions and therefore each particular case requires attention on itself.

However the answer can be further qualified. There exists a difference regarding generalization of operational and improvement capabilities. In principle, operational capabilities are less path dependent than improvement capabilities and therefore easier to generalize. It would not surprise me if there are organizations that have managed to develop similar benefits derived form operational capabilities. For example considering the dispatching process at Taxi Stockholm, a similar case would be the police core. Police dispatchers work in a very similar way to taxi call-centers. Some patterns at the operational level are thus recognizable. However although a number of challenges and capabilities can be applied cross-case, specific analysis of the differences between the companies should also be performed. And it is important to remember that the benefits derived from *operational capabilities* are shorter term and easier imitable than those from *improvement capabilities.*

Second, the discussion above does not necessarily mean that there are no general results developed in the thesis. Walsham (1995) explains that beginning with the descriptions of a case the researcher can generalize to concepts, to a theory, to specific implications or to rich insight. A number of generalizations made from empirical statements to theoretical statements are included in this thesis. Some examples of generalized results include the presence-management chart (cf. Figure 39), the renewal strategies discussion

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[39] Lee and Baskerville (2003 p.224ff) discuss the uniformity of nature proposition by addressing the *problem of induction* identified by Hume and discussed in more detail in Rosenberg (1993 p.75). The uniformity of nature proposition succinctly implies the impossibility of generalization by expanding the sample size of a particular study. Although gathering additional material can be beneficial to the reliability of scientific study, they explain that this is different from increasing the generalizability of a sample to a population.

(cf. Section 5.1.1), etc. This is moreover an example of generalizing to theory according to Lee and Baskerville (2003).

One last issue that could be interesting to discuss is whether the findings above represent knowledge from a particular unexplored area, i.e. the level of originality of research. Though it is difficult to point out one's own research originality, this dissertation builds upon the combination of different areas and so in sometimes unexpected ways. For example, wireless information systems are combined with the soft IS management area in the research literature. More common are the studies of technological characteristics of different wireless technologies. Furthermore, mobile users are studied through the investigation of blue collar workers. This is also a less common approach where studies of business people, sales personnel and similar categories have been in focus in earlier wireless application studies. Other combinations include innovation and implementation theories, life cycle and teleological approach, etc.

Finally, one important aspect worth highlighting is the fact that this study applies a business to business (B2B) perspective. Our impression working together with telecom operators is that their interest so far has been on new business models for emerging wireless applications framed as mobile commerce, wireless peer-to-peer applications, etc. However, the area of enterprise computing has not yet received the attention required by these players.

It is honest to mention that each particular combination in itself has not gone either totally unnoticed. Nevertheless additional research has been welcomed and it is, as often the case, the whole set of combinations that provides certain degree of originality.

To summarize the findings, we have seen that a combination of innovation and implementation theories together with the cases analyzed provides us with an organizational innovation process that stresses a number of challenges. By applying a resource-based view of the firm a number of wireless-specific capabilities were identified as a result of managing these challenges.

7.3 Practical Implications

One goal of management studies within the social sciences research field is to identify implications for practice. This is especially important taking into consideration that this study applies foundations from the field of information management when investigating innovation processes. As already stated in the early chapters of the dissertation, the field of information management is clearly anchored in practice (Lee and Baskerville 2003 p.221). Thus, a number of practical implications will be discussed below.

More specifically, the discussion in this section sheds light on *the myths* introduced in Chapter 1 based on the dissertation's findings. These myths, namely *IT does not matter, IT is easy* and *Wireless, the next big thing*, represented the research drivers in this work. They evolved from different misperceptions about the impact of IT on businesses.

First, the debate initiated by Carr (2003) identified a need to be clearer about where the value of IT resides. This dissertation claims that the value of WIS is not primarily derived from the specific technology. This insight is in line with a conventional piece of wisdom, namely that what matters is not the technology in itself, but how you can use it. Experience has shown over and over again that it is what a particular piece of technology can help you do in your business that matters, or put differently, the capabilities it helps you build.

The distinction between improvement and operational capabilities is an attempt to address the complex issue of where the value of IT resides. The distinction between perishable benefits derived from operational capabilities and recyclable benefits derived from improvement capabilities makes the former benefits easier to copy and thus less sustainable than the benefits derived from improvement capabilities. In addition, the re-usability of improvement capabilities makes these benefits more path-dependent and more difficult to copy.

All these characteristics of improvement capabilities (reusability, technology independency and path dependency) imply that the derived benefits last longer. Therefore, a recommendation for managers is to identify required improvement capabilities to sustain a competitive position before performing an analysis of how technology can help the organization to reach this position. The observation from the cases studied showed that managers did not always act so. The recommendation here is that it is not always so important to possess the right operational capabilities, it is more important to posses the right improvement capabilities that help organizations develop new capabilities.

However, these arguments do not support the insight that IT, or more specifically WIS, is a commodity input to the process of production and would therefore not matter. The malleable characteristic of IT (described earlier as the intellectual character of IT), represents an important vehicle to achieve sustainable benefits through improvement capabilities, although the benefits are not directly derived from the technology.

IT differs from other types of infrastructural commodities such as e.g. electricity because of IT's capacity of being altered. Therefore WIS implementation processes are complex and more challenging. This discussion links to the second myth above. The earlier discussion of challenges contradicts that IT would be easy. Even if success stories stimulate creativity and assist in envisioning future business opportunities it is also important to highlight the difficulties of the process. The challenges described in Chapter 5 highlight the drawbacks of the implementation processes.

At the same time, challenges represent the antecedents in change processes. Therefore another recommendation for practitioners would be to search for the organizational challenges that can help them to develop sustainable advantages. It is easy to focus only on the problems but as described earlier the difference between challenges and problems is that challenges are often stimulating whereas problems are not stimulating more often than not. Thus, challenges can kick off true change ventures. Often the identification of challenges is a framing issue. A problem can be framed as a challenge when described in positive and stimulating terms. The transformation of problems into challenges can be important and a source of sustainable advantages if adequately managed.

Another argument in the same line and against IT being easy is the difference between wireless voice and data services. Hopefully, this study managed to show the differences between the provision of voice services and data services. Voice services, such as plain telephony, either fixed or wireless, are homogenous and can be rolled-out to many customers at the same time. However data-based services are far from homogenous. Data applications can be tailored in many different ways.

This means that the old days when voice-based services became killer applications are gone. Mobility-enhancing applications targeting the enterprise sector require a larger degree of adaptation. Thus, applications that can easily be rolled-out to many customers simultaneously are rarer. Each industry has its idiosyncrasy, and each organization presents particularities that have to be taken into account.

The recommendation to system suppliers is that enterprise applications require careful segmentation of customers and detailed knowledge about existing work practices to tailor the applications. This should be carried out together with the customers in a consulting-oriented manner. Therefore, in-depth, organization specific and longitudinal studies will be needed to create advantages for the organizations that implement these technologies. Another practical implication for the implementing organizations is that ready-to-plug-in applications are not realistic in the short term. This is the case because we study WIS, which represent an emerging technology. Thus integration and tailor efforts are required to make the technology both useful and used.

Contrary to an established opinion within the telecom industry, wireless information systems did not represent any revolution for the organizations studied. The mobilization of workforces represented an evolution of capabilities, not a revolution. The discussion in the dissertation suggests a more reflective approach to the value of wireless technologies.

Wireless information systems are special in a number of dimensions compared to other traditional information systems. Specific features discussed earlier included user orientation and personalization of the applications because WIS address a wider user-group; technological functionality for development and operations because of the system's limited processing and memory capacities; methodological differences because wireless clients still develop rapidly; etc. The wireless information systems studied represented cases of both multi-layered and multi-user technologies.

Another aspect that has emerged from this research is that wireless information systems influence social interactions at the organizations. One consequence is that the implementation of wireless technologies can create islands of social interactions, especially when working with blue collar workers. These islands may require special connection patterns. A recommendation would thus be to think twice when working with blue collar workers and mobile workforces. The sense of freedom and the opportunity of connectedness should be managed in such way so that the privacy aspects of the workforces are safeguarded.

Finally, a recommendation that has evolved from this research is that living with paradox often means embracing ambiguity. This evolves from the view presented in this study of the organizational innovation process as an open mode of change that generates new forms of un-prescribed envisioned end states.

We may conclude this section with the arguments that IT does matter and it is not easy. In addition wireless is a new thing but moderately big. This can be summarized by stating that, at the end of the day, what really matters is the piece of music composed rather that the instruments used.

7.4 Avenues for Future Research

During my research journey a myriad of alternative research ideas have both inspired me and kept me off-track. One lesson learned is that research ultimately is about selecting some alleys, making them viable and leaving aside other interesting yet less relevant paths. These paths are both thrilling and unexplored but keep you often away from the target. It is fair to give them some room in this dissertation. They are thus presented here as fructiferous alternatives that could complement this research.

There is a central aspect related to the research design in this study, namely that of variation of cases studied, that provides an interesting avenue for further research. In this study I have investigated the implementation of wireless technology leading to the development of capabilities in firms. The organizations studied illustrate successful cases of wireless information systems implementation. They moreover developed both operational and improvement capabilities.

An alternative approach would have been to include cases of organizations that did not manage to develop these capabilities and/or failed to implement the technology. This represents a complementary study that could provide interesting results about the development or non-development of capabilities under the pressure of failure. Such a study could contrast with the capabilities discussed in this dissertation. A hypothesis is that even failure can promote the development of some improvement capabilities whereas it is more unclear whether operational capabilities can emerge from failed implementation ventures. Even the reasons for failure could be better understood with the help of the idea of path dependency of improvement capabilities as described in this work. The lack of particular improvement capabilities may represent one reason for failure. In this regard we should point out that case access has been a restriction earlier. However, as times goes by and wireless information systems become more widely spread, firms will welcome researchers even for investigations of such failed implementations.

This dissertation consists of a descriptive study and does not foreground variation per se. Therefore there was no intention to explain when the development of capabilities in firms happens and the advantages that follow from such capabilities or when this does not happen. The focus was on describing the process by maximizing the number of cases where capabilities were developed. As explained earlier, the exploratory research design was therefore based on literal replication to develop the organizational innovation process model.

It is my opinion that expanding the sample of cases does not automatically increases the generalizability of the results. Path dependency of capability development requires for closer investigations of each particular case. However a larger sample, an alternative that would use sampling logic as in the case of explanatory case studies, could for example better explain competitive advantages. Here we have only discussed sustainable or long-term advantages. However to be able to argue for competitiveness of benefits we should look at a number of firms within an industry and not just one firm from each industry. This could also be a fructiferous path, namely to further analyze to what extent the advantages achieved were sustainable advantages by comparing with other firms within the industry.

It could be worthwhile also to consider another investigation of sampling logic by studying the advantages and capabilities derived from inter-organizational relationships between technology based and technology intensive companies. Such a study could include both technology suppliers and implementers in cooperation. An opportunity would be to investigate to what extent the decision episode model (Clark et al. 1992) impacts the capability development activities. Clark et al. (1992) describe the innovation pool shaped by technology suppliers in the form of simplifications such as packages and solutions. Additional improvement capabilities could emerge from such a study complementing the capabilities described in this dissertation.

In addition there are a number of implicit hypothesis that could be tested through a follow-up study with several cases. For example one hypothesis developed in Chapter 6 was that there occurs an organizational decentralization process because new activities are pushed down the organization to blue collar workers through automation. This and other hypothesis could be closely analyzed with a greater variation of cases.

Besides these interesting paths alongside my dissertation, a number of new avenues for future research have been opened as a consequence of the findings in this dissertation. For example, the renewal process of technology applications represents one important avenue for future research. A number of studies that specifically look at alternative renewal strategies could of course deepen our understanding for the renewal process.

Such a study could provide interesting contributions into the field of migration strategies and switching costs. However from the renewal perspective, wireless information systems are less suitable because of the technology's relatively recent development and their longer life cycles. Therefore the subject was not developed further in this dissertation.

However, a more appropriate empirical setting could consist of less complex applications such as operating systems.

Finally, my research has identified a number of wireless operational capabilities through the study of mobile workforces in general and blue collar workers in particular. It could be interesting to contrast these capabilities with other types of users. A hypothesis in this line would be that there are both intersections such as the benefits originating from the spatiotemporal capability and differences such as the freedom aspect of the connectivity ability.

7.5 Final Words

Arriving at the end of the journey the main message of this thesis is worth repeating. High performance firms are not those that are able to implement different breeds of technology but those that are able to learn from that process and develop long-term abilities from the challenges they are confronted with and do so repeatedly along interlinked organizational innovation processes. Thus, a piece of wisdom suggested in this thesis is that it is not always so important to possess the right capabilities from the beginning but to possess the right capabilities to develop new capabilities.

All the results presented in the dissertation hardly represent everything there is to know about managing the organizational innovation process when implementing emerging technologies, and they easily bring you to the conclusion that the more you learn the less you know.

A dissertation is about not only doing things right but also doing the right things. This was summarized earlier as producing consumable research, a mixture of both relevance and rigor. My expectation is that this piece of work can contribute to managerial action and the scholarly debate about the diffusion, transfer and implementation of information technology as described in the mission statement of the International Federation for Information Processing (IFIP) Working Group 8.6.

However, it is my opinion that the main contribution of this dissertation is more of personal character, i.e. the learning that has accompanied the process. This dissertation has been a cumbersome learning journey: a journey filled with experimentation and both frustration because of blocked roads and satisfaction when finding viable routes. At the end of the day, satisfaction with the path chosen remains. Although things could have been done differently, I do not regret any of the choices made and I am satisfied with the approach taken in this work.

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8 Article 1: The Value of Mobility for Business Process Performance

By Hans van der Heijden and Pablo Valiente

Version included in the Proceedings of the 10th European Conference on Information Systems (ECIS) held in Gdansk (Poland) 6–8 June, 2002 (ISBN: 83-7326-077-3).

Abstract

Identifying and assessing the benefits of mobile technology in a business context is often problematic. In this paper we start from the position that the benefits of mobile technology are hard to quantify in isolation, and that the unit of analysis to identify value should be the business process. An exploratory case study approach is used to identify the benefits of mobile technology at the level of the business process. We discuss one case from Sweden (vehicle dispatching) and one case from the Netherlands (mobile parking). We illustrate that benefits are contingent to the difficulty of coordinating mobile actors. Next, the value of mobility is contingent to the costs of not being able to coordinate during the period that the actors are difficult to reach. It is also related to the costs of available substitutes for mobile technology in a business process.

THE VALUE OF MOBILITY FOR BUSINESS PROCESS PERFORMANCE: EVIDENCE FROM SWEDEN AND THE NETHERLANDS

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ABSTRACT

Identifying and assessing the benefits of mobile technology in a business context is often problematic In this paper we start from the position that the benefits of mobile technology are hard to quantify in isolation, and that the unit of analysis to identify value should be the business process. An exploratory case study approach is used to identify the benefits of mobile technology at the level of the business process. We discuss one case from Sweden (vehicle dispatching) and one case from the Netherlands (mobile parking). We illustrate that benefits are contingent to the difficulty of coordinating mobile actors. Next, the value of mobility is contingent to the costs of not *being able to coordinate during the period that the actors are difficult to reach. It is also related to the costs of available* substitutes *for mobile technology in a business process.*

1. INTRODUCTION

Two important novel technology success stories over the last decade have been the Internet and the mobile phone. Development and spread of these technologies have been rapid, and this development has over time resulted in substantial and sometimes unforeseen changes in consumer behaviour. Lately, interest has grown in applying mobile technology not only in consumer markets but also in business markets. Because of this, the linkage between mobile technology usage and business performance improvement has become an issue of practical concern.

Companies with an interest in selling mobile technology and services provide numerous success stories on actual business benefits (the so-called "killer applications"). While these stories are useful in many ways, they also tend to distort our understanding of the linkage between mobile applications and actual performance improvement. As most of them are vendor and product-biased, it is quite understandable that the benefits are overestimated and the drawbacks underestimated. How

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In this paper we are interested in exploring the linkages between the usage of mobile technology and the actual improvement in business performance. We take the position that the benefits of mobile technology are hard to quantify in isolation, and that the unit of analysis to identify value should be the *business process*. The purpose of the research described in this paper is to explore the benefits of mobile technology at the level of the business process.

To meet the research objective, the project has employed the case study method, combined with a literature review and expert sessions. The methodology used is explorative in nature, and has sought to identify important constructs and relationships between them. In this paper, we report on the conceptual and empirical study, and present the findings in the form of three generic propositions (c.f. Yin, 1994).

The paper is structured as follows. First, we discuss the research to date on mobility, in a search to identify what it is that makes mobile technology useful in a business setting. We then seek to link these findings to the literature on business process improvement. This eventually results in a conceptual framework that we used as a venture point for our case study research. Two of the cases are described in section three. We also expand our study design in this section. In section four, we discuss these cases and derive the propositions. Finally, we discuss the limitations of our study and suggest directions for further research.

2. Mobile Business Processes

2.1 Mobility

Research on mobile technology in an information systems (IS) setting has been very limited, and has - to the best of our knowledge – only lately appeared in major IS journals and conferences. A number of recent publications about mobile technology focus specifically on application development (Mennecke & Strader 2001; Eklund & Pessi 2001; Varshney & Vetter, 2001) and marketing strategies (Kannan et al, 2001). These papers reflect the increasing interest of IS academics in mobile technology, but they do not specifically deal with the use of mobile technology in business markets. Therefore, they will not be covered here.

This is not to say that the implications of mobile technology in a business environment have gone completely unnoticed. A few authors have focused on the *mobility* of the users, and how mobile technology can improve this mobility. For example, there are different types of mobility in performing music. Both a marching band and a street musician require mobility to perform. Yet the former plays while moving whereas the latter plays at different locations. Kristoffersen et al. (2000) distinguish between three different types of mobility, namely *travelling*, *wandering* and *visiting*. Depending on the required mobility, different technologies will support activities in different ways. Another approach, presented by Abraham (2001), describes two main functions of enterprise mobile computing: *synchronization* and *information access*. This classification is targeted towards the attributes of communication.

Mobility is an ambiguous concept which proves difficult to define in a meaningful way (Kristoffersen et al., 2000). One approach to capture the concept of mobility is to look at some of its attributes. The removal of *geographical constraints* has been identified as an important part of mobility (Abowd et al, 1997). Location theory emphasizes geography as a factor for location decisions and has been used fruitfully to describe the role of location-based mobile services (Mennecke & Strader 2001). Distance is therefore a major aspect when studying mobility.

Another attribute of mobility is derived from its *temporal* characteristics. Mobility enables performance independently of time. It allows continuity of a certain activity avoiding time interruptions that would, otherwise, appear. This fact relates to the possibility of information access whenever you need it, often referred to as connectivity.

2.2 Business Process Performance

The business value of mobile technology –like other applications of information technology– is typically hard to evaluate in isolation. There is general consensus that the value needs to be assessed in conjunction with the *business process* that is affected or enabled by the technology (Davenport & Short, 1990; Davenport, 1993).

The concept of business process has been used in a large number of contexts and for far different purposes. Several authors have developed definitions of business processes (Davenport & Short, 1990; Davenport, 1993; Hammer & Champy, 1993; Melan, 1992; Pall, 1988). We adopted the well-known definition of Davenport (1993) that a business process is a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs (p. 5). Business processes have different degrees of complexity (Fiedler et al, 1995), and typically cross departmental boundaries and even organisations (Seibt et al., 1997).

An underlying assumption often adopted is that business processes can be improved through the adoption and integration of new technology (see Hammer & Champy, 1993 for strong views on this topic). Indeed, a number of measurements and indicators connected to the performance of business processes have been identified in former research efforts. For example, the EU Cebusnet project distinguishes between 'generic' performance indicators and 'dedicated' ones. Dedicated indicators are closely connected to specific business processes whereas generic can be generalized along a larger number of processes. Some of the generic indicators identified in the project are *customer satisfaction*, *effectiveness*, *efficiency*, *lead-time* and *flexibility* (Seibt et al. 1997).

A research framework based on the elements described above was developed to guide the field study and the data collection of this study, cf. Yin (1994, p. 28). This "blueprint" for our case studies is depicted in Figure 1. The diagram expresses the notion that both business processes and mobile technology together determine the benefits that are derived from mobile technology. These benefits, in turn, may impact business process performance.

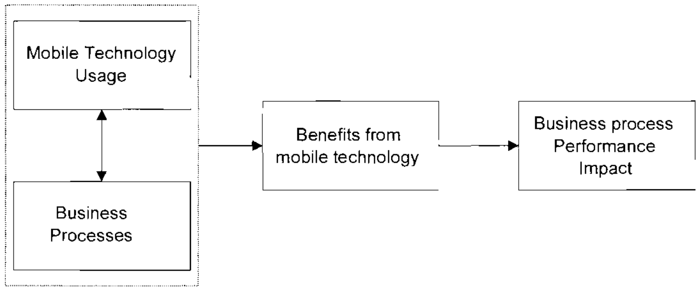

Figure 1 Preliminary research framework used to study the cases

3. Field Study

3.1 Study Design

A multiple case study was adopted to further explore the relationships between mobile application usage and business process performance (cf. Yin, 1994). Specifically, we selected business processes that met two primary criteria: (1) proven mobile technology was demonstrably used, and (2) the technology was used in the core of the business process, not in the peripheral parts.

Eventually, we selected three cases for our study. It is fair to say that in the final selection, motivations of site accessibility also played a significant role. A great deal of mobile business processes we identified were either (1) in a very early stage of the life cycle, (2) abandoned prematurely, or (3) considered too confidential by the companies involved. A significant amount of our time went into reviewing candidate business processes that were eventually discarded because they looked promising but after close inspection did not meet our requirements.

The study used graphical methods for describing the business processes studied. Modeling has become a useful method for business process analysis, especially for studying cross-departmental and cross-organisational processes (Steneskog et al, 1996). There are a large number of methods to describe different aspects of business processes, usually borrowed from related areas such as IS system design, manufacturing, architecture, engineering, etc. P-Graphs is one of these methods that describe business processes in a semi-formal way (Steneskog et al, 1996). P-Graphs model process components such as actors involved, activities and time, and they have been used in earlier research in similar settings (e.g. the EU Cebusnet project, Konrad & Schäfer, 1996).

We studied the cases from September to November 2001, and used public material, interviews, P-graph modelling, documentation and personal experience for our data collection. Case study reports were reviewed by the interviewees, and two expert sessions were organised to discuss our findings. The project involved international cooperation between the Vrije Universiteit Amsterdam in the Netherlands and the Stockholm School of Economics in Sweden. This was materialised by five joint meetings in Sweden and the Netherlands during the fall semester of 2001.

The three cases we studied were Taxi Stockholm (Sweden), Graninge (Sweden) and Mobile Parking (Netherlands). Space limitations inhibit an extensive description of the Graninge case. Briefly, Granninge is a forestry and sawmill company in mid-Norrland (Northern Sweden) that uses mobile information systems to improve the supply chain management of timber. The company has implemented a radio-based information system to enhance co-ordination between units operating in the forest (harvesters & forwarders) and the main office for management and planning of transports at Bollstabruk.

Taxi Stockholm and Mobile Parking will now be described in more detail.

3.2 Taxi Stockholm

Taxi Stockholm AB is a taxi driver company owned by Taxi Trafikförening, a 101-year-old Swedish cabdriver cooperative with a membership of about one thousand taxi owners. Operating in a deregulated market, Taxi Stockholm runs by far the largest taxi circuit in Sweden, with over 1,500 vehicles, and a total capacity of around 50,000 transport requests per day. Year 2000 drivers completed 9.3 million trips representing a turnover of SEK 1,500 million. Taxi Stockholm employs 163 people and has 3840 cabdrivers associated. Year 2000 revenue was 9.1 million SEK.

Taxi Stockholm's heart is located at Luntmakargatan 64 in Stockholm where the dispatch system matches around 25,000 transport requests per day with available cars. Reservations pass through the customer service centre and are relayed on to drivers via the taxi dispatch system.

The technological platform of Taxi Stockholm is build upon four different systems whereas the dispatch system is one of these four components. The *Telecom system* is the interface used when the customer proceeds with a Taxi reservation. Once the customer transport need has been registered, the

Dispatch System matches the requirement with an available car. This system represents the heart of the Taxi business. Next piece of technology is the *Radio system* keeping track of Taxi Stockholm's entire taxi fleet. Finally the *Mobile Equipment* constitutes technology located at each particular car and represents the driver's daily work-toolset.

Today it takes around six seconds to allocate an idle car from the instant the customer contacts Taxi Stockholm's call centre. The underlying dispatching process can be divided into four different steps as described here. First, a customer contacts the call centre through any of the channels available (telephonist, Interactive Voice Response, Internet etc). Secondly, the *confirmation of location* process starts. The main objective is to identify the origin of the customer. Thirdly, the dispatch system allocates a car. Finally the car is contacted and it picks up the customer (cf. fig 2).

This particular process has a number of mobile actors which need to be co-ordinated, namely the customers and the drivers. The call centre, situated in the heart of Stockholm, carries out the allocation of customers and taxi drivers. The origin of the customer is the main parameter that influences the allocation process. Drivers are located in a particular taxi zone. Taxi Stockholm divides Stockholm into 200 zones. A zone with a customer, that has required a taxi, is denoted a *primary zone*. Each zone has a number of adjacent zones called *backup zones*. The mobile actors are represented in the process graph as independent lanes interacting with the other actors (cf. fig 2).

Finally a number of co-ordination patterns arise for the allocation of the mobile resources. These patterns are represented in figure 2 as dashed lines. Co-ordination between the call centre and the customer is required during the contact and confirmation process. Cars need also to be co-ordinated during the allocation process. Information regarding location and status of the car is sent to Taxi Stockholm's headquarters. Another co-ordination pattern arises in order to contact the allocated car. Information about the address where to meet the customer, special instructions to the drivers, tariff based parameters, etc. must be forwarded to the cars.

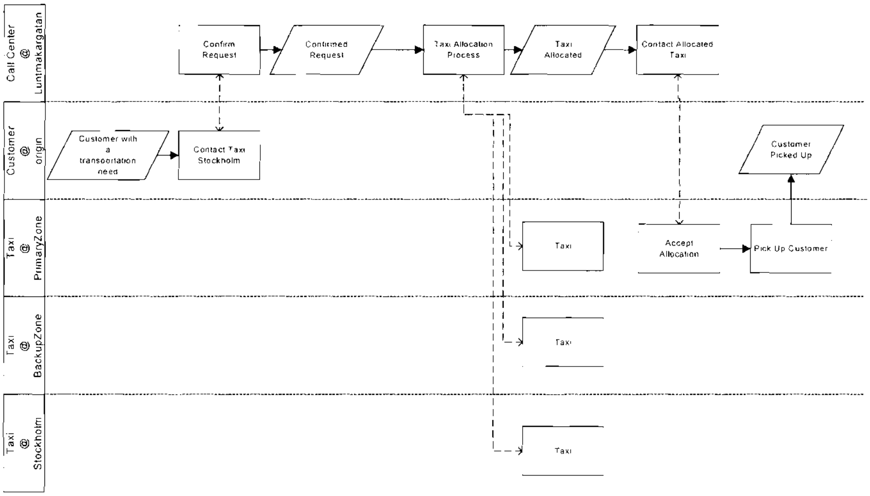

Figure 2 P-graph of Taxi Stockholm dispatch business process

Based on a number of requirements the company has identified an opportunity to improve the dispatching process through the use of improved mobile technology based on GPS, radio communication and information system technology. Better load balance, automatized checking process and future customer information requirements represent the main change drivers.

There are a number of benefits associated with the implementation of the technology. Frequency re-allocation and upgraded data-rate have increased the capacity of the radio network by 50%. The main benefit is increased information flow, which enables improved coordination of resources. The installation of GPS equipment in the cars allows for automatized checking process into a zone. With the previous system, drivers used to check into a zone manually. This process was inefficient and the reason for reduced car load. For example, drivers were aware of the high demand on the route Kista – Arlanda (route joining a dense industrial suburb with the Airport). Many drivers on their way to Arlanda checked in the Kista zone, even though they were still at the airport. Available cabs arriving to Kista were allocated high queue numbers on check-in at the area. A large number of available taxis left therefore the zone, discouraged of getting any customer although no free cabs were available at Kista because they had not arrived yet.

Finally, the new information system performs a large number of measurements. The company has been able to identify savings by a reduction of the distance from vehicle to customer by 20%. Other benefits for taxi drivers are better information access, new services available and improved work environment. Customers experience reduced estimated time of arrival and faster reservation process. The traffic control office is able to perform real-time information retrieval from the cars and at the same time benefits from location based retrieval advantages, improved information retrieval from the mobile resources and finally, real time notification advantages are also achieved.

3.3 Mobile parking

"Mobile parking" is a term used to describe situations in which car drivers use their mobile phones to pay for the occupation of a parking space. The business process can be described by a few simple steps (cf. Fig. 3). First, users register with parking authorities for participation in the project. This is most often done by returning a leaflet to the municipality, but can also be done through a website. Upon successful registration, participants can pay for parking through the use of their mobile phone instead of the parking meter. When they arrive at a designated parking space, they call a central information system (either using IVR or WAP). This system authenticates drivers using their mobile phone numbers and then logs the parking arrival time. When drivers leave the parking space, the system needs to be notified again, and the departure time is logged accordingly. Drivers are then billed by a clearing house according to the parking tariff for that zone.

In our case, we focused on a mobile parking project in the Netherlands that was carried out during the fall of 2001 in the city of Haarlem. To accommodate mobile parking, the city also introduced a novel mobile application used by parking enforcers as they walk around the neighbourhood. If they spot a mobile parking transponder (a credit card) behind the windshield of the car, they can check whether the car is legally parked through their mobile phones. After the enforcer has logged on to the system, he or she can transmit the city and the zone. The application will check its ongoing transactions database and return all licence-plates that are currently operational in this zone (the "white list"). The enforcement application is optimised for the Ericsson R380 smartphone, which has a relatively wide screen. A lightweight printer on to their belt is connected to the phone using Bluetooth and it prints a parking ticket when the license plate of the car is not in the white list.

The business process benefits for the mobile parking case are as follows. From the perspective of the car driver, the benefits include greater convenience, and savings because drivers only pay for actual time parked (with parking meters, drivers usually overestimate the parking time). Of course, parking authorities do suffer loss because of this, but gain because the number of parking meters (who are very costly to maintain) can be reduced. Surprisingly, one of the greatest benefits the enforcers saw in their application was the fact that mobile phones were very lightweight compared to the "system" they use now. Their former system was a wearable device consisting of a PC and a printer. It weighted 3.5 kilogram and they had to carry it around for around 4 hours. Since there was no backlight (and hence could not be accessed during the night), carrying around a flashlight was also required.

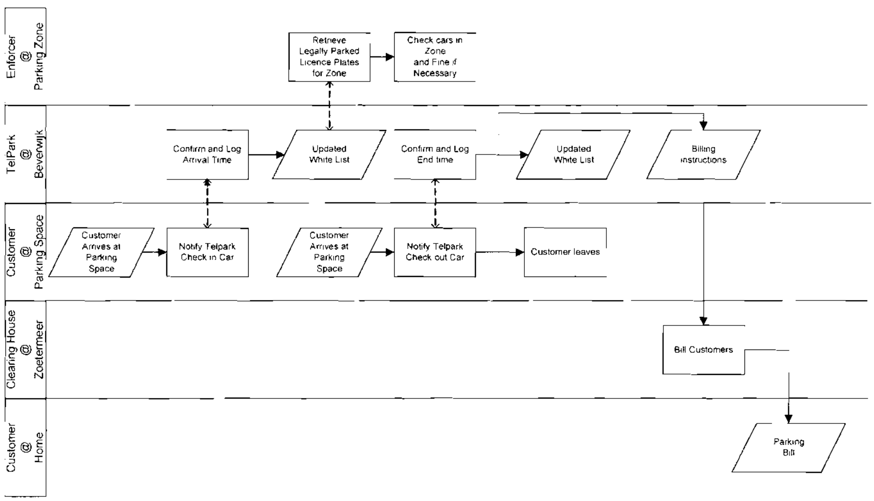

Figure 3 P-graph of Mobile Parking business process

4. Discussion of Findings

Each case focuses on a specific business process and the complementary mobile technology. In this section, we will study what they have in common. This will be done along the lines of three propositions that we have derived from the case studies.

Proposition 1

- *A business process can benefit from mobile technology if coordination is required between business process actors who are (temporarily) difficult to locate*

In the cases we studied, mobile technology is applied for the purpose of *coordination.* For clarity of exposition it is useful to distinguish between one *central* actor and several *decentralised* actors. Central actors coordinate the business process, and decentralised actors carry out the business process (they are, to a certain extent, "subject" to coordination). The following table depicts who the coordinating actors and operating actors are in each case.

Case	*Business Process*	*Coordinating Actor*	*Operating actors*
Taxi Stockholm	Taxi dispatching	Call centre	Customers Taxi drivers
Telpark	Parking enforcement	Municipality	Customers (car drivers) Enforcers
Graninge	Supply chain management	Management & Planning Transport Office	Harvesters

Table 1 Business processes, coordinating actors and operating actors

Mobile technology is used because it solves coordination problems that arise when the operating actors are difficult to locate by the coordinating actor. In each of the three cases, the coordination actor is at a fixed location, and the operating actors are at variable locations. The location of the coordination actor is stable and hence certain, and the locations of the operating actors are dynamic and uncertain. Because of location uncertainty, operating actors are difficult to reach. Mobile technology alleviates this difficulty by making the actors "accessible" to the coordination actors. In all three cases, the business process can "continue" because the actors are traceable even while they are on the move.

In the three cases, we could see that mobile technology enabled coordination adjustments because it allows 1) location-based and/or 2) real-time information be exchanged between coordination actors and operational actors. Therefore, we can argue more specifically that a business process can benefit from mobile technology if a) knowing the location of the operating actors is required for coordination purposes, and b) timeliness of information retrieval or information access is required for coordination purposes. The first condition follows directly from the observation that location is unknown. The second condition follows from the first, in that sending information to or receiving information from an actor can only occur if the location of the actor is known.

Our cases provide empirical evidence that mobile technology has addressed the difficulty of coordinating operating actors. Table 2 displays the specific coordination problems for each case and what the mobile benefits were.

Case	*Required for coordination (from the viewpoint of the coordinating actors)*	*Location attributes for operational actors*	*Mobile benefits*
Taxi Stockholm	Locations of taxis locations of customers, real-time notification to taxis	Location a priori unknown both for customers and for taxi drivers	Access to locations of taxis Notification to taxis
Telpark	Customers Real-time notification of white list to parking enforcers	Locations known, but moving between zones	Freedom of movement Access to white list
Graninge	Real-time access to daily work done Real-time notification of revised production plans to region chiefs	Locations known (at least to some extent), but no fixed line infrastructure available	Access to daily work done, notification of production plans

Table 2 Coordination requirements, location properties, and mobile benefits

Proposition 2 ("price of non-mobility")

- *The benefits of mobile technology are related to the opportunity costs of not being able to coordinate during the time when actors are difficult to locate*

Severeness of the missed coordination opportunity turned out to be an important driver for the perceived value of mobile technology by the case study participants. It is not that mobile technology *by itself* contributes to value, it is simply that without mobile technology there would not be coordination in the first place! If operating actors are "on the move", they can no longer be subject to real-time or location-based coordination adjustments. In each of the cases, this problem was critical.

This finding also has implications for business processes in which operating actors are *sometimes* on the move. A typical example is the employee on an international business travel. The value of mobile technology for this employee is dependent on the severeness of him or her not being able to communicate with head office during this time. One of the interviewees with which we discussed our findings spoke in this context about the "price-tag of non-mobility": indicating that the *opportunity costs* of not being able to be coordinated determined the eventual value placed on the mobile application.

Proposition 3

- *The benefits of mobile technology are related to the attractiveness of substitutes to solve the coordination difficulty. Substitutes include fixed terminals, predetermined fixed locations, and the usage of different coordination modes (typically standardisation)*

It is important to recognise that mobile technology is not the only solution to the coordination difficulty. The cases demonstrate that substitutes are available and will be used. First, the process owners could install fixed terminals along the way so that coordination adjustments could take place there. The parking meters are an example of this. Second, operating actors could go to a pre-arranged location to make themselves known. Taxi ramps are an example of this. Third, the lack of coordination adjustments could be circumvented by more stringent coordination *before* the operating actors go on the move. These are usually called "standardisation" coordination structures (e.g. Mintzberg, 1979). The attractiveness of each of these substitutes also impacts the added value placed on the use of mobile technology.

4. Conclusion and Recommendations

In this paper we have been concerned with the value of mobile technology at the level of the business process. We have examined the literature on the subject of mobility and business process performance. Using the preliminary framework that arose out of this literature, we have studied three cases from Sweden and the Netherlands. A number of generic findings were condensed from the empirical evidence available.

Based on the findings, we can conclude that a business process can benefit from mobile technology if coordination is required between difficult to locate actors. The value of mobility is contingent to the costs of *not* being able to coordinate during the period that the actors are difficult to reach. It is also related to the costs of available *substitutes* for mobile technology in a business process.

These findings have implications for practitioners who seek to identify opportunities for mobile communication in their business processes. We believe such an identification process need not be haphazard and can in fact be structured: our findings suggest that a systematic analysis of actor locations in a business process, and the difficulty of coordinating them can be productive. Spotting substitutes is one element of this identification process, and "complicating" the existing locations another (so that the mobile technology can enable the business process to continue even in more difficult to reach locations). A useful area of further research would be to develop a step-wise method to seek mobile opportunities for existing business processes.

We realise that our analysis has been bottom-up, and that another selection of cases would likely have produced a different set of findings. For example, we have not been able to explore a case with a *mobile* coordination actor, but clearly these business processes exist (consider for example Airforce One). We would encourage other researchers to study other mobile business processes, and see how and why these applications contrast with our findings.

The value of mobile technology at the level of the business process is still a relatively unexplored area. We believe that the three cases that we have studied offer some insight into the relationships at issue, but we also acknowledge that we are not yet in the "theory testing" stage. Nevertheless, our research has been a first step towards a better understanding of the relationships between mobile technology and business process performance.

5. Acknowledgements

The authors would like to thank the members at the department of Information Management (Stockholm School of Economics) for the insightful comments at the different seminars hold during this research project. Special thanks go to Mats, Martin, Christofer, Björn, Anders and Kristina. We would moreover like to thank Olof Hanssen, Hans Nyström and Ulf Gimbringer working at Taxi Stockholm for their openness to research. Hans Torin, Michael Welin-Berger and Ivo Kukavica from the Center of Excellence Mobile business at Cap Gemini Ernst & Young gave us valuable hints and encouragement on our work. The authors would also like to thank Steef Peters, Els van de Kar, Marc de Groot, Louis Kinsbergen, Menno Schilder for their exceptional co-operation and straight comments.

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9 Article 2: Bringing the Enterprise System to the Front Line

By Alf Westelius and Pablo Valiente

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Abstract

This paper draws on the need to understand how mobile technology is implemented and used at the organisational level. IT is a general-purpose technology and its use involves a high degree of uncertainty. Therefore, managers have trouble in identifying the real scope, the functionality, and the impact of new mobile applications. However, these three types of uncertainties need to be handled in change management projects where new information technology is involved. Gradual uncertainty reduction at these three different levels – that is, what technology can do, will technology work, and will users adopt it – is studied in this chapter. This is achieved through an analysis of the implementation process of an information system at BT Europe, a leading supplier of forklift trucks. The analysis shows how the computerised parts of the information system are complemented by mindful intertwining with the noncomputerised communication and manual data processing in order for the information system to work.

Chapter X

Bringing the Enterprise System to the Front Line: Intertwining Computerised and Conventional Communication at BT Europe

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Abstract

This paper draws on the need to understand how mobile technology is implemented and used at the organisational level. IT is a general-purpose technology and its use involves a high degree of uncertainty. Therefore, managers have trouble in identifying the real scope, the functionality, and the impact of new mobile applications. However, these three types of uncertainties need to be handled in change management projects where new information technology is involved. Gradual uncertainty reduction at these three different levels—that is, what technology can do, will technology work, and will

Introduction

The possibilities of mobile technology continue to broaden and expand. Many organisations have invested, or are considering investing, in this technology. The present slowdown in investments is expected to be temporary, and hopes for the future are high. One area that is attracting attention is the use of mobile terminals that can give mobile employees access to central information systems, such as enterprise resource planning (ERP) systems.

At the level of the business enterprise, investment decisions related to new technology in general and mobile technology in particular are usually fairly challenging. Some industry analysts and telecommunications providers claim dramatic business improvements, but many IT and business managers have expressed concern that the business value of mobile technology may not be quite as substantial as suppliers would like them to believe. One reason for this may be IT's "ambiguous" (Earl, 2003) and open-ended character (cf Asaro 2000; Orlikowski & Hofman, 1997). Earl (2003) proposes that three important sources of ambiguity are uncertainty regarding what technology can do, whether the technology will work, or if it will even be adopted. The aim of this chapter is to describe and analyse the uncertainty resolution process in a large-scale implementation of mobile technology, and the interplay of new and old technology and organisational solutions. This chapter analyses the implementation process of an information system (EASY–Engineer Administration SYstem) at a leading supplier of forklift trucks where mobile terminals are used to give service technicians access to the ERP system. The mobile terminals provide service technicians with an interface to structured, written data in order to rationalise the entire service order process. The project was carried out as a follow-up to a business process reengineering (BPR) project that resulted in the implementation of a common ERP system across the European division of the company.

The chapter is organised as follows. First, we present models central to the article, followed by a brief account of the research method. Then the implementation of the mobile application is described. The description includes the project background, a number of identified benefits, the project itself, the organisational impact and the management of change within the project, and finally some technical considerations. We conclude the paper with a discussion of three different kinds of ambiguity of IT implementations that are based on open-ended technologies, how the uncertainties interact, and how computerised and manual parts of the information system intertwine to create a functioning system.

Utilising Ambiguous Technology

In the research literature, it has long been acknowledged that technology interacts with other aspects of organised work, and that change in one aspect affects the others. Leavitt's "diamond" (1965) suggests that interaction with and among people, organisation, and task is important when dealing with technological change. Lundeberg's "levels of abstraction" (1993), dealing specifically with IS-related change, further divides technology into hardware and software, and distinguishes between information and activities. Talking of "results," rather than "tasks," perhaps reflects the rhetoric of the 1990s, while "people" and "behaviour" are seen as two important aspects pertaining to the individuals who are involved or affected. Both these models, and others like them, specify important subsystems that need to function in ongoing operation, and that require careful planning and consideration.

Orlikowski and Hofman (1997) developed the idea that IT-related change, especially regarding partially novel and "open-ended" technology, cannot be fully planned. Important opportunities–and obstacles–will arise, and be noted, over time, as people learn about the technology being applied, and reflect on the interaction between the computerised and noncomputerised aspects of the work being performed. An opportunity-based strategy for change acknowledges, and tries to benefit from, the emergent and changing understanding of IT-related change over time.

Earl (2003) further develops the notion of uncertainties connected with the use of ambiguous technology, suggesting that the actual benefits derived from the use of IT in an organisation will always be uncertain when envisaged in advance. He proposes three important types of uncertainties: enabling uncertainty, what technology can do; commissioning uncertainty, whether the envisaged application can be built; impact uncertainty, whether the application will be adopted and gainfully used. Robey, Schwaig, and Jin (2003) finally turn the focus back to the interaction between the virtual and the material. They suggest that full digitalisation is probably neither desirable nor feasible. The objective should instead be to develop a mindful intertwining of virtual and material communication. We will draw on these ideas of interrelations and interactions between aspects of technology and the use of it, of different types of uncertainties, and on the intertwining of computerised and noncomputerised aspects when analysing how a vision of computer-supported work is turned into practice.

Method

The BPR project and the hardware and ERP projects that formed the background for the EASY project were studied through interviews and project document studies. Close to 70 interviews with people in these projects, at headquarters and in three of the market companies, were performed, and extensive project documentation was made available to that research team, which included one of the present authors and three additional researchers: Linda Askenäs, Klas Gäre, and Cecilia Gillgren. The other present author has met with the supplier of the EASY application software. The present authors have in addition interviewed representatives of the EASY project team: one from the service process side at headquarters, one from the division's IT department, and a service market manager from a market company. The authors have also been able to study the application itself, and have been given access to training material and project evaluations from a market company. The interviews have been semi-structured (Patton, 1990) and lasted 2-3 hours each. They have been tape recorded and transcribed in their entirety. The material has been analysed in a qualitative tradition. The interviews and documents relating to EASY have been searched for indications of uncertainties and trade-offs in the development and implementation process. These indications have then been used to explore connections between levels of uncertainty and concerning the intertwining of computerised and noncomputerised aspects of the administration process, when viewed as an information system.

Implementing Easy – Computerising Service Technicians Across Europe

Project Background

The organisation in focus for this study is BT Industries, part of the Toyota group. BT Industries is a leading supplier of forklift trucks, with a world market share of more than 20%, annual sales of euro 1.2 bn, and 8,000 employees. The company offers a wide range of forklift trucks plus servicing facilities and has manufacturing locations in Sweden, Italy, Belgium, United States, and Canada. From the middle of the 1990s onwards, the European division, BT Europe, embarked on an ambitious computerisation venture. A

BPR planning project to explore IT-enabled business change was carried out. A shared hardware and communication platform was designed and implemented, and after thorough evaluation, an ERP system (Movex) was chosen and rolled out across Europe in a strategic partnership with an ERP supplier.

Having installed a shared information platform, new ideas related to technology-enabled projects started to appear in the organisation. In 2001, BT Europe decided to further improve quality in its customer offering through rationalisation of its service order process. Moreover, the common ERP platform could enable a pan-European project making the exchange of ideas between different local market units possible.

A project group with approximately a dozen participants was formed. The members had different background, coming from local operations, central staff personnel, and technology consultants.

Identified Possible Benefits

The group identified a number of possible administration-related cost reductions. BT Europe's field service engineers were processing 5,000 assignments daily. Annually, 1.2 million handwritten work orders were delivered on paper to the administrative offices, and fed into BT Europe's back-office ERP system. This was a costly and time-consuming process. BT Europe's service process management decided to implement an automated solution, which extended the back-office system to the field service force by providing them with handheld mobile devices for access to the job, contract, or product information required.

The original idea was to use information technology and to modify the business processes in order to benefit BT's customers and the company itself. Faster service routines could lead to more efficient service operations. Customers would benefit from less risk of human error, faster and more accurate communication and repairs, and more motivated and informed technicians. The technicians could reduce time-consuming processes such as work-order and service-contract processing, and they could access data about products and customers resulting in more informed employees. This could eventually change the role of the technicians to becoming more business oriented. Moreover, increased flexibility to plan their work could lead to more motivated staff. The mobile access to the ERP application would provide technicians with the possibility to plan their work based on the pending work orders, report service orders and assignments, order spare parts, review service contracts, and access extensive data about products and customers. Online reporting would also speed up the invoicing process, thus reducing the amount of capital bound up in the service process.

Service technicians would not only change role but also work practices. The physical work reports manually delivered on paper to the administrative office would be substituted with virtual work reports directly fed into the ERP system resulting in automatically completed invoices. A shift from physical work practices to virtual ones would be required when interacting with the mobile terminals. Automated service order process solutions could moreover reduce the administration workload by elimination of manual routines for invoicing, processing work reports, and service assignment scheduling. Instead of dedicating time to copy invoices into the system, administrative personnel could focus on giving feedback to service technicians when necessary. A consequence of these new work practices would be to rationalise the back-office function, enabling a reduction of the number of employees.

IT projects can provide organisations with an opportunity to revise work practices and business processes (Davenport, 1997), although the opportunity is not always utilised (Asaro, 2000). As indicated above, revising work processes in BT Europe was an important aspect of the EASY project. The pan-European character of the project could moreover facilitate benchmarking between local markets and improvement of the service order processes to reflect company best practice. There were, thus, a large number of potential benefits to be derived from the project. However, the process of getting there was not streamlined. A number of issues had to be dealt with during the project.

The EASY Project

Although the idea to give service technicians access to the ERP system had appeared already during the BPR study in the middle of the 1990s, the time had not then been considered ripe. Partly, the reason was that reliable and cost-efficient mobile platforms were not yet available on the market. One of BT's main competitors had equipped its service technicians with laptops and printers accessible at the service vans. However, that project was believed to be expensive and did not show the benefits the company had hoped for. Managers in BT were pleased that they could learn from the "bleeding edge" experience of others. Part of the lessons learned from that project was that service technician computerisation should be based on easy-to-use, robust, handheld devices.

Another reason why the project had not begun earlier was the lack of a common hardware and software platform in the company. Then, by the year 2000, mobile terminal development and the development of administrative software for such terminals had progressed to the point where computerisation of the service technicians' administrative tasks seemed feasible. Local tinkering had begun (cf Ciborra, 1994), but centrally placed imaginators (cf Hedberg, Dahlgren, Hanson, & Olve, 1994) envisaged a more thoroughly transformed organisation than they believed the local imaginators did. Although the centrally placed imaginators did not envisage a business-logic transformation that would revolutionise the industry (cf Cross, Earl, & Sampler, 1997; Hopper, 1990), they believed substantial benefits would be achieved through coordinated action, and state-of-the-art use of mobile technology. To achieve potential benefits of streamlining the service process across the entire division, and to be able to split the development cost, a joint project was initiated by divisional headquarters. Not only had mobile technology developed far enough, but the division also had a sufficiently common administrative platform in place to make a joint service administration possible. Unlike in other cases where ERP implementation has been found to *prevent* business changes (e.g., Hanseth & Braa, 1998), in BT Europe the shared Movex platform was *a prerequisite* for further change.

The idea to make BT Europe's 1,150 mobile service technicians more effective was therefore discussed at an annual brainstorming meeting of market and service development held centrally in 2000. Mobile technology was by that time often debated in media and mobile technology opportunities created visions about cost reductions and improved efficiency. Many people at BT regarded the project as a prestigious one. EASY could profile the organisation as a company at the cutting edge of new technology.

From the beginning, BT managers hoped to be able to learn from other companies where similar PDA-based systems for the service function had been implemented. However, such implementations on a multicountry scale could not be found, and the company was obliged to become a first mover to some extent. BT Europe managers did not want to undertake such a large-scale and innovative project purely on faith, and therefore asked for business case calculations from the market companies. As they had hoped, it turned out that there was a sound business case for a joint project, but that no market company could muster one for developing such a solution on their own. Based on the business case, the EASY project received a go ahead, but the consequences and the details were not yet fully known. Among other things, a degree of uncertainty regarding what technology could do was certainly present. Moreover, functionality to be implemented also evolved as the project matured. As an example, it was not until after the system launch that service managers realised the potential to automatically attach marketing flyers to work order notifications e-mailed to customers directly after performed repairs. This unforeseen, new communication channel also gave EASY marketing potential.

Organisational Impact

The intended change was substantial, and for the back-office function it was truly of a reengineering scope (cf Cross et al., 1997; Davenport & Short, 1990; Hammer, 1990; Hammer & Champy, 1993). Therefore, the development team had strong participation from back-office functions to access relevant operational knowledge and to achieve organisational credibility (cf Asaro, 2000; Westelius, 1996). Those responsible for the project certainly did not want to provoke sentiments of headquarters manipulating the local companies (cf Markus & Pfeffer, 1983), and therefore saw to it that the designing members of the team came from local operations, and that consultants and central staff personnel were only in the team as support to the ones with hands-on knowledge of the business process. In this way, the developers were to a large extent developing their own future, rather than being a specialist team stuck in the middle between demanding management and an oppositional workforce (cf Howcroft & Wilson, 2003).

A lesson from the ERP project was that without a strong enough focus on designing common business processes, a truly shared computer application would be difficult to achieve (cf Gäre, 2003). The project team thus spent close to a year on mapping the present processes in three countries, devising a redesigned process, and then requiring the service managers in the other countries to perform a gap analysis between the redesigned process and their existing ones. They were required to state what needed to be changed in the current process to implement the new one, and if there were aspects of the existing process that were essential to keep, and would require modification of the new process. In the end, just a couple of almost 70 *use cases* in the new application supported alternative subprocesses. All the others presupposed one common way of carrying out the administrative process.

It was obvious that the EASY project would require a change in the role(s) of service technicians. To some extent, their present worldview and that of back-office personnel were different (cf Checkland & Scholes, 1990). The typical service technician was viewed as having a strong customer focus–the goal was to keep the customer happy by keeping the customer's forklifts operating as reliably as possible and by getting them back into operation as quickly as possible in case of breakdown. However, technicians typically had little idea of the economic aspects of a customer's service contract. Nor were they expected to sell trucks, service contracts, or consider when it was time from a BT perspective to replace rental trucks. The role the service technician was moving into, with the introduction of EASY, would be more businessperson-like. However, rather than replace the customer-oriented perspective, the ideal would be to let it coexist with a businessperson perspective and an administrator's perspective. The new service technician role would be a multiple-identity one (cf Foreman & Whetten, 2002; Pratt & Foreman, 2000). In addition, administrative accuracy and correct filling-out of forms would now be expected from each service technician. They would in the future take full responsibility for quickly and reliably feeding the ERP system with data on service work (cf Petri, 2001), without back-office serving as support and filter, cleaning data and translating between the service technician's world and the computer system's.

Concerning information provision to the service technician, the objective in EASY was certainly not to create ambiguity to make them think creatively (cf Hedberg & Jönsson, 1978), but rather to supply them with as well-tailored data as possible, to reduce the interpretive space needed to process the data (cf Thompson, 2002). The service technician's focus should initially still be on servicing trucks efficiently, not on making creative interpretations of the data they entered and retrieved. However, over time, the development of a businessperson-like role would require more interpretation of data, such as figuring out when it is time to sell the customer a new truck, or realise that the repair history of this rental truck suggests that we (BT) replace it to lower our total cost, and so forth.

Change Management

Change initiatives expecting a change in perceptions of identities or regarding tasks or even the existence of work, can be expected to evoke strong reactions (Checkland & Scholes, 1990; Fiol & O'Connor, 2002; Huy, 1999). The need to feel support in taking the step into the unknown is then highly important (Huy, 1999; Schein, 1993). In BT Europe, they have tried to achieve this through ambitious training programs aimed at back-office personnel and service technicians, and have provided a filtering function that buffers for errors the service technicians make in handling the administrative software, until the service technician masters the application at a virtually error-free level. Regarding the back-office personnel, the strategy has been to cut the number of staff at the beginning of the implementation, partly in order to get the remaining staff highly motivated to give feedback to the service technicians so they handle the application with fewer and fewer errors. A decreasing amount of errors from service technicians will reduce the workload for back-office personnel. The drawback of this strategy is that the workload on the (reduced) back-office staff is high and it is difficult for them to give adequate support to the service technicians. The learning period for the technicians is thus considerably longer than it would have been, given ample feedback. On the other hand, having kept people in back-office who would ultimately be laid off, would give them an incentive to prove that they are needed, and thus maybe keep their job, by showing that the service technicians cannot handle the application well enough on their own. The equation is thus not an easy one, and it is not obvious that it will ever be possible to determine if the path chosen was better or worse than an alternative one.

Further development of the application and its use would be based on a mix of planned changes and opportunity-based change (cf Mintzberg, 1989; Orlikowski & Hofman, 1997). Some further development could already be foreseen, based on ideas that had been deferred from earlier stages for budget reasons or in order not to risk complicating the application design that had been planned for that developing stage. In an organisation, change is taking place continuously, at a micro level, because people are not machines, and do not faithfully repeat a process in an unchanging manner forever (cf Tsoukas & Chia, 2002). The challenge in the EASY project (and for future operation) was on the one hand to stop change, getting people to adhere faithfully to the carefully designed service administration process, while not stifling initiative (cf Galgano, 2002) and instead channelling it into a "versioning" system. The process should be carried out in the agreed manner. Change ideas should be submitted to the process owner, evaluated, prioritised, and if accepted by the process owner, sorted into the next or a future version of the service process. Preserving change initiative while not being in charge of deciding on implementing the changes is challenging, and can lead to reenactment rather than change becoming the ideal people follow (Westelius & Askenäs, 2004), or require strong and visible feedback on the handling of the proposed changes (Borovits & Neumann, 1988; Petri, 2001).

Technological Considerations

At the beginning of the project, few decisions regarding the technological platform were made. However, two agreements were made relatively early. One was that the operating system had to be future proofed and relatively well established so that competition could be guaranteed. To provide 1,150 technicians with portable devices could otherwise become expensive. At the decision point, Palm OS enjoyed a larger installed base. However, terminal suppliers consulted by BT managers foresaw Pocket PC to become more available in the future. This led to the choice of Pocket PC-based solutions, because that platform seemed to offer a lower risk of terminal supplier lock-in than other competing solutions. The other was to build the application based on offline synchronisation update methods and GSM networks. Tests had shown that connectivity was often a problem and that GSM was the only type of mobile network that offered a relatively extensive coverage in the dozen European countries where the application would be implemented. Technicians often work in areas with bad network connectivity, such as in rural areas, and inside industrial buildings with massive cement walls.

Using GSM networks, users at BT Europe can synchronise data, work offline, and then synchronise data again afterwards. The solution provides access to all necessary information through the PDA, so service technicians can carry out assignments independently of external factors, such as the lack of a network connection. However, service technicians are expected to synchronise several times a day to update data both in the handheld devices and in the ERP system. To facilitate this, a one-button synchronization feature was built. Because of the selected networking solution, connection between PDA and the ERP system via middleware has to be initiated from the PDA. However, the mobile telephones the technicians carry provide back office with a way to reach a specific technician. Back office can send an SMS to a technician's cell phone to indicate when a new urgent work order needs to be downloaded and taken care of. If the technician has not synchronised the PDA within a certain period of time, a follow-up mail is sent to back office, where further action to allocate the service task can then be undertaken.

When the system had been implemented, service technicians began to experience the terminals as slow. The application is uploaded from resident to primary memory and runs in primary memory. It can take several seconds to change screen image. At the beginning, this was not an issue. However, as technicians became more acquainted with the tool, waiting for the next screen to load was experienced as highly annoying, and gave the impression that filling out electronic forms was more cumbersome and took more time than filling out the paper-based version. However, recent measurements have shown that the computerised process seems to be no worse, and perhaps even faster overall than the paper-based process, but the stress of not being able to control the progress yourself leads to a subjective evaluation that differs from the measurements.

In general, during the pilot installations, the PDAs have proven reliable, the offline work mode and synchronisation processes have worked, and the training of the service technicians and back-office personnel has gradually led to the establishment of a new work process that is close to the intended one. Believing in the validity of the business case, the service process management of BT Europe then decided on a complete rollout of the application to all mobile service technicians in all the market companies. The rollout progressed according to plan, and now, March 2004, the 1,150 mobile service technicians use EASY. At the same time, work on enhanced versions of the application and the administration process is going on. Over time, the initial uncertainty will resolve, while new opportunities–and problems–will appear and be addressed.

Discussion

The story of EASY could be viewed as an account of deployment of mobile technology. However, as the case illustrates, that would be a too limited scope. It is rather a story of change management, where mobile technology is an important aspect, but one that has to intertwine with work processes and other technologies.

Moreover, a challenge that managers face when deciding on new technology investments is that change management involving open-ended technologies is an uncertain and ambiguous process. This is so because change related with open-ended technology is an ongoing process rather than an event with an endpoint after which the organisation can expect to return to a reasonably steady state (Orlikowski & Hofman, 1997). In the EASY case, this shows up as a number of projects that follow on each other, and as a learning process regarding the use of the EASY application. This learning process is far from finished today, and will also surely come to incorporate new steps from as yet unforeseen follow-on projects. Some uncertainty can be resolved through planning at an early stage, but some remain and will only resolve gradually as time passes.

In addition, new challenges will arise as the use of the open-ended technology develops. Orlikowski and Hofman (1997) distinguish between emergent and opportunity-based change. Emergent changes are changes that were not intended, but developed "spontaneously from local innovation." Opportunity-based changes are not anticipated either, but are purposefully implemented in the change process in response to an unexpected opportunity, breakdown, or event. A pan-European project, such as EASY, spanning different cultures, different organisational units, and a large number of users with little or no contact with most other users, is subjected to many forces pulling in different directions. It is then important to meet the unexpected with opportunity-based change rather than by relying on spontaneous, emergent processes. Otherwise the envisaged, shared service administration process will not be long lived, but soon dissolve into local variants, and then the shared mobile application will probably become a hindrance to development to local companies that cannot afford developing the application on their own.

To address this aspect, EASY has been set up with a process for handling new ideas, demands, and opportunities. Suggestions for changes and further development of the process or the computer application should be substantiated with a business case, and evaluated centrally in BT Europe. To allow for orderly development of the application and uniform implementation, a versioning strategy is followed, where suggested changes that would disrupt the present version are likely to be deferred to a later version. The submission of suggestions is not expected to develop unaided; an IS coordinator has been appointed and given the task of encouraging exchange of good ideas for use of the application. Earlier experience from impromptu modifications of software have made both central and local managers wary of unexpected complications, and the service process is believed to be mature enough to allow for a somewhat slower process for implementing good ideas.

As Earl (2003) has suggested, the ambiguities of an IT-related venture can be analysed in terms of three essential uncertainties: enabling, commissioning, and impact uncertainties. Resolving the *enabling uncertainty*, determining what could and could not be achieved with the help of mobile technology is a first step. The original vision behind the EASY project was to provide the service technicians with a direct, computerised link to the shared ERP platform, rather than having them rely on paper- and telephony-based communication with back-office personnel. The early vision of online access proved infeasible. GPRS coverage was not sufficient on a geographical basis, and local connectivity problems would add to make off-line solutions necessary. Thus, that part of uncertainty concerning what technology could do was resolved. The uncertainty concerning convenient portable terminals resolved itself in a more positive manner. Expensive and cumbersome PC terminals developed into more robust, less expensive, and more reliable PDAs. However, PDAs are developed for office workers, consultants, and so on, and are equipped with a number of applications that service technicians are unfamiliar with and that could cause confusion and prolong the training period needed. Part of making the PDAs suitable as terminals for EASY was then to block out standard functionality that was not required in the EASY application. Thus, the idea of portable terminals that all 1,150 technicians could use finally seemed to be feasible. The business case they had developed indicated that the technical capabilities expected from EASY had sufficient economic potential. This was then supplemented, for example, by the rather late realisation that the application delivering electronic work order notifications to customers could also be used to deliver campaign leaflets and offers. Further examples of resolving of the enabling uncertainty are certain to evolve over time. The challenge in the BT case will be to allow experimenting within the fairly strict, newly designed administrative process, and to identify and grow the good ideas into widely implemented practice.

The next level, *commissioning uncertainty*, was an issue right from the start. IT projects can easily escalate or fail to deliver altogether, and people within BT Europe wanted to avoid this as far as possible. One attempt was appointing an experienced project manager. Starting with developing and agreeing on the new administrative process before finally choosing the actual handheld device and programming the application, and then keeping a strict regime concerning versions and changes to the specification was another. Yet another attempt was choosing a widely licensed technology from a powerful company like Microsoft, rather than proprietary technology from a smaller, specialised player. A final example was letting suppliers "go public" with the case, and thus making their public image dependent on the success of the development. So far, the strategy seems to have worked. The project has kept to the schedule, and it has also been possible to take advantage of an improved version of PDA that appeared on the market after the first pilot tests of the application.

There have also been parts of the commissioning uncertainty that have been solved through different kinds of intertwining (Robey et al., 2003) between the new and existing modes of communication. One is that error-free input by service technicians cannot be achieved through programmed controls alone. To deal with this, a filtering function was built in the middleware, giving back office an opportunity to set filtering conditions on an individual level for manually scanning transactions before releasing them to the ERP system proper. Another example is that due to the way the synchronisation is initiated from the PDA, not from the ERP system or from back office, efficient handling of rush orders includes the use of mobile telephones. The service technicians were already equipped with telephones, used them often, and will continue to use them. Calling the telephone or sending an SMS to it is thus a way to reach a specific technician. But informing of the details of a new job by telephone, rather than via the PDA would be an awkward duplication of the administrative process. Thus, the telephone is used to signal that it is time to synchronise the PDA. Similarly, since the EASY application is not built to give online access to stock levels of spare parts, that feature is solved by telephone when deemed important by the service technician. The order for the spare part is placed via the PDA, but when it is important to know if an unusual spare part is actually in stock, the service technician calls someone with direct access to the ERP system.

Enabling uncertainty and commissioning uncertainty can be viewed as mere hurdles. You have to get over them, but they do not guarantee success. Unless *impact uncertainty* is resolved in a satisfactory manner, the business case projections will not be met. In the EASY project, a start was to have frontline managers and users develop the specification with support from central managers, IT specialists, and consultants, rather than the other way round. The gap analysis in the companies that did not take part in the development project was another element in reducing the impact uncertainty. Here, a problem is that the enabling uncertainty is larger for someone who has not been part of the development project, and who has a less intimate understanding of what the actual technical flexibility will be, than the understanding possessed by those who have spent months or even years exploring the issue. There is thus a risk of not truly realising what gaps there will be between the actual, computer-supported process and the present, manual one. Since the implementation is well under way, there do not seem to have been any major surprises, but the late addition of at least one important *use case* alternative indicates the presence of some impact uncertainty after it was believed that it had already been dealt with.

Strong focus on user training has been another way to reduce impact uncertainty, and so far it appears that is has been successful. Reportedly, customers have also been positive to the introduction of EASY, and want to see it developed even further. Perhaps the most challenging part regarding impact so far has been to get the feedback loop from back-office personnel to technicians to work. With the manual process, clerks at back-office could correct much of the inaccuracies that existed in the service job reports that arrived on paper. For the new process to work as intended, technicians need to achieve error-free reporting. The filtering function described above gives back office the possibility to filter out transactions for control based on the data-entry proficiency of the individual service technician. But to learn from their mistakes the technicians need feedback concerning inaccuracies. Some of it can be handled by controls in the application itself, but some are less obvious. Should this job be charged to the customer or is it covered by a guarantee, or by a service contract? Is this replacement of this wheel noted on the right truck or on another of the same model? Is this spare part in my van really registered in the ERP system? These and a host of other questions need to be handled, and typically require communication between the technician and another human being, and maybe even repeatedly, before they become part of the active knowledge of the service technician. This again is an example of the need for intertwining between the new, mobile application and previously existing modes of communication. Given efficient feedback, this learning process will require many months. Given less efficient feedback, it will take longer or perhaps even result in a negative answer to the question: "Will EASY meet the high expectations?"

Conclusions

If we look at the conclusions the actors in the project reached and the decisions and actions they took at the different levels of uncertainty, interrelated chains become evident. At the enabling level, the wish for a light, robust terminal that would be likely to be useful in the service technician job and at a sufficiently low price finally found a match when PDAs where believed to meet the requirements. Nevertheless, actually having service technicians interact with the ERP system would require correct input of data from the service technicians. In addition, adoption would be unlikely unless the service technicians felt that they could master the application. The design of the PDA with a pen-like pointing device and touchscreen instead of keyboard seemed to match service technicians' present skills, but would require the construction of a menu-based interface. Such an interface has since been built, but by itself it does not guarantee complete and error-free input, and has also started to appear annoyingly slow to the more experienced users. *Thus, what at one point seems to lessen impact uncertainty can at another point in time increase it.*

To facilitate the role transition for the service technicians, the error-reducing capabilities of the software was complemented with a filtering function, prompting back-office personnel to manually check input from service technicians before passing the transactions on to the ERP system. If back office would also give feedback to service technicians and to trainers (outside the EASY application), the service technicians could with time improve their handling of the application. *Thus, attempts to improve the EASY application at the commissioning and impact levels had to be complemented by manual routines and conventional communication.*

Similarly, the synchronisation of the PDA and the ERP system relied on service technician initiative. At the commissioning level, it was possible to build an easy-to-use, one-button synchronisation function, but at the impact level, it rested on the routine that service technicians actually synchronise a number of times a day. In addition, to solve push of urgent service jobs from back office to service technicians, the PDA application had to be supplemented with SMSs to the service technicians' cell phones, prompting them to synchronise the PDA. Also, the replication of spare part availability data from the ERP system to the middleware being less than real-time, important spare part availability had to be checked via telephone, outside the EASY system. *Thus, consequences of design choices affected the impact level, and required intertwining of the EASY application with noncomputerised communication support to achieve certain functionality.* The analysis of chains linking different levels of uncertainty, intertwining computerised and noncomputerised communication between actors, modifying roles, and intertwining manual routines and IT processing of data could be carried to a greater depth, but the examples above illustrate our basic idea.

In technology-related change process literature, it has long been noted that successful change demands attention to the interplay between technology, tasks, and organisation, and with attention to the people who are involved in the change (e.g., Checkland & Scholes, 1990; Leavitt, 1965; Lundeberg, 1993). Often such literature has had a strong focus on planning, thereby trying to overcome obstacles and reduce uncertainty, while other authors have focused the emergent nature of change (e.g., Mintzberg, 1989; Orlikowski & Hofman, 1997; Tsoukas & Chia, 2002). In our analysis, we have attempted to combine these ideas, illustrating how the uncertainties of providing mobile service technicians access to a central ERP system have been resolved over time, while new problems and opportunities have arisen. The analysis has focused on three levels: uncertainty concerning what technology can do (enabling uncertainty), concerning if the envisaged application can be built (commissioning uncertainty), and concerning if the application will be gainfully used (impact uncertainty). We have also shown how these levels interact, and how the computerised parts of the information system are complemented by *mindful intertwining* of the computerised application and noncomputerised communication and manual data processing, in order for the information system to work as intended.

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10 Article 3: The Role of End-Users for Wireless Information Systems Usage

By Pablo Valiente

Version included in the Proceedings of the 14th International Conference on Information Systems Development (ISD 2005) held in Karlstad (Sweden) 14th–17th August 2005 (ISBN: 0-387-30834-2). With kind permission of Springer Science and Business Media.

Abstract

Among best practices recommended by leading CIOs who participated in the "State of the CIO 2003" survey (Overby and Varon 2003), user involvement was ranked third within the actions they deemed most critical to successfully lead IT in their organizations (Overby 2003). Today's real challenge consists of figuring out who to invite to the party and how to get them involved. This paper analyses the involvement of users during the implementation of wireless information systems from an organizational innovation perspective. The coincident appearance of a widely popular innovation, wireless information systems and the renewed interest for socio-technical theories, provides the opportunity to further develop the understanding of user involvement in technology management processes. This is done through a literature review on user involvement and the analysis of a case study about the implementation of a wireless information system in a forestry and sawmill company located in the northern part of Sweden.

The Role of End-Users for Wireless Information Systems Usage

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Introduction

This paper is about innovation processes studied in the light of the involvement of users during the development, implementation and usage of wireless information systems in organizations. The coincident appearance of a widely popular innovation, wireless information systems and the renewed interest for socio-technical aspects of information systems development (Wallace, Keil et al. 2004), provides the opportunity to further develop the understanding of user involvement in technology management processes.

At the organizational level, a similar pattern is observed as one of the most central challenges when innovating organizational processes with new technology are not usually the technological problems that need to be solved. A more frustrating part of the process is to understand what the end users of the system really need, i.e. their both expressed, unexpressed, uncertain and unidentified needs (Leonard-Barton 1998, p.183ss). Independently of how good the technical solutions are, if technology does not provide value to the end-users, it will not be accepted nor used. Although the problem of understanding the users' needs is not a unique issue to the implementation of wireless information systems there are a number of topics that make it specially challenging and they will be developed here.

The involvement of users in the development of new products and processes has been widely documented, however there is still much we do not know about how and why user participation sometimes delivers benefits and sometimes not (Leonard-Barton 1998 p.94; Gallivan and Keil 2003). User involvement from a product development approach in marketing has been widely documented and described. The best-known research in the area of customer innovation is probably that of von Hippel (e.g. 1982, 1986, 1988). Here the focus is however on adopting information systems at

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Therefore in this article different types of involvement will be investigated. The aim of this research is thus to investigate underlying dimensions of mobile user involvement.

Methodology

This paper uses a single case study that describes user involvement during the implementation of a wireless information system at Graninge Timber AB, a forestry and sawmill company located in the northern part of Sweden. The company implemented a wireless information system to improve their supply chain management. Although the description included in this paper describes the process during the early 1990s the company has gone through some mergers and acquisitions, which are still the object of research.

Several data collection methods were used, including interviews, secondary source material and system documentation. Furthermore, case study reports were reviewed by the interviewees. The description included in this paper borrows heavily from Nilsson (2000). During the process to develop the conceptual results presented in the paper, the analysis has continually alternated between theory and practice. The primary objective of the case was to use it for illustrational purposes. However, it has also improved the final results.

Although user involvement is an important issue independently of the technology being studied, this paper will specifically focus on the management of wireless information systems (WIS) for mobile workforces. As wireless information systems are but a sub-category of information systems, we will now briefly discuss some distinctive characteristics of a wireless information system. (a) The novelty of the technology makes user involvement a central issue. In fact, during the early phases of their development, technologies are formed in close collaboration with the users. As technology matures the technology commoditization process shifts the locus of development from users to vendors; (b) Invalidation of the unity of time and place. This general feature applied to mobile workforces particularly means ubiquity data access. New opportunities appear for the users since workforces are able to access data at different locations. On the other hand the invalidation of time and place enables the development of navigational monitoring systems, i.e. systems that make usage more easily monitored. In addition, the implementation of WIS reduces work freedom. Workers have to adhere to the fixed pace as the reduction of inventory buffers makes workers increasingly dependent on work-flow time-sequencing that is governed by the technology employed; (c) Complexity of the system. Wireless information systems consist of interconnected parts interacting with each other in such a way as to produce unpredictable outputs. They combine both services and products including hardware, software and network equipment as a whole. This complexity makes integration between the work system and the technical system more intricate.

Mobile User Engagement for Innovation

This section starts with a clarification about terminology being used in the remainder of the paper. Although the term user involvement has been used so far, Barki and Hartwick's (1989) distinction between user participation and user involvement introduces a subtle but important distinction for our purpose. *Involvement* is described as a subjective psychological state, reflecting the importance and personal relevance of an issue (psychology), of a product (marketing) or of one's job (organizational behaviour) or finally of a system to its user (IS) whereas *participation* can be defined as the activities that users or their representatives perform in the system development process. The later introduction of the term *engagement* by Hwang and Thorn (1999) as a common term to refer to the two terms mentioned above will be used in the rest of the paper (cf. Figure 1 below).

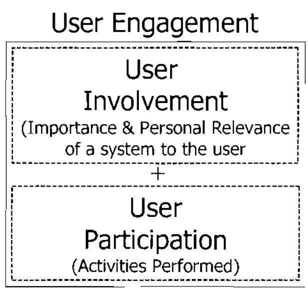

Fig. 1. Distinction between participation and involvement

There are a number of reasons for engaging users in the implementation of new technological systems in organizations. Some of these are reduction of risks; rapid diffusion of systems (Alam and Perry 2002); catalysis for new ideas (Magnusson 2003); user education (Alam and Perry 2002) or mutual learning (Magnusson 2003) in the form of input provisioning during the systems design process (Hwang and Thorn 1999).

The main goal for involving users in the adoption process of new technological systems within the area of information systems research has been the successful implementation of technology. Thus, the main dependent variable studied has often been *system success,* representing the overall goal for involving users in the design process (Tait and Vessey 1988) (Hwang and Thorn 1999). Salem (1996 p.145), for example, explains that: 'It is intuitively appealing that user participation leads to system success".

A discussion along three mobile-related key elements of user involvement in Alam et al's (2002) follows here.

a. Type of user: For delimitation purposes it may be informative to include the distinction used in the marketing area between customers and consumers (cf. Magnusson 2003 p.23). Users of a certain system can be represented by customers, consumers or employees. There are two central dimensions in this distinction. First depending on whether the user is internal or external to the producing organization you can distinguish between customer and employee. Second, depending on who consumes the acquired product you can distinguish between customer and consumer.

Looking at the first dimension, a central issue appears in connection with user engagement. Employees are in general more accessible to the innovating organization than its customers. Therefore expensive focus-group interviews or field experiments with customers are seldom required in this particular case. Nevertheless the versatility of usage patterns and contexts in which usage takes place pose other types of constraints such as the difficulty of directly observing mobile users. In addition, whereas customers often decide on the adoption of a product by themselves, employees are expected to adopt new technology based on someone else's decision, such as in the case of the implementation of a new corporate e-mail system.

	User	*Non-User*
Pays	Consumer	Organizational Customer
Doesn't Pay	Employee	n/a

Table 1. Focusing the research.

Another important distinction is that customers often pay for the usage of a product whereas employees get paid. When the customer and the user are the same individual, he/she can be referred to as a consumer. In the present study the focus is placed on the special case where the customers (organizations paying for the systems) are different from the users of the systems represented by the firm's employees as illustrated in Table 1.

b. Stages of engagement: Another important issue is to determine when user participation can be advantageous. Should users be involved in the predevelopment stages or is engagement more convenient at later stages instead? This issue connects to the life-cycle of the system. Robey and Farrow (1982) make an analysis based on three different phases: (1) Initiation; (2) Design; and (3) Implementation. They admit the need to differentiate between phases where different types of activities take place. Barki and Hartwick (1994) follow Robey and Farrow (1982) by basing their discussion about user involvement on conflict resolution. Participation and influence may give rise to conflict, which can be solved through different resolution mechanisms so that user involvement becomes an arena for bargaining (McKeen et al 1994). Hartwick and Barki (1994) explain that participation is required especially during the system development stage (or the ISD phase). However according to the authors, during the pre-development phase and post-implementation stages it is more appropriate to aim at involvement. According to this view on user engagement, a sketch model can be developed as in Figure 2.

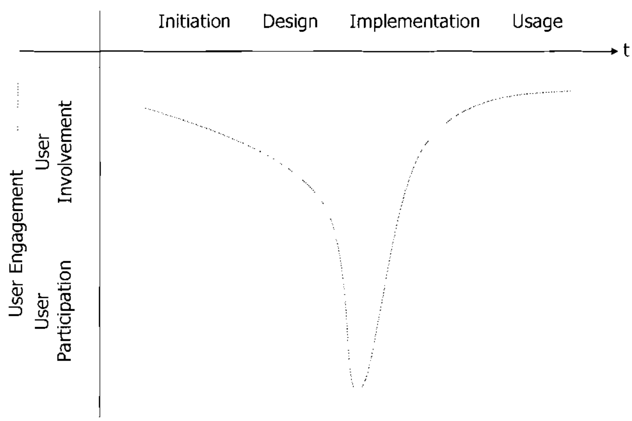

Fig. 2. A life-cycle approach to stages of engagement.

The involvement in the post-implementation phase has to do with the attitude towards the system. A positive attitude will increase the importance and the personal relevance of the system to the user, particularly as we are dealing with mobile users who are more difficult to map out due to their higher degree of location diversity.

c. Mode of engagement: The next step would be to fill participation and involvement with content: what do these terms really mean? The mode of involvement is thus related to *what* or *how* questions, such as what types of activities are performed in the involvement process at the different stages of development and use.

Newman and Robey (1992) introduce a relevant distinction, namely that of *analyst-led development* and *user-led development* as the extremes of a continuum and in-between *joint-system development.* They also introduce the term *equivocation* to refer to a fourth state arising as a consequence of communication problems. According to the authors the first mode of involvement is characterized by the use of structured and formal development methods whereas user-led development is characterized by high-level development tools. The joint-system development is characterized by the use of prototyping as an effective method for information systems development. Alam et al (2002) describe a number of activities that are useful in our particular context although they are borrowed from the marketing research area. These are face-to-face interviews, user-visiting and meetings, brainstorming, focus-groups, observation and feedback, ethnography, etc.

It is now due time to look at the case of Graninge before analysing mobile user engagement for innovation.

The Case

Graninge Timber AB is a forestry and sawmill company located in the north of Sweden. The company implemented a wireless information system to improve their supply chain management. The project (SKINFO) started in the late 1980s when the company became interested in using radio-technology to enhance coordination between units operating in the forest (harvesters and forwarders) and the main office for management and planning of transports. The company experienced a number of problems that led to the implementation of a company-wide solution.

Ideas about how to utilize wireless data communication in the supply chain management started to appear around 1988-1989 when a radio work-group was made responsible for analyzing the problem of work coordination to reduce the time spent searching for sawn logs out in the forest. This pre-phase was called the mobility-quest phase.

At the same time, SkogForsk (the Forestry Research Institute of Sweden) and Telia (incumbent telecom operator in Sweden) approached Graninge who during the mobility-quest phase had allocated some money budgeted for wireless data communication projects. Skogforsk had previously approached Domänverket (now Sveaskog AB) another Swedish forestry and sawmill company but negotiations between them did not work out. Graninge had moreover some enthusiastic persons – one could even call them visionaries – during this period who were keen to launch new projects that could make the supply-chain more effective.

The initial formal project included a pre-study (pilot) and a second phase for implementing and rolling out the solution. In the pilot project participants from Graninge, Telia and SkogForsk were put together. Moreover as the team lacked competence in information system integration Telesoft Uppsala was invited to join the project team by Telias initiative. The project started around 1990 and in May 1995 it was officially completed.

a. The Pilot Project: The pilot project consisted of a steering committee with participants from the main actors established; a project team with users from Bollstabruk sawmill (3 work-leaders and a representative from the head office); system developers and a project manager from Skogforsk. In addition the pilot project was carried out in close cooperation with nine operators. They developed the system for three machines (one harvester and two forwarders). The project group included three operators per machine from the Wilhelmina forest district that worked in shifts from 6 a.m. to noon. One of the project leaders was clearly an enthusiastic person that could take the computers home to test functionality even at weekends. He was then nearly 60 years old but very active.

During this phase a functional system was developed and ready for being implemented on full-scale already 1992. The pilot project included a definition phase consisting of mapping current operations (IPUV) and a design phase when the specification for the base system was developed and designed. Some add-on functionality was also discussed. However due to time constraints it was never implemented. During this phase Telesoft advised the project team to choose a HuskyHunter16 as the wireless vehicle computer.

Activities connected to the development of the information system at the sawmill were carried out by SkogForsk resulting in the software package *Local Info*. Changes and modifications were made during the pilot project in close co-operation with the end-users. The system development activities for the mobile side were carried out by Telesoft. They developed a prototype to get feedback from machine operators on the interface and functionality at an early stage of the pilot project. The first prototype without radio communication was already finished at the end of the year 1990.

As Nilsson (2000) points out: “Birger Risberg described the project participants as real enthusiasts who sacrificed nights, weekends and even holidays. Without the enthusiasm and will to sacrifice leisure time among these people the project would never have come off”.

During the pilot project there were technical problems with radio communication. A number of complaints from the users of the system emerged as it was considered cumbersome and difficult to use. The project went through a hard time and it was only thanks to the enthusiasm of key individuals that it survived.

Users were from the beginning involved in the design of interfaces and routines. They carried out the testing of the prototype so that additional development could be made before the equipment was tested in the final pilot project. The specification of the system was difficult due to the fact that there was no previous experience within the area of the forest sector. During the project users had the opportunity to give their viewpoints about the systems. One example is that when working on the detailed specification of the routines for the vehicle computer one saw the need of being able to print out salary cards in the machine. This function was then added. Also the database in the office was compressed to enable quicker data processing when calculating bonuses.

b. Roll-out: The pilot project was finalized in 1992 but the organization delayed the full roll-out decision more than one year. It was not before 1993 that the decision to go ahead was taken. The decision involved the total workforce of approximately 100 machine operators that would start using the new system for reporting activities. For many of these Skinfo was their first contact with IT. Some did not even know what a keyboard was. This period was before the Internet had become widespread.

The company divided the woodland into five districts that needed to be upgraded to the new system. The roll-out was carried out one at a time. First, representatives from Ericsson visited machine operators and installed the computers in the harvesters and forwarders. Then the project leader from Skogforsk, Bertil Lidén, visited all machine operators and installed the software and demonstrated the application for the users. After that they could play around with the system a couple of days before an indoor training session was arranged. All machine operators were visited during the roll-out. There was relatively little training: one half-day indoors to demonstrate the functionality. Additional testing was provided and then a final meeting to resolve specific problems was arranged. All together the training session covered one full-day.

Work-leaders in each district were responsible for roll-out and acted as ambassadors for the project. They were responsible for helping with the roll-out and took care of problems that could develop in the field. One issue that emerged was that people are often afraid of admitting they do not understand something. And as Skinfo in particular was such a new concept for end-users they often adopted the strategy of keeping silent.

c. Usage: Bertil Lidén tells with pleasure one story from a machine operator who commented for one of his colleagues that he now felt himself a part of the IT-society. Skinfo had enhanced his status. He felt he had been upgraded. Operators now were able to send faxes and to some extent messages could be sent between machines acting as a rudimentary and very primitive form of an e-mail system. For many this meant their first contact with the IT-era. The work was made more interesting for machine operators.

Nevertheless the first step is not equally big for all people. Thus the implementation had to proceed slowly and with parallel systems initially. This was however not always the case and due to rapid implementations the users often blamed SKINFO for problems despite the fact that failures depended on the users.

Regarding the usage, operators were obliged to send rapports to the sawmill. This fact encouraged usage and increased the technical skills of the operators. "This is similar to playing the piano, you have to train again and again" said Bertil Lidén. In the long run this had a positive effect. Through the usage of the system increased information became available: so much so that the competitive spirit between operators in different districts developed. By knowing the number of fallen trees competitions between the districts were arranged. This increased the spirit of the workers in the districts.

Discussion and Results

The description given above is an example of an organizational innovation process where a wireless information system was implemented at an early stage. In the late 1980s there was limited experience about the usage of wireless data communication. Skinfo represents therefore an early example of a project that benefited from heavy user engagement. Obviously, the case would be different if we were dealing with mature technological innovations which are out of the scope of this paper. Even though the case is 15 years old, we can still see similar patterns in many recent implementations of wireless information systems as an indication that some of the issues raised in the paper are still relevant.

Let us now proceed to the analysis of the different aspects of engagement in the Skinfo case presented above. First, the Graninge case illustrates the importance of visionaries to give a flying start to the whole project. Often these visionaries inject new life during the initial phases of the process. However, it is clear that their engagement is not limited to the initial phases of the innovation process. Moreover, this commitment is based not so much on concrete activities but on enthusiasm and encouragement. This is especially important in the case where development is led by experts and the workers' involvement in decision-making is only limited to consultation. It is doubtful that system design methods carried out by experts and presented in an authoritative way will lead to participation in and ownership of the resulting work processes (Niepce and Molleman 1998). The most adequate design comes from those whose jobs are under review. In the case of WIS, where technology has centralizing effects and a strong influence on workflow activities becoming more interdependent, it is hard for it to succeed if such design methods carried out by experts alone are employed.

Furthermore, the Graninge case showed an example of ongoing changes made by users as a result of engagement by participating in concrete development activities. This was in addition carried out early in the pilot phase. The functionality added to support salary cards illustrates this fact. This could be understood as an unplanned change requirement that became evident along the process. The need for circles of experimentation and learning is thus illustrated.

Prototyping was moreover considered necessary in the case above as a powerful method during development. Nevertheless the choice of site to test prototypes is also critical (Leonard-Barton 1998 p.96). Through prototyping and continuous evaluations in close cooperation with users the risk for *overshooting* is decreased. Otherwise, the absence of users in such a process may lead to the development of too much functionality that may never come into use (overshooting).

Another interesting fact emerging from the case is that the design process started by re-designing existing activities and people's roles. People with interdependent tasks had to be interconnected. In the case of mobile workforces the data requirements are truly complex. The larger level of complexity, referred to in the introduction, may not be solved by just putting persons with similar tasks together as this in many cases may not be possible at all. However a difficulty also observed above is the versatility of user patterns of mobile workforces. This makes the mapping of current operations more difficult.

Furthermore, the issue of first-step balance was also raised in the case description. This in relation to the implementation phase (called roll-out in the case) means that the first step is not equally big for everyone. For example the amount of effort necessary to understand the concept of data transfer is not equally large for all members of the organization. Especially in the case of Graninge, the concept of mobile data was unknown to some parts of the organization, unclear to others, while within the pilot team we could find experts in the area.

According to the role of human resources during the system development phase, it is important that the means utilized, i.e. the information systems, fit the ends. For instance, the work system has to fit the technical system. In our particular case the implementation of WIS makes the workflow both more effective and technology dependent. Stress factors due to technology illiteracy may thus appear. In the case we see the *keep silent* reaction of some machine operators. This is evident during the implementation and the usage phases of the system implementation process. When machine operators feel that technology overwhelms them instead of influencing the development and implementation process, the "keep silent" position is adopted.

This is extra critical in the case of WIS due to the risk of revelation of patterns that make work/usage more easily monitored and therefore the boundaries of privacy traversed. This fact was not directly observed in the Graninge case. An explanation for this may be the training sessions during the roll-out phase.

These are just but a few examples taken from the Graninge case. These have been distributed in the model developed earlier in order to illustrate how different activities vary during the process (cf. Figure 3).

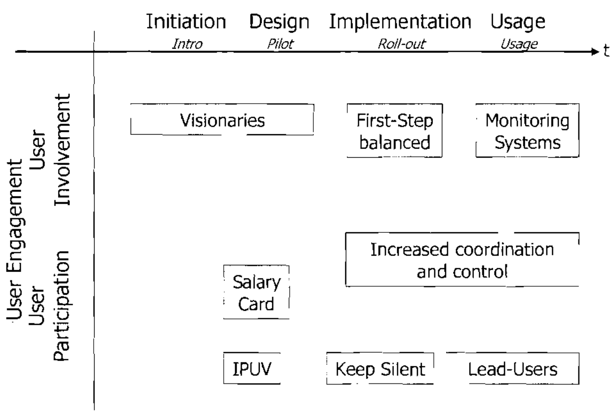

Fig. 3. The Graninge case from a user-engagement perspective

An observation that can be drawn from Figure 3 is that both involvement and participation are present in the different phases of the innovation's life-cycle. Earlier contributions such as Hartwick and Barki's (1994) intention to separate participation and involvement may be completed with a view where both are required but where the degree of engagement may be different. Moreover, in connection with the issue of innovation introduced above user engagement particularly means that innovation processes should not be regarded as a development process alone but a technology appropriation and the related social practices of usage associated to the process.

As far as mobile users are concerned, the conclusion of this present research is that there is a need to understand the workplace environment of the users. Researchers should be involved in the development of prototypes after observing the users. Their empirical setting is however based on the establishment of meetings. In the case of mobile users this observation may become more complicated as the variety of locations may impose certain restrictions.

A couple of new ways for developers to become users and for users to understand developers were described in the paper. This is for example done by applying *use cases* as a way to freeze change requirements from mobile users. However a deep training in these use cases is necessary as the users being located in the field may have a more reduced access to tacit know-how. Considering the impact and benefits achieved in the project, Graninge has become a best-practice example because of its pioneer-role in wireless data communication and user involvement.

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11 Article 4: Understanding Migration Strategies by Decoupling Application Roles and Technology Generations

Reprinted from Technovation, Vol 26 (2006), Anders Mårtensson and Pablo Valiente, *Understanding migration strategies by decoupling application roles and technology generations*, pp. 351-358, Copyright (2004), with permission from Elsevier.

Abstract

Companies invest large amounts of money in new technologies. Not surprisingly, much of the research carried out in relation to IT-investments has focused on the adoption of new technology and the related implementation barriers such as knowledge barriers and psychosocial factors. However, the process of abandoning old technologies has not been so much in focus.

In this paper, the analysis focuses on renewal investments where subsequent technology generations fulfil a similar application role. Taxi Stockholm is used to illustrate this long-term process where slowly evolving requirements on the dispatch function over time forces technology changes.

A CCT-model is presented using Customers, Companies and Technology as factors to support the understanding of technology shifts. This model is used to express the relation between the application role and technology generations. The importance of considering not only a complete life cycle of a specific technology, but also multiple such technologies providing a long-term perspective is stressed.

As the use of IT matures in companies, adopting new technologies increasingly means abandoning old technologies. By combining a business perspective (through the application role), a technology generation perspective and a technology switching perspective and finally adding the time component, an analytical expression is presented.

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Technovation 26 (2006) 351–358
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Understanding migration strategies by decoupling application roles and technology generations

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Keywords: Technology adoption; Life cycle approach; Technology abandonment; Technology switching

1. Introduction

Companies invest a lot of resources in new technologies. There is a widespread assumption that the mechanism of innovation is closely related to such investments, which often are IT-related (Baskerville and Pries-Heje, 2001, Karlsson and Nyström, 2003). Investing for innovation purposes, however, imply a high degree of uncertainty since aspects such as timing and cost control issues often turn out to be difficult to manage.

Not surprisingly, much of the research carried out in relation to IT-investments has focused on the adoption of new technology and the related implementation barriers such as knowledge barriers (Attewell, 1992) and psychosocial factors (Orlikowski, 1992). The process of abandoning old technologies has not been so much in focus; instead the adoption of new technologies has been central for IT-innovation studies. This type of research often assumes investments and implementation of new technology to be clean slate projects with little or no pre-existing applications to be considered. However, this conception of technology adoption tends to ignore the organization's existing IT-portfolio and current solutions.

Our observation is that the fact that companies today manage quite complex IT portfolios that evolve over time (Mårtensson, 2003) has not yet fully influenced the IS research community. The amount of research on this issue does not reflect its importance for practitioners, even though some scarce research does exist (e.g. Weill and Vitale, 1999; Ward and Peppard, 2002). This paper will focus on renewal investments where the application role remains stable, but subsequent technology generations result in overall improvement of the organization's IT platform. Thus, our research aims at covering not only adoption and implementation of new technology but also abandonment of obsolete technology.

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doi:10.1016/j.technovation.2004.11.004

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Abandonment is often motivated by lacklustre performance of old technologies, which may be due to the economical, technical or physical ageing of existing technologies (Karlsson, 1988), government legislation (Achilladelis and Antonakis, 2001), competition among firms (Leoncini, 1998), etc. Independent of the underlying reasons that may initiate the renewal process, decision-makers often face a challenging problem to find the optimal timing of the technology transition. The abandonment of old technologies implies high costs due to path dependencies arising from earlier applications. The issue then is to be able to maximize the utility of existing technologies, minimize the switching costs of the transition and at the same time cope with uncertainty.

Starting from the technology life cycle, this paper discusses how sequential technology generations fulfil an application role in the company. This is illustrated by the Taxi Stockholm case. An analytical model that describes the process of technology switching at organizations is finally presented. The discussion aims at increasing understanding of the application development through successive technology generation renewals. But first we turn to some methodological issues.

Methodology

Our main sources of inspiration for this paper have been theories about technical change and experiences from real-life situations in companies. We have used a single-case approach where data was collected during the fall of 2001 by one of the authors. Several data collection methods were used, including interviews, business process modelling, public material, project documentation and system demonstrations. The use of multiple data collection methods has allowed for data triangulation (Denzin, 1989). Furthermore, case study reports were reviewed by the interviewees, and two expert sessions were organized to discuss previous findings.

During the process to develop the conceptual results presented in the paper, we have worked iteratively between theory and practice. The primary objective with the case was to use it for illustrational purposes. However, it has also helped us to develop and improve the final analytical expression.

Finally, we have chosen to present our results through an analytical expression. In natural science, mathematics is the ideal form to express theory. Although less common in social sciences, we found it helpful in order to establish accurate relationships between concepts in a consistent way (cf. Lee, 1999, pp. 12-13).

Technological change

Schumpeter (1939) based his ideas on technological change on the assumptions of disequilibrium, non-linearity, cumulativity and path-dependency. Many, if not most, theories on technological change have since then been based on Schumpeter's work in some way. The technological system theory (Metcalfe and de Liso, 1996) is one example. Leoncini et al. (1996, p. 417) use the concept of technological system by taking into consideration different interacting components to explain technological change. They suggest four sub-systems as important when explaining the root of such change: the science and technology sub-system, the industrial sub-system, the commercial-market sub-system and the institutional one. Thus their effort tries to explain technological change beyond the analysis of particular technological artefacts. This effort is similar to the approach taken in this paper, which will apply the product life cycle beyond the individual product or technology by considering the application portfolio in the company.

The life cycle concept

The life cycle concept is well established both empirically and theoretically. The term was introduced during the early decades of the 20th century (Kuznets, 1929; Schumpeter, 1939). The concept was developed later during the 1960s by Vernon (1966) and Hirsch (1967). Since then a number of researchers have contributed to the establishment of the concept (cf. Kim, 2003, p. 372).

The product life cycle theory explains how a product develops through a number of different phases from introduction to growth, maturity and decline (Forrester, 1963; Brockhoff, 1967). Karlsson (1988), based on Cole (1981) and Batten and Johansson (1987), even considers a conceptualisation and creativity phase prior to product introduction, which we find important to take into account for the purposes of this paper. Although the number of stages and their labels differ, the general idea remains the same, i.e. to explain the product's development through its total life span. In Fig. 1 below we illustrate our conceptualisation of the product life cycle.

The product life cycle concept has proven to be a powerful analytical tool to describe product development. Therefore, the concept has been applied at different levels not only to study products but also technological innovations (cf. Bauer and Fischer, 2000; Chase et al., 2001).

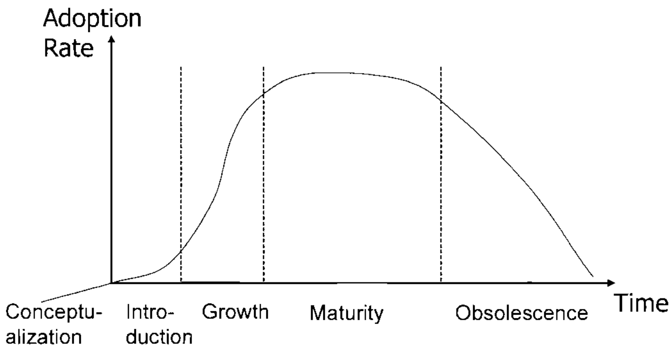

Fig. 1. Product life cycle.

Kim (2003) defines a technology life cycle as the life cycle through which a technology generation evolves. Thus we would like to introduce for the purpose of this paper the concept of the *application life cycle*, which is closely related to the earlier uses of the concept. The application life cycle, however, differs from the technology life cycle since it deals with a company applying some technology to create a value proposition rather than a technology itself.

A company perspective on technology change

It is noteworthy that even though product life cycles are commonly applied to products, and thus linked to the typical S-shaped curve of diffusion (Rogers, 1995), it is more seldom applied to an organization's use of a technology. In 1974, Gibson and Nolan (1974) published an influential article on stages in electronic data processing growth suggesting four stages of growth: *initiation*, *contagion*, *control* and *maturity*.

A slightly different approach was used by McFarlan et al. (1983) who identified four phases for technology assimilation, i.e. instead of studying the electronic data processing of the whole company (as Gibson and Nolan did), they studied the assimilation of a specific technology. The four phases are *Identification and initial investment*, *Experimentation and learning*, *Control* and finally *Widespread technology transfer*. With minor adaptations, this model is still in use (Applegate et al., 1999).

There may be many reasons for the exclusion of the abandonment phase from the model. In Gibson and Nolan's case (1974) this is to be expected since they are studying the company's use of information technology, which is likely to be an on-going process up until the company itself is closed down. In the case of McFarlan et al. (1983) one interpretation is that the model focuses on *assimilation* of new technology. The decision not to deal with the abandonment of the technology is, however, not made explicit. Other studies, such as Nilsson (1991), present a life cycle model for information systems consisting of the three phases *development*, *operations and maintenance* and *decommissioning*.

Quite naturally, innovation studies have traditionally focused on the early stages of the product life cycle, that is product introduction and market growth. However, the mechanism of innovation and technical change can be explained by not only the introduction of new technology or the imitation of existing technology but also by the removal of an obsolete technology (cf. Karlsson and Nyström, 2003).

In this study, we will focus on the abandonment of obsolete technology and the interrelation with adoption of the next technology generation. Therefore, we will study subsequent life cycles for a particular application through its development along technology generations. To do this, we will now turn to Taxi Stockholm and see how that organization has lived through several technologies related to their taxi dispatch system.

Taxi Stockholm

Company introduction

Taxi Stockholm AB is a taxi company owned by Taxi Trafikförening, a 101-year-old Swedish cabdriver cooperative with a membership of about 1000 taxi owners. Operating in a deregulated market, Taxi Stockholm runs by far the largest taxi circuit in Sweden with over 1500 vehicles and a total capacity of around 50,000 transport requests per day. In year 2000 drivers completed 9.3 million trips representing a turnover of 1500 million SEK and a profit of 9.1 million SEK. Taxi Stockholm employs 163 people and has 3840 cabdrivers associated.

The heart of Taxi Stockholm is located at Luntmakargatan 64 in downtown Stockholm where the dispatch system matches around 25,000 transport requests per day with available cars. Reservations pass through the customer service centre and are relayed on to drivers via the taxi dispatch system.

The technological platform of Taxi Stockholm is built upon four different systems where the dispatch system is one of these four components (see Fig. 2). The Telecom system is the interface used when the customer proceeds with a Taxi reservation. Once the customer transport need has been registered, the Dispatch System matches the requirement with an available car. This system represents the heart of the Taxi business. The next component of the platform is the Radio system keeping track of Taxi Stockholm's entire taxi fleet. Finally, the Mobile Equipment component constitutes technology located in each particular car and represents the driver's toolset for his or her daily work.

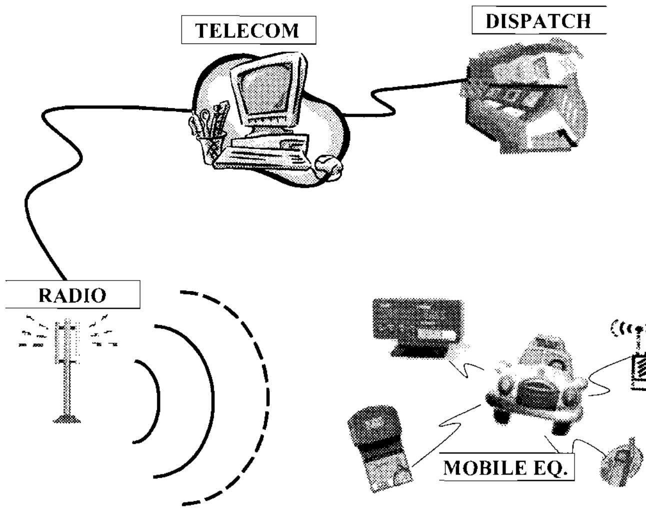

Fig. 2. Technology platform components at Taxi Stockholm.

Today, it takes around 6 s to allocate an idle car from the instant the customer contacts Taxi Stockholm's call centre. The underlying dispatch process can be divided into four different steps. First, a customer contacts the call centre through any of the channels available (telephone, Interactive Voice Response, Internet, etc). Second, the confirmation of location process starts. The main objective is to identify the origin of the customer. Third, the dispatch system allocates a car. Finally, the car is contacted and it picks up the customer.

Situated in the heart of Stockholm the call centre carries out the allocation of customers and taxi drivers. The main parameter that influences the allocation process is the location of the customer. The city of Stockholm is divided into 200 zones, and any zone that currently contains a customer that has required a taxi is called a primary zone. Each such zone has a number of adjacent zones called backup zones. The customer is assigned among the available taxis in the primary zone. If there is no available taxi in that zone, an available taxi in a backup zone is selected.

Need for improved mobility

Taxi Stockholm computerised its dispatch system already in 1984. The company then used a combination of Telia and Volvo systems called Taxi80. The system was originally developed in the late 1970s by a small organization within Volvo Busses, Volvo Traffic Information Systems. The name was chosen because the company tried to sell the system together with taxi cars for the Moscow Olympics in 1980 (Holmén and McKelvey, 2002). Later on, Telia further developed the system for mobile data applications by integrating it with its Mobitex system for radio communication. It lasted until 1991 when Taxi Stockholm migrated to a Motorola system called TaxiPak. Lack of programmers of the old RSX11-language used in Taxi80 increased consult tariffs incurred when upgrading the system. Thus, it quickly became obsolete. The migration was performed by a forklift, or big bang, process where the old system was replaced all at once. The migration was problematic and resulted in extensive downtime periods.

When the new Motorola system was implemented it allocated 12 frequencies to the 12 masts located around the city. Each mast, therefore, used one radio channel and when a car moved between different city zones, the radio channels were allocated to the car depending on proximity to the masts. However, the channels easily become overloaded, especially in dense areas such as the city centre. One consequence was that drivers had to wait up to 30 s between interactions with the mobile terminal. Drivers were annoyed at this. Attempts to reduce the interval down to 10 s failed due to traffic congestion problems. Bandwidth shortage led the company to revise the Motorola-based infrastructure. Thus, load balancing was a driving factor behind the late 1990s upgrading of the system. Re-using the limited number of channels to obtain better load balancing was an important requirement for the new system.

Another problem with the old system was the process of checking into a particular zone. With TaxiPak, drivers used to check into a zone manually. This process was inefficient and caused lost business. For example, drivers were aware of the high demand on the route Kista–Arlanda (a route joining Kista, a dense industrial suburb, with Arlanda, the main airport). Many drivers on their way to Arlanda airport checked into the Kista zone, even though they had not even arrived at the airport yet! As a consequence, available taxis arriving to Kista were allocated high queue numbers on check-in at the area. A large number of available taxis therefore left the zone, discouraged of getting any customer although no free taxis were actually available at Kista as they had yet to arrive. An automatic check-in process dependent only on the car's location and not on drivers' wishes was therefore required.

Finally, the taxi industry is shifting from the traditional radio/voice method of managing fleets to more efficient data operations. This implies future customer demands that cannot be addressed by today's system. For example, Taxi Stockholm expects that precise information on time of arrival will soon be required by customers as will route taxes based on distance rather than the taximeter. Moreover, drivers are in need of advanced information and probably future services like navigational systems, Internet access, etc. These expectations and others, not yet identified, will have to be meet by the new system.

Better load balancing, automatic check-in process and future customer information requests represent the three main needs for improved mobility identified at Taxi Stockholm.

Migration

Due to the aforementioned problems, the company realised that their technology platform had to be modernised to meet future customer demand. The process started in 1998 when a group was established to revise the dispatch, radio and mobile systems.

Market research was carried out, and around 10 different potential providers were evaluated. Taxi Stockholm decided to abandon the Motorola platform and to install a solution provided by a Canadian company called Digital Dispatch Ltd. Digital Dispatch System (DDS), the company's flagship product, would provide Taxi Stockholm with a complete solution for the dispatch (PathFinder), radio, and mobile terminals at the cars. The company abandoned the Motorola system for two reasons, namely Motorola's decreasing interest in the taxi industry and the fact that the terminal equipment offered by the company was based on thin clients, without any processing capacity. Due to a slow-connection of 9600 bps Taxi Stockholm's fleet needs processor capacity at the terminals in order to decrease traffic-load.

The upgrading of the system was to be performed during a 3-year period. The migration strategy agreed upon was a seamless upgrade instead of the forklift approach used previously. The company is today halfway with the implementation, which will be carried out in three different steps.

First, the radio infrastructure will be upgraded. Two main goals will be achieved with the upgrade of the system. Due to the bandwidth shortage in the current infrastructure and the fact that no additional frequencies will be made available by Sweden's National Post and Telecom Agency, frequency reuse was necessary. DDS will deliver a new infrastructure that places each frequency on three adjacent masts instead of one frequency per mast. To avoid interferences between the different radio signals, base stations send alternately within short time intervals. Allocation of frequencies on several masts increases capacity, especially in highly dense areas such as Stockholm city. The other goal with the new infrastructure is to achieve higher throughput in the network. These two actions will increase the capacity of the network by 50%, which enables for faster interactions with the mobile terminals, availability of new services from the cars, etc.

Second, the mobile terminals in the cars will be replaced with a DDS terminal. The replacement has been carried out gradually by one frequency channel set up and 50 terminals installed at a time. Finally the dispatch system will be replaced. Pathfinder will replace TaxiPak. However, the upgrade will be postponed if problems are experienced before that.

Technology shifts

One of Taxi Stockholm's most essential business needs focuses on the dispatch of customers. In the description above we can observe how the company over time has implemented three different technology generations in cooperation with different suppliers as illustrated in Fig. 3.

Technology Generation	1st Gen	2nd Gen	3rd Gen
Supplier	Volvo & Telia	Motorola	DDS
System	Taxi80	TaxiPak	PathFinder
Change Drivers		Computerization Dispatch	Bandwidth Shortage & Load Balancing
Migration Strategy		Big Bang	Seamless Upgrade
	1984	1991	1998

Fig. 3. Technology shifts at Taxi Stockholm.

The different technology generations were implemented to meet the customers need to be dispatched. Taxi Stockholm's need to be able to dispatch customers remained stable over time at the same time that opportunities derived from new technological advancements changed the way and level of efficiency of the dispatching process. The timing and decision of technology renewal was central for the company to become a leader of an old-fashioned industry.

Discussion

Application roles and the CCT-model

The story of Taxi Stockholm can be considered as an example of technological change at the organizational level. To explicate the process leading up to the need for technology generation switches we would like to introduce our CCT-model (see Fig. 4 below). Its core components *Customer*, *Company* and *Technology* can be found in other frameworks such as Björn-Andersen et al.'s (2003, p. 156) MTO-framework consisting of Market, Technological and Organizational factors. Moreover, our CCT-model builds on Leoncini et al.'s (1996) components described above, namely *science and technology*, *industrial*, *commercial-market* and *institutional*. Worth noticing is that the institutional component is not explicitly included in our model since the focus of the article is on the organizational level. This is not to be interpreted as if institutional factors are not important. Rather, other factors are in focus and it is fully acknowledged that the factors of the model exist and interplay in an institutional environment.

The CCT-model helps us to understand technology shifts by addressing the following three aspects:

- What does the company offer?
- What do the customers demand?
- What can the technology provide?

The intersection between Company and Customer reflects the organization's value proposition; there is an application role to be fulfilled. For example, Taxi Stockholm's value proposition is to dispatch customers with transportation needs. Therefore, the company makes use of a dispatch application to fulfil this need. The dispatch value proposition of the company is therefore fulfilled by the dispatch application role. This role can be fulfilled by different technologies reflected by Technology circles of varying sizes each covering different areas of this intersection. These circles are not stable over time; instead they are continuously evolving since the answers to the three questions above develop constantly.

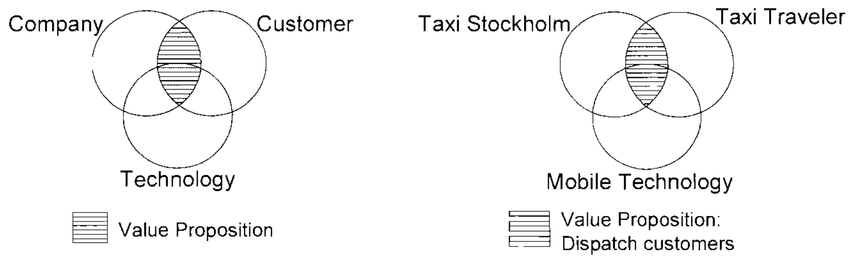

Fig. 4. CCT model.

The CCT-model presents a snapshot of how these factors interact. Taxi Stockholm and its customers have always had a need for efficient dispatch of available cars to prospective customers. In CCT-terms, this is reflected by the intersection between Company and Customer (the organization's value proposition). Over time, this need has evolved as customers' demand and what the company wants to offer have changed. The taxi industry is shifting from the traditional radio/voice method of managing fleets to more efficient data operations. Moreover customers have shifted their behaviour from hailing taxis on the street to reserving through the call-centre. In the future, a customer may for example demand precise information on time of arrival, route taxes based on distance and not based on the taximeter, etc. This is conceptually illustrated in Fig. 5.

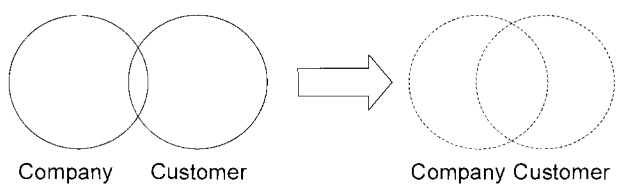

Fig. 5. Evolving application role.

At the same time several technologies have met this value proposition as described in the case above. At a specific point in time a certain technology, when applied by the company, manages to meet this application role to some extent. In CCT-terms this means that the Technology circle partly covers the intersection between the Company and the Customer. For example, the underlying technology in both the Motorola and the DDS system would have been able to fulfil the need of dispatching customers. However, the DDS system through reallocation of frequencies could offer a better-suited technology and therefore the intersection with the value proposition is larger as shown in a similar figure (see Fig. 6). The figure illustrates how different technologies at a specific point in time meet the business need to different extents.

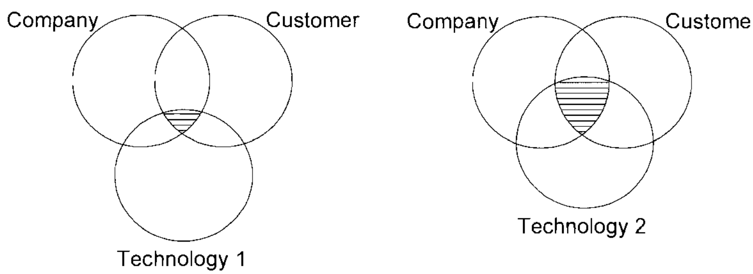

Fig. 6. Different technology generations at a certain point in time.

Over time these circles will evolve in the same way as illustrated in Fig. 5. Technology develops and more efficient ways of dispatching customers appear. This indicates that the time aspect is therefore central in such an analysis.

Application role and technology generations

A different way of looking at this is to study the relation of technology generations and the application role over time. The application role is constantly evolving over time and different technology generations could provide this utility to varying degrees as illustrated in Fig. 7. The application role function can conceptually be thought of as the area of the intersection between the Company and Customer circles in the CCT-model. The different technology functions on the other hand conceptually correspond to the area of this intersection covered by the technology in question.

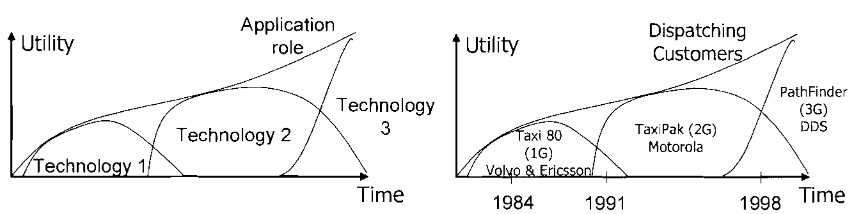

Fig. 7. Application roles and technology generations.

Fig. 7 illustrates to what extent different technology generations are able to fulfil the application role. At any given time, there may be multiple technology generations that to varying degrees are able to fulfil this role. Companies more or less continuously have to evaluate emerging technologies to determine whether switching to a new technology generation is warranted or not. This process corresponds to Karlsson's (1988) product life cycle phase of conceptualisation and creativity prior to the introduction phase (see Fig. 1 above). The company also has the option of deploying either one of these technology generations or multiple concurrent generations, i.e. there are different ways of switching technologies.

Technology switching

Apart from the continuous challenge of reaching the full potential of different solutions, companies also face the challenge of managing technology switching. Even if, as in this simplified case, it is at every point in time apparent which technology generation is superior, timing issues become critical due to the lead times involved when switching technologies.

Looking from a timing perspective there are a number of factors that influence technology transition decisions that can be expressed in analytical form. The goal normally is to maximize the utility from the application (*U(t)*). At any given point in time there can be one or more technology generations able to provide this utility to different degrees. If *F(t)* denotes the fraction of application utility potential a certain technology can provide for the company at time *t*, *F(t)* will always assume a value ≥ 0 and ≤ 1. In CCT terms, *F(t)* corresponds to how much of the intersection between Customer and Company that is covered by the Technology. *U(t)•F(t)* will represent the utility the company enjoys as it successfully deploys the technology.

In a simplified case, a company deploys one technology to gain the utility of a certain application. If *D(t)* is used to denote whether a technology is deployed at time *t*, it will assume the value of 1 if the technology is deployed and 0 otherwise. The utility gained from time 0 to *T* by deploying a technology in order to fulfil an application role thus becomes:

$$(1)\quad \int_0^T U(t)F(t)D(t)dt$$

By extending this to cover multiple technology generations we get:

$$(2)\quad \sum_i \int_0^T U(t)F_i(t)D_i(t)dt$$

where F_i and D_i corresponds to technology generation *i*.
An important restriction in this more general case is that:

(3) $\forall t \sum_i D_i(t) = 1$

This simply implies that if one (and only one) technology were deployed, *D(t)* would be 1 for this technology and 0 for all others. If multiple technologies are deployed, they must be weighed in a manner so that the 'sum of their deployment functions' equals 1.

The two simplified migration strategies of big bang and gradual from Technology 1 to Technology 2 would thus result in the *D(t)*-functions illustrated in Fig. 8.

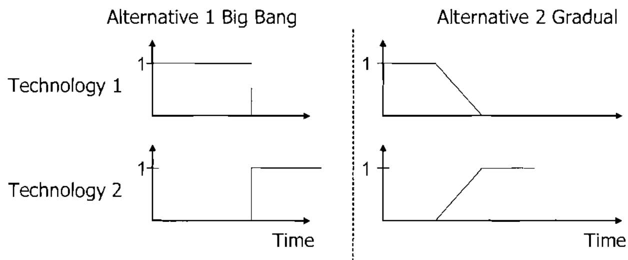

Fig. 8. Deployment functions.

In terms of traditional life cycle research (e.g. Brockhoff, 1967) the deployment function plays a role similar to the penetration level of a product in the market. In the big-bang case Technology 1 goes from a penetration of 100 to 0% overnight as it is overtaken by Technology 2. In the gradual shift, this takes place over some period of time.

The analytical expression (1) above is obviously quite intricate to evaluate, but it does encompass three different important aspects when considering different technology generations:

- *U(t)* covers business aspects and is related to the company's value proposition. Technologies are not an end in themselves but instead a means to achieve some business goal, i.e. to fulfil some application role in the business.
- *F(t)* implies that the potential utility the technology can offer, if successfully implemented in the organization, varies among technologies. The utility the company gains from implementing the technology in reality will of course depend on how successful the implementation is. The success can, for instance, depend on user perception of usability and the organization's ability to make the best possible use of the technology.

- *D(t)* incorporates the fact that when switching technologies there are different ways of going about it. For the purposes of this paper, only the two main alternatives big bang and gradual solutions have been discussed.

Finally, expressing these factors as functions of time implies that things are evolving over time.

Concluding remarks

As the use of information technology in companies mature, adopting new technologies increasingly means abandoning old technologies or, maybe even more commonly, having different co-existing technologies. By combining a business perspective (through the application role), a technology generation perspective and a technology switching perspective and finally adding the time perspective, an analytical expression has been developed:

$$\sum_{i} \int_{0}^{T} U(t) F_i(t) D_i(t) dt$$

By explicitly considering not only the complete life cycle of a specific technology deployed in the company but also multiple such technologies, this expression contributes to a long-term perspective. The importance of discussing processes longer than a technology generation is often underestimated and existing theories and tools tend to take a technology generation perspective. This is of course important, but adding a longer-term perspective is also beneficial.

To conclude, it should also be noted that there are a number of simplifications made in this paper. For instance, the discussion above implicitly assumes, for reasons of simplicity, that the potential utility of an application is given and that different technologies have different abilities to achieve this utility. In reality there is almost certainly more of interplay between different aspects than the discussion above implies. Since an important point in this paper is the distinction between application roles and technology generations, which we believe is often neglected or ignored, we find it necessary to be explicit on this point. However, we find these simplifications to open up very interesting and promising avenues of further research.

Acknowledgements

The authors would like to thank Olof Hanssen, Hans Nyström and Ulf Gimbringer at Taxi Stockholm for their openness to research. This research has been possible thanks to the financial support from the Bank Research Institute in Sweden (Anders) and the Swedish Agency for Innovation Systems (Pablo).

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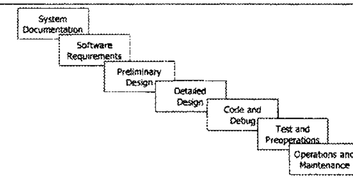
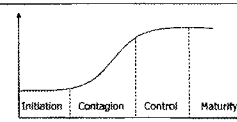
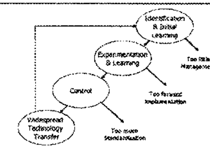
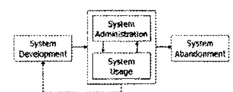
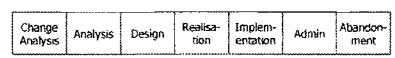
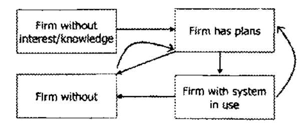
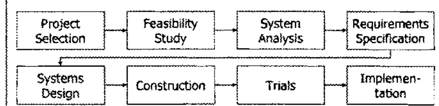
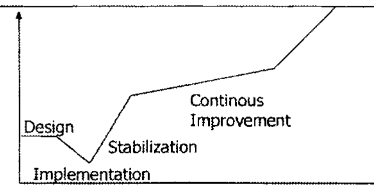
Appendix 1 – Implementation Factors: A Literature Review

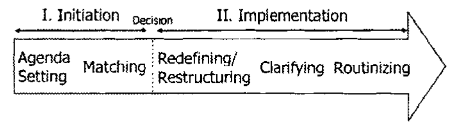
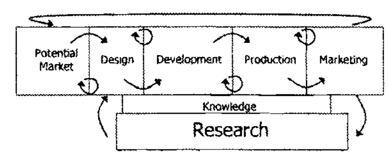
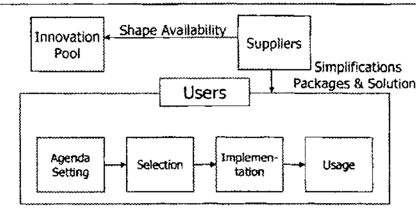
Cluster of factors	*Factors*	*Description*	*References*
Organizational Factors	Organizational Commitment	*Top management support*	Robey, Ross and Boudreau 2002 Bjørn-Andersen, Henriksen and Larsen 2003
		Organizational-wide commitment	Robey, Ross and Boudreau 2002
		Organizational misfit The incongruence between the original artifact and its organizational context	Hong and Kim 2002
	Project Management	*Management execution* The way the actual implementation is actually executed (e.g. phases, big-bang, etc.)	Markus, Tanis and van Fenema 2000
		Effective project team Project staffed full-time with top business and information technology people	Linton 2002
		Project management metrics Management of deadlines and project budgets	Robey, Ross and Boudreau 2002
	Structural Factors	*Degree of specialization and centralization*	Kwon and Zmud 1987
	Organizational Adaptation	*Job redesign*	Bjørn-Andersen, Henriksen and Larsen 2003
		Strategic alignment between business and technology	Feeny and Willcocks 1998
	Business Benefits Realization	*Inventory reduction and decreased labor cost*	Robey, Ross and Boudreau 2002
		Benefit identification	Eason 1988

Technological Factors	Software Design	*Software systems design*	Sumner 2000
		Software configuration	Markus, Tanis and van Fenema 2000
		Ease of use	Davis 1989
	Platform Integration	*Complexity* Degree of difficulty users experience in understanding and using an innovation	Kwon and Zmud 1987 Bjørn-Andersen, Henriksen and Larsen 2003
		Standards	Bjørn-Andersen, Henriksen and Larsen 2003
		Reliability	Bjørn-Andersen, Henriksen and Larsen 2003
	Technology Planning	*Technological newness*	Sumner 2000
		Application size	Sumner 2000
		Application complexity	Barki, Rivard and Talbot 1993
	IT Architecture Design		Feeny and Willcocks 1998
Human Factors	Involvement	*Role involvement* Positive attitude towards change	Kwon & Zmud 1987 Sumner 2000
		People's resistance to change	Markus 1983
	Training and Knowledge Barriers	*Skill mix* Technological expertise and application knowledge	Sumner 2000 Robey, Ross and Boudreau 2002
		Education	Kwon & Zmud 1987
	Usefulness		Davis 1989
Other Factors	Environmental Factors	*Uncertainty and variability of organizational environments*	Kwon & Zmud 1987
	Market Factors		Bjørn-Andersen, Henriksen and Larsen 2003

Appendix 2 – Stage Models: A Literature Review

Area	Author/Year	Unit of Analysis	Stages	Underlying Metaphor	Picture
IT Management	Boehm 1976, 1981	Software Development	1. System Documentation 2. Sw. Requirem. 3. Prel. Design 4. Detailed Design 5. Code 6. Deploy 7. Operations	Waterfall Model	
	Nolan and Gibson 1974	Experience in managing IT (Data Processing Growth)	1. Initiation 2. Contagion 3. Control 4. Maturity	S-curve	
	McKenney and McFarlan 1982	Technology Assimilation	1. Identification 2. Experimentation 3. Control 4. Transfer	Waterfall	
Systems Design	Nilsson 1991	Information Systems (IS)	1. Development 2. Administration 3. Usage 4. Abandonment	System life cycle	
	Andersen 1991	Information Systems (IS)	1. Change Analysis 2. Analysis 3. Design 4. Realization 5. Implementation 6. Administration 7. Abandonment	System life cycle	

Area	Author/Year	Unit of Analysis	Stages	Underlying Metaphor	Picture
Systems Usage	Thodenius 2005	Use of Executive Support Systems (ESS)	1. Not interested 2. Planning to implement 3. System in use 4. Without system	Usage life cycle	
IS Implementation	Eason 1988	Organization	1. Project selection 2. Feasibility study 3. System analysis 4. Requirements 5. Systems design 6. Construction 7. Trials 8. Implementation		
	Cooper and Zmud 1990	Organization	1. Initiation 2. Adoption 3. Adaptation 4. Acceptance 5. Routinization 6. Infusion	Stage Model	n/a
	Ross and Vitale 2000	ERP Implementation	1. Design 2. Implementation 3. Stabilization 4. Improvement 5. Transformation	Journey of a prisoner escaping from an island prison	
	Bhattacherjee 2000	SAP-R/3 implementation at Geneva Pharmaceuticals	1. Focus on supply-side processes 2. Focus on demand-side processes 3. Integration supply and demand	Phased approach	n/a

Area	Author/Year	Unit of Analysis	Stages	Underlying Metaphor	Picture
Organizational Innovation	Thompson 1965	General	1. Generation 2. Acceptance 3. Implementation	Innovation	n/a
Diffusion of Innovations	Rogers 1995	Product Innovations	1. Agenda Setting 2. Matching 3. Redefining 4. Clarifying 5. Routinizing	Stage Model	
	Kline and Rosenberg 1986	Technology diffusion (high-tech industry)	1. Potential Market 2. Design 3. Development 4. Production 5. Marketing	Chain-linked model	
	Clark et al. 1992 (also in Robertson, Swan and Newell 1996)	Diffusion and appropriation of an innovation	1. Agenda setting 2. Selection 3. Implementation 4. Usage	Decision Episode Model (DEF)	

Appendix 3 – Interviews

Person	*Date*	*Description*	*Company*
BT Europe			
Magnus Bergstrand	May 17, 2006	Service Technician	BT Industries Sweden
Roger Buskas	May 5, 2006	Service Technician	BT Industries Sweden
Patrick Carlsson	Oct 9, 2003	IS/IT Manager	BT Industries
Conny Edlund	Oct 24, 2003	Product Chief Service Management	BT Industries Sweden
Anna Harrius Conny Edlund	April 3, 2006	Project Manager Business Developer Service Market	BT Industries
Ivo Kukavica	Dec 5, 2001	Manager Center of Excellence Mobile business	Cap Gemini Ernst & Young
Hans Torin	Dec 5, 2001	Global Director M-commerce	Cap Gemini Ernst & Young
Michael Welin-Berger	Jan 22, 2001	Mobile Business Director	Cap Gemini Ernst & Young
Fredrik Wigh	Oct 9, 2003	Product Manager, Service	BT Industries

Taxi Stockholm			
Peter Bergström	Nov 15, 2001	Taxi Driver	Taxi Stockholm
Per-Olof Fahlander	April 3, 2005	Vice President Europe	Digital Dispatch Scandinavia AB
Ulf Gimbringer	Nov 16, 2001	CEO	Taxi Stockholm
Olof Hanssen	Oct 24, 2001	System Manager Traffic Control Centre	Taxi Stockholm
Olof Hanssen	Jan 18, 2005	Manager Taxi Stockholm Academy	Taxi Stockholm
Göran Jaxéus	March 8, 2005	CEO	Taxi Stockholm
Ulf Jensgård	Oct 24, 2001	Controller Traffic Control Centre	Taxi Stockholm

Person	*Date*	*Description*	*Company*
Hans Nyström	Oct 19, 2001	Department Manager Traffic Control Centre	Taxi Stockholm
Hans Nyström	March 14, 2005	Quality and Development Manager	Taxi Stockholm
Hans Ottosson	April 3, 2005	Technical Manager	Digital Dispatch Scandinavia AB
Lena Persson	March 15, 2005	System Manager Mobile Equipment Project Manager Pathfinder	Taxi Stockholm
Lotta Weigel	March 30, 2005	Chief Traffic Control Centre	Taxi Stockholm

Graninge			
Lars Backman	May 5, 2005	IT and Data Support	Graninge Skog & Trä AB
Magnus Hedin	March 23, 2005	Business and IT Consultant	Forest Industry Data Centre (SDC)
Roger Johansson	March 22, 2005	IT specialist	Sveaskog Timber Market
Bertil Larsson	May 3, 2005	CIO	SCA Forest Products
Katarina Levin	May 2, 2005	Product Chief	SCA Timber AB
Bertil Lidén	Feb 11, 2005	Senior Researcher	Skogforsk
Joakim Nordlander	May 2, 2005	Production Manager	Bollsta Sawmill SCA Timber AB
Kurt-Arne Öh	March 23, 2005	Timber Supply Manager	Bollsta Sawmill Graninge Skog & Trä AB
Johnny Olsen	April 15, 2005	Product Manager Mobile Data	Multicom Security AB
Birger Risberg	May 14, 2002	Manager Forest & Wood	Graninge Skog & Trä AB
Bengt Sjölander	April 15, 2005	Sales Manager	Multicom Security AB

Person	*Date*	*Description*	*Company*
Sten Gunnar Skrutin Martin Ekstrand	March 22, 2005	Researchers	Skogforsk
Magnus Tjärnskog	May 3, 2005	IT Manager	SCA Forest Products
Börje Wallgren	May 5, 2005	Retired Machine Operator	Graninge Skog & Trä AB

Others			
Linus Ågren	April 20, 2001	Project Manager – Business Development Mobile Computing & Wireless Solutions	SAS
Johan Ålander	June 21, 2001	Director BA LTL Parcel Domestic	Danzas ASG Eurocargo AB
Erik Bohman	April 25, 2001	Director Strategic Partnerships	EHand Mobile Startup
Peter Gillbrand	June 19, 2001	Managing Director	Scania Infotronics
Kenneth Karlberg	Aug 13, 2001	CEO	Telia Mobile AB
Östen Mäkitalo	Repeated Contacts 2003-2006	Senior Vice President Mobile Business	TeliaSonera AB
Sven-Christer Nilsson	Feb 13, 2001	Former CEO	Ericsson
Bo Persson	May 14, 2001	IT Manager	ARLA Foods
Renis Marie Rahn	Nov 12, 2003	Senior Advisor, Enterprise Lab	Ericsson
Lars Stanghed	Jan 28, 2001	CEO	IBM Sweden

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