TAMARA HÖGLER

EVALUATING THE BUSINESS VALUE OF INFORMATION AND COMMUNICATION SYSTEMS IN A MOBILE WORLD

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EVALUATING THE BUSINESS VALUE OF INFORMATION AND COMMUNICATION SYSTEMS IN A MOBILE WORLD

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To my husband and son:
Gunther and Julian Schäfer

Preface

"The whole is more than then the sum of its parts" (Aristoteles).

This statement is not only valid for systems – the main focus of the present work – but also for doctoral dissertations as they are usually not the work of a single person, but kind of a joint effort: Every single discussion, every single publication let the thesis more and more take shape, enabling the research work to become a full-fledged doctoral thesis. As this work took quite some time, numerous people supported me and it would take pages to list them all. I apologize to all people who contributed to this work but are not mentioned. Nevertheless, I would like to thank some people personally for their outstanding contributions without forgetting to appreciate everybody who made this research work possible.

First of all, I would like to express my special gratutide and appreciation to my doctoral supervisor Professor Dr. Johan Versendaal. He believed in my research work although I had left research already for many years. I would like to thank him for encouraging me in continuing and finishing my PhD thesis – besides a challenging full-time job in a management position, for his patience, for his excellent, continuous support and for providing me the opportunity to make my PhD at the Open University of The Netherlands. Without you, dear Johan, this PhD thesis would not exist! Prof. Dr. Ronald Batenburg merits recognition for his support as regards to various publications, reviewing activities and his contributions as co-supervisor, which made the work unique and useful in the research and practical context.

Sincere thanks are given to the committee members: Prof. Dr. Dieter Hertweck, who supported my research work since its very beginning and who encouraged me to write my first conference paper and who enabled me getting insights into Social Science as private lecturer at the University of Applied Science Heilbronn – which later turned out to be a crucial element of my work; Prof. Dr.-Ing. Eric Sax, who was immediately willing to support my research work and to become a committee member; Prof. Dr. Ir. Remko Helms and Prof. Dr. Rob Kusters for their critical discussion with my research work; and Dr. John Hobbs to put up with the long trip from Ireland to The Netherlands to serve as committee member (and for the fruitful discussions during our joint conferences and the Be Wiser project). I am grateful that you all made my defense a memorable moment, and for your helpful comments and suggestions. Same applies to the mobile business experts who contributed as interviewees to the validation of my thesis, amongst others Prof. Dr. Hans Mulder, Dr. Asarnush Rashid, Daniel Stucky and Rüdiger Bäcker.

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Last, but not least, I would like to say thank you to my family. Words cannot express how grateful I am that I had the opportunity to follow all my eagerness for knowledge which was always supported by my father Miro Högler. He taught me the integrative view on life and its aspects and he gave me the confidence that whatever I want to learn I can learn as nothing is that complex that it cannot be understood. This was the basis for changing subjects from Geo-Ecology during the studies to Economic Science for the PhD. Thank you also to my inlaws, who always believed in me and prayed for me to "survive" this challenging time, particularly having the defense just a few weeks after giving birth to my son Julian.

A special thanks to my beloved husband, Gunther Schäfer. Thank you for always supporting me, for believing in me, for taking over all these unpopular household chores and for taking care of our beloved dogs when I had to spend the evenings, weekends, vacations and holidays with writing conference papers and this thesis. Thank you Julian, for being such a kind baby and letting me do all the re-formatting of the thesis although you needed me at the beginning of your life more than anyone else. And sorry Quinny, for not having had the time I would have loved to spend with you when you have been with us. You left fingerprints of grace on my life – I will never stop missing you.

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PART 1: INTRODUCTION & MOTIVATION

1 Introduction

1.1 Motivation and Theoretical Lens

In this chapter, we ground the context of our research and motivate the necessity of this research work by providing insights into the work already done by other researchers in this field. Citations of particularly acknowledged authors buttress that the chosen research field is still very up-to-date and that it offers enough place for new research work, like it is addressed within this work.

Already early applications of information and communication *technologies* (ICT) and information and communication *systems* (ICS) were business process oriented, as their main expected contributions were the automation of processes and cost reductions. As *the "field of Information Systems emerged from concerns that organizational and human factors need to be addressed when designing technical systems"* (Hemingway, 1999, p. 77), we distinguish between ICT (with focus on technologies only) and ICS that comprise besides technologies also non-technical components like human beings and processes. At the same time, the terms 'IT' and 'ICT' and accordingly 'IS' and 'ICS' are used synonymously.

Yet, more than three decades ago, the discussion about the cost-efficiency, and later about the business value of ICT and ICS intensified (cf. (Brynjolfsson, 1993; Weill & Broadbent, 1998; Hitt & Brynjolfsson, 2002; Carr, 2003; Song & Letch, 2012; Uys, 2015)[1] as it seemed that such systems did not meet the expectations in many cases. The reasons for this are manifold, but many of them are connected to the fact, that these systems evolved *"from small projects focused on productivity improvements and cost savings to large-scale enterprise-wide strategic implementations that enable companies to gain and sustain competitive advantages"* ((Kornak, Teutloff, & Welin-Berger, 2004) in (Basole, 2005, p. 364)). It is obvious for example, that the *"rapid expansion of the Internet (Butler, Barker, & Levitin, 1996) and developments in mobile information and communication technologies (ICTs) (Puuronen & Savolainen, 1997) and electronic commerce (Edelheit & Miller, 1997) suggest that the continued exploitation of ICTs is likely to have significant social and economic implications"* (Hemingway, 1999, p. 1). At the same time, with the increasing complexity[2] of these systems in terms of their scope and functionality – from data processing to management information

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1 For a comprehensive review see e.g. (Kohli, Sherer, & Baron, 2003) and (Melville, Kraemer, & Gurbaxani, 2004).

2 *"[…] complexity relates to interdependence of the system elements and their interacting aspect and as a result, is focused on the relations among the system parts"* (Matook & Brown, 2017, p. 314) (cf. (Bertalanffy, 1972)). Changing or adding new elements, like mobile technology, increases the complexity of a system (Glazatov, 2015, p. 12).

systems (MIS) to strategic information systems (SIS) (cf. (King, 2015; Peppard & Ward, 2016)) – their contribution to business value became manifold (Melville, Kraemer, & Gurbaxani, 2004) and thus also increasingly complex to evaluate (cf. (Hemingway, 1999, p. 1; Berghout & Remenyi, 2005)). The terms 'evaluation' and 'assessment' are used in this thesis synonymously.

It needs to be observed that the term '*business value*' is an informal term that includes all kinds of value that contributes to the well-being of a company in the long run and that also depends on what is meant by an ICS (Melville, Kraemer, & Gurbaxani, 2004). Melville et al. delineate *"IT business value as the organizational performance impacts of information technology at both the intermediate process level and the organization-wide level, and comprising both efficiency impacts and competitive impacts"* (2004, p. 287). We modify this definition by focusing on the objectives that shall be achieved by implementing ICS. We define business value as the

measure that describes how much a specific ICS contributes to the objectives of an organization that should be achieved by implementing this specific ICS, including up-front unintended or unforeseen informational, strategic, transactional and transformational effects on a company (Gregor, et al., 2004).

We add that ICS business value *"emerges as a result of complex interactions between ICT and other organizational resources"* (Ceric, 2015, p. 20), (cf. (Nevo & Wade, 2010)); consequently, it *"emerges when ICT synergistically operates with other organizational factors"* (Ceric, 2015, p. 20), cf. (Kohli & Grover, 2008).

In the early era of data processing the main focus of ICS was on improving operational efficiency (Elliott, 2004; Basole, 2008), which could have relatively easily been evaluated by traditional input-output-focused evaluation approaches, i.e. traditional finance (accounting) and economic based analyses (Hemingway, 1999, p. 4). But with the increasing complexity of such systems (Scheepers & Scheepers, 2008), the existing approaches became less sufficient for evaluating them (cf. (Willcocks & Lester, 1996; Pietsch, 1999; Farbey, Land, & Targett, 1999; Brynjolfsson, Hitt, & Yang, 1998; Irani & Love, 2008)), as the purpose of evaluating ICS turned towards gaining an understanding of how ICS *"were contributing to organisational performance in a given organisational context"* (Ceric, 2015, p. 19), cf. (Hemingway, 1999, p. 1).

This paradigm shift led to the development of newer, multi-dimensional and multi-criteria evaluation approaches, respectively (cf. (Couger, 1987; Strassmann, 1990)). They overcame some of the shortcomings of their predecessors by considering besides monetary also non-monetary, qualitative and indirect effects. Nevertheless, also these approaches did not reach far enough in evaluating the business value of strategic information systems (SIS) that aim at improving competitiveness and enhancing strategic advantage, which is sustainable (Peppard & Ward, 2016, p. 15). A plausible explanation is that although it is *"important that* *these transformational technologies actually align with the strategic objectives of the organization"* and that it is *"critical to have an understanding of how the new technology will affect people and processes, and fit within the organizational culture"* (Basole, 2005, p. 367), it is not easy to address these challenges.

While traditional key performance indicators (KPIs) are still applied for evaluating the business value of ICS, it has become increasingly clear that these date back to the industrial era (Kaplan & Norton, 1992) and the era of basic data processing where economic benefits were quite easy to calculate. In contrast, technologies and systems of the management and strategic information era have fundamentally different characteristics, particularly with regard to technical and organizational conditions. ICS become increasingly linked to strategic and thus to business value (Rastrick & Corner, 2010), which is more than the economic or qualitative impact of any technological change. It takes rather an *'effectiveness view'* by asking if the right measures are taken, instead of questioning if things are done right (*'efficiency view'*) (cf. (Stratopoulos & Dehning, 2000; Basole, 2005)). These considerations can – at least partly – explain the fact that still many ICT projects fail or at least do not achieve the objectives set (Gingnell, Franke, Lagerström, Ericsson, & Lilliesköld, 2014). This situation has not much changed for the last 40 years (Hughes, Dwivedi, Simintiras, & Rana, 2015). Even now *"technology investments are often made without understanding or identifying the business benefits that could or should result from improving the performance of activities by using IT. […]. It is important to acknowledge that IT has no inherent value – the mere purchase of IT does not confer any benefits on the organization; these benefits must be unlocked, normally by making changes to the way business is conducted, how the organization operates or how people work"* (Peppard & Ward, 2016, p. 3).

For the period 2004-2012, the widely cited Chaos Report (cf. (Standish Group, 2013; 2014)), identified success rates of IT/IS projects between a meagre 29 and 39%[3], stating that *"the most common reasons for project failure are rooted in the project management process itself and aligning of IT with organizational cultures"* (Tilmann & Weinberger, 2004, p. 28). In general, reasons for project failure are manifold, but various studies come to a number of recurrent reasons why projects fail. These are in addition to the above mentioned mainly, but not exclusively[4]:

- unrealistic expectations (Standish Group, 2014)
- insufficient executive management support (Standish Group, 2014; Mandal & Pal, 2015; Khan, Khan, Khan, & Qasim, 2016)

[3] Similar results are presented by earlier studies like (Galorath, 2012) who summarizes different studies in his work and (cf. (Krigsman, 2007; Findlay & Straus, 2015; Geneca, 2017)).

[4] For a detailed literature analysis regarding offshore IT/IS project failure see e.g. (Khan, Khan, Khan, & Qasim, 2016).

- poor project planning or management (Galorath, 2012; Standish Group, 2014), (Mandal & Pal, 2015; Khan, Khan, Khan, & Qasim, 2016)
- inadequate user involvement (Kaur & Sengupta, 2011; Standish Group, 2014; Mandal & Pal, 2015; Khan, Khan, Khan, & Qasim, 2016)
- unclear project goals and objectives (Kaur & Sengupta, 2011; Standish Group, 2014; Mandal & Pal, 2015)
- unclear project requirements and thus specifications (Kaur & Sengupta, 2011; Galorath, 2012; Standish Group, 2014; Khan, Khan, Khan, & Qasim, 2016)

This overview shows that it is not only the lack of appropriate approaches for evaluating the benefits and business value of ICS that explains low ICS projects success[5] rates. Projects also can fail due to improperly defined objectives, as technical and non-technical requirements – which are fundamental for any ICS project – are derived from them, connecting project success to a proper definition of objectives (King, 2015). Based on his literature review, (Hemingway, 1999) confirms that progress in investment evaluation has been limited and leaves space for further research.

The implementation of ICS is not only a technology-related task, but *"it affects the organization as a whole, the related business process[es] and those people inside and outside of the organization that have to use these information systems"* (Bernsteiner, Kilian, & Ebersberger, 2016, p. 72). The cognition that different types of components (technology, people, processes) need to be considered mutually suggests a socio-technical perspective (Kowalski, 1994). In that respect, note that *"information systems and the organizations they support are complex […]. They are composed of people, structures, technologies, and work systems"* (Hevner, March, Park, & Ram, 2004, p. 78), cf. (Bunge, 1985; Simon, 1996; Alter, 2003; Findlay & Straus, 2015)). Socio-technical approaches consider ICT as one of several components of an ICS which is *"designed, used and influenced by people"* (Ceric, 2015, p. 19), cf. (Checkland & Holwell, 1998; Orlikowski & Iacono, 2001).

However, it remains challenging how to operationalize such a socio-technical perspective.

In this thesis, we take systems theory as leading perspective for our research (see also section 3.2). General systems theory is an interdisciplinary study of systems – originating from the work of Bertalanffy starting in the 1920s (cf. (Bertalanffy, 1945; Bertalanffy, 1968; Bertalanffy, 1972; Bertalanffy, 1976)) – which combines principles and concepts from different natural and social sciences, like biology, philosophy and sociology (Ceric, 2015). Meanwhile, various IS researchers have recognized the multidisciplinary nature of IS and IT evalua-

5 For a detailed discussion on Information Systems success see (DeLone & McLean, 1992; Petter, DeLone, & McLean, 2013).

tion (Berghout & Remenyi, 2005), and some of them see systems theory as a foundational theory also for IS research (cf. (Hirschheim, 1983; Checkland, 1988; Galliers, 2003; Saunders & Wu, 2003)) as it connects the socio and technical perspective of organizations.

1.2 Focus on Mobile Systems

For this research work we put emphasis on leveraging mobile technologies in organizations and thus on *mobile ICS / mobile systems*. The terms mobile ICS and mobile systems are used in this work synonymously. We define mobile systems as set of mobile technology and human (system) components, which are inherently related (for further details see chapter 3).

Mobile systems can be classified as appropriate examples of strategic information systems. The fast development and diffusion of mobile devices like smartphones and tablets and the current wireless communication network coverage enable meanwhile not only Internet and thus data access *'anytime, anywhere'* that was previously only possible within the company, but also new business processes and opportunities (cf. (Picoto, Palma-dos-Reis, & Bélanger, 2010; Euler, Hacke, Hartherz, Steiner, & Verclas, 2012)). In general, mobile technology implementations are an interesting field to apply in SIS evaluations due to following partly overlapping reasons.

First, for many years mobile computing has proven its *strategic value* for organizations (cf. (Scornavacca & Herrera, 2007; Schönberger, 2014); moreover, it has been and still is an important trend in information systems research and practice (cf. (Bernsteiner, Kilian, & Ebersberger, 2016; Imran, Quimno, & Hussain, 2016).

Second, mobile technologies have *innovated* business processes and shaped the way of working considerably during the last decade as they allow time- and place-independent task fulfilment, enabling employees to hold down their jobs in a flexible way from different locations (Weiser, 1991; Basole, 2008). The increasing freedom to perform a specific task anywhere at any time can have positive effects not only on productivity[6], but also e.g. on the job satisfaction of employees. It can also enhance the quality of work[7] in general and reduce job fluctuations (Hanhart, Jinschek, Kipper, Legner, & Österle, 2005).

Third, mobile systems are characterized by *specific singularities* (for details see section 4.4) that make them even more complex in comparison to stationary ICS (cf. (Camponovo &

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[6] e.g. by avoiding media breaches or by being able to transform unproductive time (e.g. waiting times during business trips) into productive working time by e.g. answering emails or processing other business-related tasks

[7] e.g. by reducing or avoiding media discontinuities, providing a faster access to the gathered information

Pigneur, 2003; Prinz & Schwarz, 2003; Krupp, 2015; Bernsteiner, Kilian, & Ebersberger, 2016; Xiu, Fulgenico, Asino, & Baker, 2017)). These are, amongst others:

- *technical hardware-related aspects* like usability[8], battery life, storage capacity, bandwidth (cf. (Dinh, Lee, Niyato, & Wang, 2013; Pryss, Reichert, Bachmeier, & Albach, 2015))
- *security aspects* like (data) security, privacy and identity (cf. (Sadkhan & Abbas, 2014; Modares, Lloret, Moravejosharieh, & Salleh, 2014)) in general, but also in particular as mobile devices are exposed more often to theft or damage than stationary (desktop) computers or as employees use their own mobile devices[9] which usually do not have the same security level as professionally administered devices (Hasan & Gómez, 2017). In addition, wireless networks are inherently more vulnerable than their wired counterparts (Sadkhan & Abbas, 2014)
- *data-related aspects* like context-sensitivity or integration of context-information which is not possible with desktop computers; or personalized data which adds significant value to the user (Basole, 2005, p. 367)
- *environment-related aspects* like heterogeneity of devices (cf. (Schönberger, 2014; Pryss, Reichert, Bachmeier, & Albach, 2015)) as a result of their extremely fast life cycles; heterogeneity of applications and networks; scalability and availability or respectively disturbance of wireless networks (cf. (Punithavathi & Duraiswamy, 2008; Dinh, Lee, Niyato, & Wang, 2013))
- *organizational aspects* like the mobilization of business processes and workflows ('anytime, anywhere') (Euler, Hacke, Hartherz, Steiner, & Verclas, 2012; Pryss, Reichert, Bachmeier, & Albach, 2015)); or environmental distraction of users (cf. (Forman & Zahorjan, 1994; Bernsteiner, Kilian, & Ebersberger, 2016))

Particularly organizational aspects of mobile systems seem to play a prominent role. Organizations can be *"seen as consisting of two interdependent systems: a technical system and a social system. The technical system is composed of equipment and processes; the social system consists of people and tasks"* (Wang, Solan, & Ghods, 2010), cf. (Ketchum & Trist, 1992). Due to these interdependencies, the identification and evaluation of benefits caused by mobile technologies in a business context is problematic in many cases (cf. (Heijden & Valiente, 2002; Mahmood & Soon, 2007; Picoto, Palma-dos-Reis, & Bélanger, 2010)), and motivates us to develop a comprehensive approach for mobile systems evaluation that is based on (socio-technical) systems theory.

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[8] According to Hemingway, *"user acceptance has been shown to relate to productivity and other aspects of organizational performance"*, consequently *"usability […] must clearly be accounted for"* (1999, p. 4).

[9] 'BYOD': 'Bring Your Own Device' results in many different operating systems, different app versions, different security standards etc.

1.3 Objectives of the Work and Research Questions

According to Ceric, the *"purpose of evaluating Information Communication Technology (ICT) is to gain an understanding of how ICT is contributing to organisational performance in a given organisational context"* (2015, p. 19).

Based on the considerations discussed in the previous sections, the starting point of this thesis is the assumption that approaches that are appropriate for the economic evaluation of mobile systems have serious shortcomings (cf. (Willcocks & Lester, 1996; Farbey, Land, & Targett, 1999; Brynjolfsson, Hitt, & Yang, 1998; Heijden & Valiente, 2002; Mahmood & Soon, 2007; Irani & Love, 2008)). Including both the socio and technical perspective on the matter seems to be promising if we are able to operationalize it (cf. (Orlikowski, 1992; Hemingway, 1999)). Such a view is characterized by the following:

- It gives *"paramount importance to people as the major and most significant asset of a business within the information systems domain"* (Elliott, 2004, p. 10f.) and it integrates the three fundamental resources: organization, people and technology. An organization *"exists of a set of business processes, that each of subsist of activities"* (Schuurman, Berghout, & Powell, 2012). ICT on its own has no value (Peppard & Ward, 2016) – only when being used / applied by humans, ICT can generate value.
- The single system components are constantly influencing each other and hence the overall outcomes as well as business value of an ICS (Irani & Love, 2001). As *"systems theory posits that the performance of a system depends on how well that system's elements interact and fit together, and also how that system functions in relation to the larger system that conditions it"* (Ceric, 2015, p. 21), the interrelationships and interdependencies between the single system components are important for the overall business value of an ICS. The better such components are aligned to each other and the more they act as a 'clockwork', the better their potentials can be exploited for a higher business value.

So it seems important that an *"effective evaluation and management of a system requires managing the interactions of its parts, rather than attempting to manage and control the separate parts"* (Ceric, 2015), cf. (Ackoff & Gharajedaghi, 1996). Consequentially we define the following three main objectives:

1. to have shown the necessity of an integrative evaluation approach for mobile systems by surveying why existing approaches are not appropriate for evaluating this type of systems;
2. to have defined an integrative approach for evaluating mobile systems, in particular for evaluating their business value;
3. to have evaluated the integrative approach by applying and validating it in terms of its completeness, correctness and its usefulness using different validation methods.

We use the term *'integrative'* in our objectives to emphasize the mutual constitution of the components (Sawyer & Jarrahi, 2014) related to mobile systems.

To reach the above defined objectives, we derive the following main research question (MRQ):

MRQ: How can mobile systems be evaluated in an integrative way?

To answer this main research question and to specifically address our research objectives we define the following four research questions (RQ):

RQ1: Why is an integrative approach for mobile systems necessary?

A motivation for this research question is not only given by the continuing discussion on the economic efficiency of ICS, but also by the fact that appropriate approaches for a comprehensive evaluation seem insufficient. All text related to RQ1 is elaborated in part 1 of this thesis which introduces the reader into the research topic and motivates the development of an integrative approach.

In addressing RQ1 we search for a better understanding of the challenge of evaluating ICS in general and mobile systems in particular (see chapters 1 to 1). To answer this question, the context of this thesis is described in chapter 3 and provides a definition for the term *'mobile system'* and related terms, i.e. mobile computing, mobile business, ICT and mobile technologies. Based on the yet gained insights, we define a research agenda for mobile systems´ evaluation in chapter 1.

Based on the results of this discussion and findings of the previous chapters, we formulate RQ2 which is addressed by chapters 1 and 1 in the 2nd part of this thesis, focusing on building the integrative approach:

RQ2: What are the components that build an integrative approach?

As this work elaborates a new approach that solves a relevant challenge from practice, it is of importance to understand it thoroughly. For this reason the main objectives of this research question are:

- to identify characteristics of the integrative approach
- to determine to what degree existing approaches take multiple perspectives into account
- to identify gaps of existing approaches
- to determine components of an integrative approach for evaluating the business value of mobile systems

The theoretical approach as defined by RQ2 needs to be detailed and tested in practice. Consequently, we define RQ3 that is discussed in part 3 of this thesis (chapters 7 to 9) as follows:

RQ3: How to apply the integrative approach for evaluating mobile systems in practice?

RQ3 includes the following two sub research questions (addressed in chapters 1 and 9 respectively):

Sub RQ3.1: How can an approach be developed for the economic evaluation of mobile systems, taking into account special characteristics of mobile systems, and applying an integrative perspective using systems theory, business/IT alignment, behavioral and design science?

Sub RQ3.2: How to identify (critical) success factors for the implementation of mobile systems, taking an integrative perspective?

In RQ3.1 we notably mention systems theory (Bertalanffy, 1976), business/IT alignment (Henderson & Venkatraman, 1993), behavioral and design science (Hevner, March, Park, & Ram, 2004) to represent the socio-technical perspective that we take.

Chapter 10 deals with the last research question which is addressed in the 4th part (validation) of the thesis.

RQ4: Is the integrative approach for mobile systems a valid approach?

This chapter addresses the validity of the integrative approach in terms of its completeness, correctness and usefulness from different perspectives, defining the following objectives:

- to determine the validity of the integrative approach from a retrospective perspective
- to determine the validity of the integrative approach through a case study
- to determine the validity of the integrative approach through expert interviews

Part 5 of this thesis (chapter 11) concludes the findings and provides insights into potential research activities that could contribute to the validity of the present work.

Each of the above-mentioned research questions belongs to one of following three different research question types (Figure 1-1):

1. descriptive questions that, in our case, describe the context and background to the topic of the present work in part 1
2. design questions that produce “*a new artifact that provides a technology-based solution to a relevant problem with significant impact and research contribution*” (Kurtz, 2015, p. 4), cf. (Hevner, March, Park, & Ram, 2004) (see our part 2 and 3). Our integrative approach is the artifact that we strive for

3. evaluation questions which ask whether and how well the produced artifacts can be applied in practice (see our part 4)

Figure 1-1 depicts the processing of research questions of a certain type in this thesis schematically.

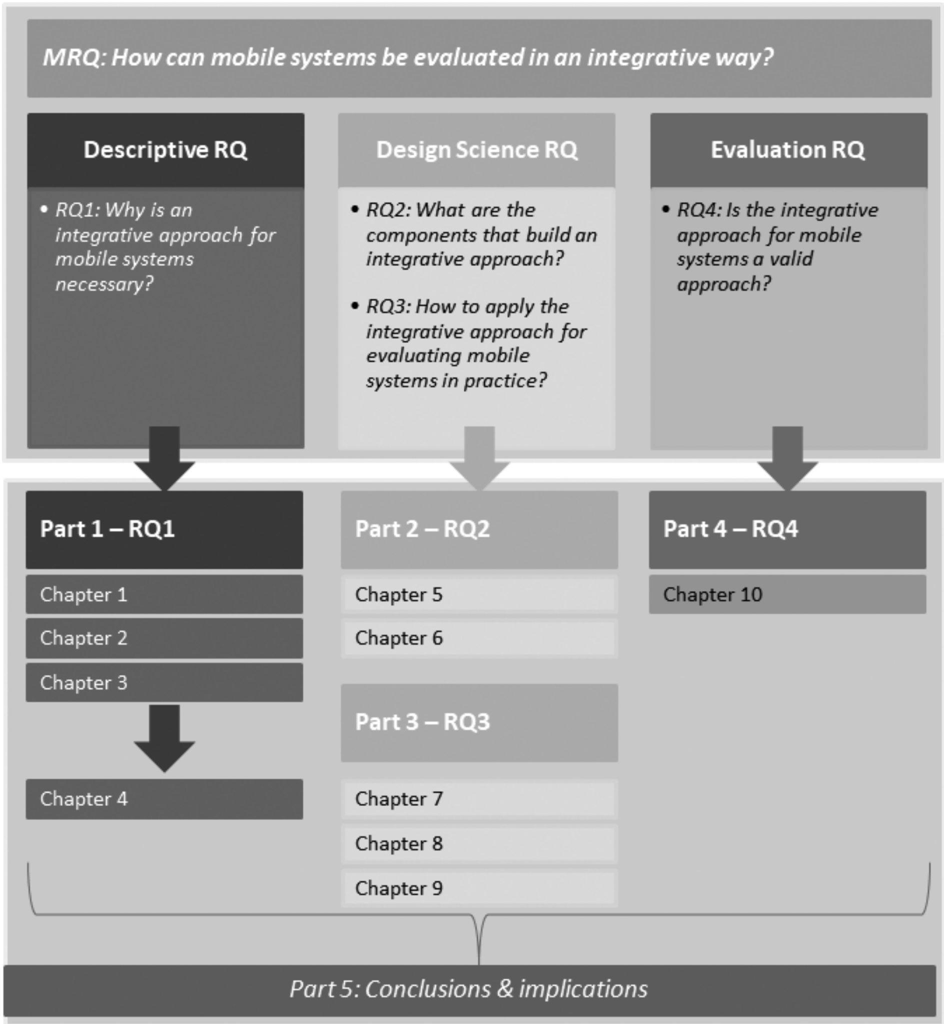

Figure 1-1: Structure of the work

1.4 Relevance for Practice and Research

The objectives pursuit by implementing ICT have changed: from increasing productivity to enhancing economic efficiency of business processes in order to reach higher business values and for strengthening the competitiveness of companies by different means. Particularly since the 90s, ICT led to dramatic changes in many industries. Results were not only an increased automatization of many business processes, but particularly the development of new products (product innovations) and business models. This progress has a significant impact on market conditions that constantly change the competitive situation of the firms.

With the increasing complexity of ICS, and with mobile systems as a particular manifestation of this complexity, also the requirements for exploring the potentials of new technologies as well as for evaluating such systems and their impact on the business as a whole became more intricate. However, existing approaches – developed during the industrial era or during the early stages of computers – are not capable anymore to determine the effects of technology as used in the current digital age. They have been developed during decades when ICT was implemented to increase productivity of employees and efficiency of business processes and hence when monetary and quantitative effects were considered the most important objectives. As a logical consequence, for their evaluation most approaches focused on economic effects only. After the early beginnings of ICT, technologies were more and more seen as business enablers and strategic tools (cf. (Weiss, Thorogood, & Clark, 2006; Agrawal & Pendse, 2015; Peppard & Ward, 2016; Rahimi, Møller, & Hvam, 2016)). This fact explains why former approaches may easily fudge the expected results as the full benefits and thus the overall business value of technologies are insufficiently reflected.

From the current state of mobile technologies and mobile systems, a change in the way of evaluating them is needed: from an economic efficiency to an integrative perspective that focuses on achieving significant business value for companies.

During the last years mobile technologies were reshaping the global economic landscape, enhancing speed and comfort of communication and information exchange, meaning that they became more and more important for many kinds of businesses. Their relevance was also reflected by countless scientific and industry publications, mostly with focus on technical, and since a few years also with focus on organizational issues. Nevertheless, publications related to the effectiveness of mobile systems are scarce and there is still a lack of appropriate evaluation approaches (cf. (Ashurst, Doherty, & Peppard, 2008; Högler, 2012)). Particularly there are no publications that take an integrative view for evaluating the business value of such systems. As such, our work addresses the scientific challenge as articulated by Sawyer and Jarrahi in their discussion on socio-technical approaches in the 'Computing Handbook: Information and Information Technology', stating *"Our goal [...] is to encourage scholars to move beyond [...] rhetorically pleasant articulation of sociotechnical thinking towards more deliberate conceptual development, increased empirical activity, and greater methodological capacity"* (2014, p. 3). Specifically, as it is noted that mobile systems have to cope with the challenges caused by singularities of mobile technologies and their application context, which becomes prominent for example in using the technology in travelling, commuting and many other types of transport.

1.5 Research Design

The research design and strategy in this work follows the concepts of Design Science Research (DSR) guidelines[10] (cf. (March & Smith, 1995; Hevner, March, Park, & Ram, 2004; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007)): *"[…] the design-science paradigm seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts"* (Hevner, March, Park, & Ram, 2004, p. 75). In addition, *"design science [….] creates and evaluates IT artifacts intended to solve identified organizational problems"* (Hevner, March, Park, & Ram, 2004, p. 77). The latter one is the key intention of this thesis as it considers both the scientific body of knowledge as well as the business needs.

The DSR approach is particularly useful for so-called *'wicked'* problems. According to (Rittel, 1972)[11], a wicked problem is a *"class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing"*.

Mobilizing a process or even an enterprise is a complex undertaking, accompanied by many transition barriers (cf. (Kornak, Teutloff, & Welin-Berger, 2004; Pryss, Reichert, Bachmeier, & Albach, 2015)). As a result, the evaluation of ICS in general and mobile systems specifically can be considered a wicked problem as it consists of different complex components, including people (*'critical dependence on human cognitive abilities'*) that influence each other (*'complex interactions'*) and hence effect the overall efficaciousness of the system as a whole. In many ICS-related projects, the business and consequently strategic context is not considered sufficiently (Basole, 2005, p. 367). Also the particular challenges that mobile systems inherit due to their promising possibilities, yet with their singularities[12], make the evaluation of such systems wicked.

This wickedness motivates a DSR oriented construction of an integrative framework for the evaluation of mobile systems – which can be defined as information and communication systems with mobile components. We apply the following two main design processes:

- build the artifact, with its components;
- evaluate and validate single artifact components by applying single activities (i.e. novelties) of the framework in practice and validate the artifact by experts´ interviews. Validation criteria are leveraged from Hevner et al. (2004) and Carvalho (2012), relating to the framework´s utility and fitness.

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[10] Design science research addresses unsolved problems in a unique / innovative or efficient / effective way.

[11] cf. (Churchman, 1967)

[12] For details we refer to section 4.4.

The single chapters of this work address the seven guidelines for design science in information systems research (Hevner, March, Park, & Ram, 2004, p. 82ff.) as follows.

Guideline 1 – Design as an Artifact

DSR in IT often addresses problems related to some aspect of the design of an ICS. In this work, we address the problem of evaluating mobile systems as they consist of different technical and non-technical components which affect each other and therefore influence the overall efficiency and effectiveness of the system. According to Hevner et al. *"the result of design-science research in IS is […] a purposeful IT artifact created to address an important organizational problem"* (Hevner, March, Park, & Ram, 2004, p. 82). In our case, we develop an artifact (i.e. the integrative framework, see chapters 5 and 6) that addresses several organizational problems (see also section 1.1)[13]. From chapter 7 of the thesis onwards, first, we apply the framework in a project at a German manufacturer for synthetic resin[14]. In a second step, we take a more detailed approach by applying the first activity of the integrative framework – the definition of a target system, one of the main contributions and innovative aspects of the approach – at an SME[15]. In a third case study, we identify success factors by applying the third activity of the integrative framework at a German Global Player of the chemical industry[16].

The main organizational problem that motivated an integrative approach is the fact, that still a huge percentage of IS projects fails or at least does not achieve the objectives set by the management to a great extent. We produce an applicable artifact in the form of an approach inheriting a method – the integrative framework for evaluating the business value of ICS with mobile components (i.e. mobile systems). This artifact includes components of the organization and people involved in the use of technologies, in our case mobile technologies. We define an integrative approach as an approach that *"postulates the need for an analysis and evaluation of an ICS as a complex entity, whereby its individual components are in constant relation with each other, so that the system has a dynamics"* (Högler, 2012, p. 25). In addition to the structures and functions of a system, the integrative approach examines the effects of the individual components on each other, caused by their respective interrelationships. The results of the integrative approach allow a prediction of the expected system behavior (ibidem). We leverage existing theory (notably systems theory and business/IT alignment) and practical experiences (identification of singularities of mobile systems, see section 4.4) as a starting point for the design process.

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[13] mainly addressed in part 2 of this thesis

[14] For details see (Högler, Versendaal, & Batenburg, 2015).

[15] For details see (Högler & Versendaal, 2016).

[16] For details see (Högler & Versendaal, 2014).

Guideline 2 – Problem Relevance

As *"organizations spend billions of dollars annually on IT, only too often to conclude that those dollars were wasted (cf.* (Keil, 1995; Keil, Cule, Lyytinen, & and Schmidt, 1998; Keil & Robey, 1999)*). This community would welcome effective artifacts that enable such problems to be addressed"* (Hevner, March, Park, & Ram, 2004, p. 85). Following this statement, this work contributes to addressing one of the mayor organizational problems that are related to ICS: increasing the success rate of ICS projects (see section 1.4 and chapter 7). To do so, in contrast to the definition by (Hevner, March, Park, & Ram, 2004), not a technology-based, but a technology-*oriented* solution for this important and relevant wicked business problem is built – the integrative framework (part 2 of this thesis, chapters 5 and 6). In our case, we deal with complex human-technology-systems (i.e. mobile systems) that have specific singularities that need to be considered during evaluation as they highly influence the overall efficiency and effectiveness of the mobile system. By doing so, a more realistic ex-ante evaluation of mobile systems becomes possible.

Guideline 3 – Design Evaluation

The DSR execution implies that the integrative framework is validated as an artifact (Hevner, March, Park, & Ram, 2004, pp. 85-87) which is implemented in part 3 of this thesis (chapters 7-10). The three generic validation criteria *'utility'*, *'quality'* and *'efficacy'* as mentioned by these scholars have been completed with following criteria suggested by (Carvalho, 2012): *'generalizability'*, *'novelty'* and *'explanation capability'*. As a single validation approach would not be sufficient for evaluating the integrative framework, the author applied a multi-method approach in chapter 10 – as presented and discussed by Mingers and Venkatesh et al.(cf. (Mingers, 2001; Venkatesh, Morris, Davis, & Davis, 2003; Venkatesh, Brown, & Bala, 2013)). The 4-step guidelines as suggested by Venkatesh et al. to define the process and structure of the validation were followed and adopted where necessary (Venkatesh, Morris, Davis, & Davis, 2003, p. 41).

As the applications of the integrative framework (in chapters 7 to 9) focused on the implementation of mobile maintenance systems only, in chapter 10 a case study was implemented at a Dutch fire-brigade to verify the correctness of the first activity of the integrative framework[17]. By doing so, the applicability of the approach in a different context was confirmed. A retrospective case study – focusing on the implementation of a mobile application for nurses in hospitals – was applied to investigate which of the activities of the integrative

[17] For details see (Versendaal & Högler, 2017).

framework can be recognized in a project in which the author of this thesis was not involved[18]. Finally experts gave their opinion on the built artifact in chapter 10.

Guideline 4 – Research Contributions

Hevner et al. postulate that *"design-science research must provide clear contributions in the areas of the design artifact, design construction knowledge […], and/or design evaluation knowledge […]"* (2004, p. 87). The contribution of this research work is the integrative framework which is an innovative solution to an identified problem – the evaluation of mobile systems (see section 1.4 and chapters 5 and 6). As such the research work aims at a *"[...] conceptual development, increased empirical activity, and greater methodological capacity"* for socio-technical approaches as encouraged by (Sawyer & Jarrahi, 2014). Specifically, novelty is given due to following reasons:

1. The integrative approach as a whole is an innovative, unprecedented approach for ex ante evaluation of mobile systems.
2. The first activity (definition of the target system taking structurally into account interdependencies and prioritization) and third activity (definition of critical success factors from singularities of mobile systems) of the integrative approach consists of unique guidelines for performing those.
3. The integrative framework extends a traditional risk analysis by integrating critical success factors.

The generality of the integrative framework was supported in different case studies (see chapters 7-10) where it was applied in different contexts. Its overall integrativeness is supposed to add to the existing knowledge of mobile systems evaluation approaches.

Guideline 5 – Research Rigor

Research *"rigor must be assessed with respect to the applicability and generalizability of the artifact"* (Hevner, March, Park, & Ram, 2004, p. 88). In the present work, research rigor is achieved by applying rigorous research methods in the construction and evaluation of the integrative framework. As regards to the construction of the framework, we take literature research as starting point for the elaboration of the integrative framework (see chapter 3). Based on the gained findings, we take a socio-technical systems theory perspective to design the integrative framework and build on strategic and business/IT alignment. The latter one is of key importance as the implementation of IS causes many organizational changes like changes in organizational structure, processes and tasks (cf. (Henderson & Venkatraman, 1993; Tallon, Kraemer, & Gurbaxani, 2000; King, 2015; Tarafdar & Ragu-Nathan, 2015)).We

[18] For details see (Versendaal, Högler, & Batenburg, 2016).

apply the framework in different case studies to test its applicability and to refine it in accordance to the needs of practice (see chapters 7-10). Experts provide their opinion on the applicability and generalizability of the framework through semi-structured interviews in chapter 10.

Guideline 6 – Design as a Search Process

This work – the integrative framework – started on a theoretical basis: literature research (see section 3.4). It was iteratively enhanced while applying it in case studies and thus follows the generate/test cycle to reach desired results *"while satisfying laws in the problem environment"* (Hevner, March, Park, & Ram, 2004, p. 90) (see part 3 / chapters 7-10). The application of the integrative framework in practice shows that the framework works in the chosen environments and that it delivers useful results that support the decision making process. Following Simon (1996), these results can be seen as satisfying, although they do not explicitly specify all possible solutions and alternatives, respectively.

Guideline 7 – Communication of Research

The results of this research were presented to different audiences with technical and management background (see chapters 2, 4-10). In several proceedings and conference presentations the results were reviewed and commented by various experts, leading to enhancements of the presented framework (see also guideline 6). Thus, a cumulative knowledge base for further enhancement and evaluation of the framework was built up in the timeframe of several years.

1.6 Research Method

This thesis follows a multi-method approach (cf. (Mingers, 2001; Venkatesh, Morris, Davis, & Davis, 2003)) that leverages the concepts of design science research (Hevner, March, Park, & Ram, 2004). The single chapters 2, 4, 5, 6, 7, 8, 9 and 10 – formerly published as papers at conferences and in books – apply various research methods to support the goal of defining the integrative framework taking different perspectives. We use literature research, case studies (some more detailed than other), and expert interviews.

Literature Analysis

All papers of this thesis include a type of literature search and review that can mainly be labelled as narrative. The narrative review seeks to identify publications on a subject or topic (Green, Johnson, & Adams, 2006), but *"does not involve a systematic and comprehensive search of all of the relevant literature. Instead, narrative reviews are often opportunistic in that they survey only that literature and evidence that are readily available to the researchers*" ((Davies, 2000) in (Paré, Trudel, Jaana, & Kitsiou, 2015)). This type of literature review is a qualitative[19] or inductive-based approach that describes the state of science from a theoretical and contextual point of view, but that does not describe the methodological approaches used to conduct the review which would allow reproduction of data (Rother, 2007).

In all cases, a mix between primary and secondary literature search was applied, while the starting point was a look at the current state of the art, digging step by step deeper into the topic and thus following the so-called *'snowball literature research'* approach. In a first step, the narrative literature analysis took place in order to get an overview on the current state of scientific research with regard to organizational topics within the broad field of mobile computing.

While during the last years literature research became a research direction itself, the literature research which forms the basis for the present thesis started already in 2001. As online libraries and research databases were at that time not common – if available at all – mainly an 'offline' literature analysis took place: books and proceedings available at the library of the University of Karlsruhe (now: Karlsruhe Institute for Technology) as well as lendable via so-called remote-lending were analyzed and used as basis and first step of the literature search. At the same time, search engines like Google and the Springer Online database (from ca. 2004 on) were used for further literature research. As the Internet developed quickly and so did the databases, and as the research topic became more and more turning from tangible effects like productivity and economic efficiency towards more intangible effects like business value ((Kornak, Teutloff, & Welin-Berger, 2004), see also section 1.1), the literature research took place continuously, checking the latest developments in the research area every year and following the latest developments. A mayor part of the literature review took place by using Google Scholar (former: CrossRef, since ca. 2006) and Researchgate (since ca. 2013), as well as via the Open University of the Netherlands (since ca. 2014) that allows access to different research databases. Standard literature and latest publications at acknowledged ICS-related conferences were chosen as basis for further and in-depth literature research, allowing step-by-step a deeper understanding of the potential research topics[20].

A last literature search took place in late 2017 and early 2018 during the development of chapter 3, presenting the current state of research and widely approved practice-oriented approaches.

[19] A qualitative survey research is – in comparison to quantitative surveys – a less structured research methodology, applying semi-structured interviews with a small sample of participants. It´s aim is to develop a deep understanding of a topic, issue, or problem from an individual perspective (Jansen, 2010).

[20] 'scoping review'

Case Study

Part 3 of this thesis is based on case studies which followed the recommendation of Yin (2013) and Maimbo and Pervan (2005). The advantage of case studies is that they can merge the usage of qualitative and quantitative paradigms (Uys, 2015). More detailed information about the case studies is included in the Appendices A, B and C.

According to Yin (2013, p. 84), case studies can be used for improving construct validity by employing multiple sources of evidence like observed application in practice and interviewing stakeholders. Thus, these case studies concerned theory testing; they were employed to further detail the approach and to apply the integrative framework in practice. In addition, the single case studies provided significant explanations for a better understanding of the integrative framework and supported, due to the different fields of application, its generalizability (see also chapter 10).

For this thesis, three different case study types were applied[21]:

- case studies that were used for evaluating single framework components: activity 1 – definition of the target system – was evaluated in 2 case studies (see chapter 1 and section 10.4.2); activity 3 – definition of success factors – in one case study (see chapter 9),
- one case study that was used for evaluating the artifact (see chapter 1), and
- a retrospective case study (see section 10.4.1)

Survey by Experts Interviews

According to Yin (2013), interviewing people with different perspectives can be a valuable approach to validate a given framework. Experts were asked to fill out a structured questionnaire. Where necessary, a discussion on open questions was conducted with these experts (see section 10.4.3). The objective of this qualitative survey was to systematically validate the construct of the framework, i.e. its axioms and the proposed activities and procedures.

1.7 Thesis Outline

This thesis consists of five different parts: The introductory and motivational part (part 1) is followed by the general introduction to the integrative framework (part 2), which is step by step elaborated in detail and applied in practice (part 3). The validity of the integrative

[21] cf. Appendices A, B and C

framework is analyzed in part 4 of this thesis. Part 5 concludes the work and provides insights into further research (see Figure 1-2).

As the thesis developed over a longer period of time, the concept of the integrative approach was labelled in the first publications (chapters 5-6, theoretical concept of the integrative approach) as holistic. In newer publications it was labelled with its final name: integrative framework (chapters 7-10, application in practice and evaluation).

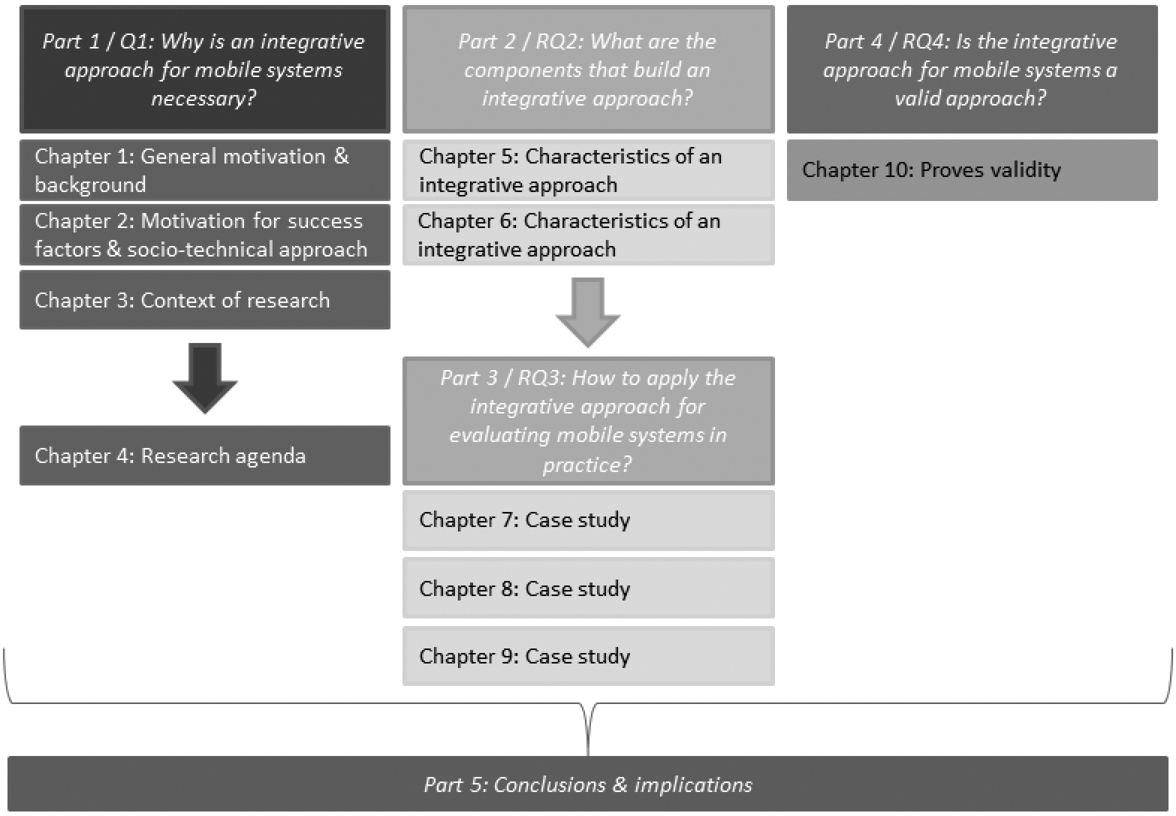

Figure 1-2: How research questions are addressed by single chapters of this thesis

Part 1 Introduction and Motivation

Chapter 2 Exploring Critical Success Factors

This work was originally published in the Proceedings of the ICMB 2006 International Conference on Mobile Business under the title 'Exploring the Critical Success Factors for Mobile Commerce' (Feng, Högler, & Stucky, 2006). Its main purpose is to explore and identify key factors for successfully implementing mobile commerce in businesses. To do so, an end-user perspective of mobile commerce is provided, based on an extensive literature research, and a value-added-based acceptance model is proposed based on the results of the analysis. A set of factors, which were deemed to positively affect the success, is identified, and a theoretical framework of critical success factors (CFS) is presented. This chapter elucidates which aspects to consider in evaluating information systems in a mobile context: a) considering (critical) success factors and b) taking a socio-technical perspective, both motivating the development of our framework and addressing RQ1 (Why is an integrative approach for mobile systems necessary?).

Chapter 3 Basis for the Evaluation of Mobile Systems

In chapter 3 the overall context of the thesis is provided, starting with the clarification what mobile computing is and how it affects business processes. We continue with providing a deeper understanding why systems theory and business/IT alignment seem to be an appropriate theoretical basis for evaluating the business value of mobile systems and by doing so, address RQ1. In the further course of the discussion, we define the holistic principles that are used as starting points for the elaboration of the integrative framework. We confirm the necessity of our approach by providing insights into existing approaches for evaluating ICS and mobile systems.

Chapter 4 Research Agenda

Chapter 4 has been originally published in Proceedings of ICEIS 2014 under the title 'A Research Agenda for Mobile Systems Evaluation' (Högler, 2014). Based on the findings of the previous chapters, it justifies the necessity of an economic evaluation model that considers singularities of mobile systems and interdependencies of their individual components and addresses RQ1. Starting point for the research agenda is the definition of the term mobile system, followed by the explanation of the single components and singularities of such systems. A profound understanding for the theoretical background of mobile systems is the basis for this thesis.

Part 2 First Steps Towards the Model

Chapter 5 Integrating Success Factors into the Evaluation of Mobile Systems

Chapter 5 presents the early beginning of this research – it was originally published in the Proceedings of the Multi-Conference Business Informatics in 2006 under the title 'Framework für eine holistische Wirtschaftlichkeitsanalyse mobiler Systeme' (Högler, 2006). It motivates the development of an ex ante and thus decision-supporting integrative[22] approach for the economic evaluation of mobile ICS that integrates existing approaches and that considers project-specific, critical success factors. Consequently, it provides first insights into the components of an integrative approach, addressing RQ2 (What are the components that build an integrative approach?).

[22] In older publications labeled as 'holistic'.

Chapter 6 Framework for an Integrative Analysis of Mobile Systems

Chapter 6, originally published in the Proceedings of the 1st International Conference on Mobile Society under the title “Framework for a Holistic Profitability Analysis for Mobile Systems” (Högler, 2008), builds on the findings of chapter 5. It elaborates further the integrative framework by updating activity 6 and adding activity 7, and by doing so addressing RQ2. Besides general definitions related to the research topic, this chapter provides a criteria framework for the integrative framework and describes its structure and activities.

Part 3 Model Detailing & Application in Practice

Chapter 7 Evaluating Mobile Systems in Practice

Chapter 7 has been published in the Proceedings of the AMCIS Conference 2015 under the title “Evaluation of Mobile Systems – An Integrative Framework” (Högler, Versendaal, & Batenburg, 2015). It builds upon findings of previous chapters and presents the integrative framework for the evaluation of mobile systems. In the construction of the integrative framework we define 1) systems theory, 2) business/IT-alignment theory and 3) identified singularities as main pillars of the framework and starting points, while taking a design science research approach. The resulting framework takes a socio-technical system perspective and consists of three main principles (detailed organization-internal evaluation, detailed economic evaluation, integrative evaluation). We apply the framework addressing RQ3 (How to apply the integrative approach for mobile systems in practice?).

Chapter 8 Determining the Target System for Mobile Systems

This chapter was originally published in the Proceedings of the 29th Bled eConference under the title “Determining the Target System for Mobile Systems as Part of an Integrative Approach for the Economic Impact of ICS: Validation at an SME” (Högler & Versendaal, 2016). It presents the first activity of the integrative framework for evaluating the business value of mobile systems, i.e. defining the target system. The basis for this activity is the Analytical Hierarchy Process, which is extended by several steps, resulting in a new approach for a so-called preference-neutral definition of targets. A case study confirms the validity and applicability of the chosen approach and provides reasons for generalization. Also this chapter addresses RQ3, by applying parts of the integrative framework in practice.

Chapter 9 Identifying (Critical) Success Factors for Mobile Systems Deployment

Chapter 9 answers the question how to identify (critical) success factors for mobile systems, taking a multi-dimensional perspective, and clarifies their importance for the implementation of such systems. Starting point is the identification of singularities of mobile systems, which differ in many aspects from stationary systems. A method is presented that determines how to identify (critical) success factors for mobile systems. It considers not only the interdependencies between the single (mobile) system components and tasks but also between success factors themselves. In addition, it provides a procedure how critical success factors can be identified and weighted. The theoretical assumptions of this method are supported by application in practice, addressing RQ3.

This work was originally published in the Proceedings of the 27th Bled eConference under the title "Identification of Success Factors for Mobile Systems Deployment: A Method" (Högler & Versendaal, 2014).

Part 4 Validation

Chapter 10 Validating the Integrative Framework in the Context of Digital Transformation Evaluation

This chapter brings mobile systems into the larger context of digital transformation, as ICT and ICS specifically enable digital transformation in enterprises (Elliott, 2004) and as they are the drivers of competitiveness and innovation of the 21st century. Yet, successfully leveraging ICT is a complex challenge, particularly when mobile technology with its many advantages and specific singularities is involved.

We present an integrative framework that supports organizations in preparing their mobile technology enabled digital transformation. It consists of seven activities that are categorized by three principles of the framework: (1) 'internal analysis', (2) 'economic analysis' and (3) 'integrative analysis'. We demonstrate the validity and applicability of the framework through a multi-method validation and by doing so, we address RQ4 (Is the integrative approach for mobile systems a valid approach?). First, by a retrospective case study about the introduction of a mobile app in a hospital, we show that most aspects of the framework are relevant and covered. Second, by qualitative semi-structured expert interviews we conclude that the need for each of the activities of the framework is underwritten. Third, by applying successfully one key activity of the framework – definition of the target system – we validate the framework´s applicability on the implementation of an electronic learning environment at a fire-brigade.

This work is peer-reviewed and accepted for publication as a chapter in a Springer Publication on Digital Transformation (expected publication 2019). The title of the chapter is "Validation of the integrative approach for digital transformation evaluation".

Part 5 Reflection

Chapter 11 Conclusions and Outlook

The last chapter of this thesis summarizes the research work implemented and answers the research questions. It discusses the scientific as well as the practical contribution of the thesis, the latter one particularly also from latest developments in IT. The work is concluded by a debate about limitations of the research and recommendations for further research.

2 Exploring Critical Success Factors

Abstract[23]

The main purpose of this paper is to explore and identify the key factors for successfully implementing mobile commerce in businesses. We first provide an end-user perspective of mobile commerce and then a value-added-based acceptance model is proposed based on the analysis. A set of factors, which is deemed to positively affect the success, was identified, and a theoretical framework of CSF is presented.

2.1 Introduction

The Internet has created an incredible marketspace. In parallel with the Internet, another technology stream has emerged to play an increasingly important role in business and society: mobile communications. Wireless and mobile networks have experienced exponential growth in terms of capabilities of mobile devices, standards and network implementation, and user acceptance that are likely to provide new opportunities for users, businesses, and services providers.

Regardless of the fact that e-commerce has not reached the explosive growth figures which were commonly predicted in the mid-1990s, scholars and industry representatives are now turning their attention towards the mobile commerce (m-commerce), and envisaging that the real phase of ecommerce growth will be in the area of m-commerce. During the mobile hype in the years 1999-2002 there were many great visions of how m-commerce could provide benefits to businesses (cf. (TowerGroup, 2002; Garfield, 2004)). For example, The Jupiter Research has predicted *"m-commerce revenues in 2003 will reach $600 million in the US, $1.7 billion in Europe, and $3.5 billion in Japan"* (Pastore, 2000). Forrester Research even claims the global m-commerce market will reach $14.5 billion by 2004 and $22 billion by 2005 (Pastore, 2000). Even more, the Gartner Group estimated in 2004 that at least 40% of consumer-to-business e-commerce would be initiated from smart phones supported by WAP (Varshney & Vetter, 2001). However, we already know that this scenario is not going to be realized, m-commerce has not gained significant market acceptance yet.

M-commerce has attracted a lot of interest lately. After the success story of Japan's mobile Internet, NTT DoCoMo, a significant amount of research was conducted in academia and in the industry. The current research is heavily skewed toward consumer issues (Scornavacca,

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23 This work was originally published as: Feng, H., Högler, T., & Stucky, W. (2006). Exploring the Critical Success Factors for Mobile Commerce. Proceedings of the International Conference on Mobile Business (ICMB 2006). Copenhagen / Denmark, 26-27.06.2006 (p. 40ff.). Washington: IEEE Computer Society.

Barnes, & Huff, 2005), but how to ensure the m-commerce success has been left virtually unexplored. Successfully implement m-commerce calls for a more in-depth understanding of the mobile applications, as well as the consumer behavior and needs with regard to mobile commerce. Hence the purpose of this thesis is to study the success of the mobile commerce adoption in business and its determinants.

The rest of this paper is organized as follows. In section 2, we first outline the definitions of mobile commerce published in literature in order to get the general core idea of m-commerce. Then we provide a brief review of the related work in section 3. Afterwards we provide end-user perspectives on m-commerce. A value-added-based acceptance model is proposed, and a set of key factors is identified in section 4. Finally, we summarize this work briefly in section 5.

2.2 Definitions of Mobile Commerce

Researchers have adopted a broad definition of m-commerce to explore its potential benefits. In this section we try to review the varied definitions, and to help understanding the core meaning of m-commerce.

Most often m-commerce is understood as mobile e-commerce, namely the use of wireless technology, particularly handheld mobile devices and mobile Internet, to facilitate transaction, information search and user task performance in consumer, business-to-business, and intra-enterprise communications. For example, (Keen & Mackintosh, 2001) defined m-commerce as the extension of electronic commerce from wired to wireless computers and telecommunications, and from fixed locations to anytime, anywhere, and anyone device. Other researchers also share a similar idea and view m-commerce as an evolution of the e-commerce paradigm from fixed networks to wireless data networks (Paavilainen, 2002). Scornavacca et al. define m-commerce as the use of mobile information technologies, including wireless Internet, for organizational communication and coordination, as well as management of the firm (Scornavacca, Barnes, & Huff, 2005). These definitions of m-commerce emphasize the use of wireless technologies and business support while users being on the move and away from their fixed network connections.

Paavilainen defines mobile business as the exchange of goods, services and information using mobile technology and notes that mobile business is a broad definition that includes communication, transactions and different value-added services using various kinds of mobile terminals (Paavilainen, 2002). In a narrow sense, m-commerce was defined as *"transaction with monetary value that is conducted via a mobile telecommunications network"* (Durlacher, 1999). Paavilainen further points out that the term 'mobile e-commerce' is misleading because the business models and the value chain are totally different from e-commerce. (Carlsson & Walden, 2003) go along with this notion based on their empirical studies that 'mobile commerce' is not a truncated form of e-commerce but a new, innovative way of conducting time-critical transactions regardless of location.

Some authors use an oversimplification of the term 'mobile commerce' by stating that it just a 'wireless form of electronic commerce', and some researchers place their own definitions of m-commerce somewhere between the extension of e-commerce and the totally innovative paradigm. There are some major differences between e-commerce and m-commerce, such as that the interaction style is unique due to the constraints of terminal devices, the usage patterns differ from those of traditional desktop computers. Furthermore, the nearly ubiquitous availability of m-commerce enables information access for many new business functions in real time that were previously unsupported and also can be easily personalized to match individual situations. So it has been recognized that m-commerce is more than an extension of ecommerce. We follow the definition synthesized by Cronin (2003) from various sources about the nature of mobile commerce. *"Mobile commerce refers to all data-driven business transactions and exchanges of value by users of mobile devices via wireless telecommunication networks"* (Cronin, 2003).

2.3 Related Works

Although m-commerce is an emerging field in its early stages there are a number of ideas of what is going to constitute the key success factors for the actors in the m-commerce arena. Early efforts to explore the critical success factors have focused on the mobile communication infrastructure, mobile devices' limitations, and the development of mobile applications, rather than on applications in business settings. (Carlsson & Walden, 2002) collected a set of key success factors (KSFs) from Durlacher Research, BroadVision, Vignette, Nokia and TechNews. The key success factors include customer ownership (of the mobile terminals), personalization, localization, ubiquity, timelines, and convenience. The user's personal data and preferences, and location sensitive information are regarded as the leading factors. Comparing these factors, the security is perhaps the most widely cited, and many researchers have contended that lacking security and privacy could be a major stumbling block to the growth of m-commerce (Buellingen, 2004).

In literature (Pramongkit, Muangthanya, & Chaikiart, 2002), the author conducted a survey about the WAP service of Thailand in an attempt to promote the WAP service and the future 3G with effective means. The results of this investigation show that the major impediments of the WAP service are due to a slow speed of data transfer and lacking usability. The author summarizes the key success factors as speed of data transfer, content and application, payment method, price of handset, customer awareness and education, and marketing and promotion. 3G is considered as a necessary underlying infrastructure for the m-commerce in the future. Researchers explore the 3G market of the world from different aspects (cf. (Muthaiyah, 2004; Curwen, 2005; Karjaluoto, 2005)). Several key success factors of 3G services for service providers and consumers are identified. For the service providers, the cooperation and partnership on the 3G value chain, market segmentation and targeting effectiveness, fast introduction and application of services, overcoming psychological barriers, target marketing efficiency, good financial situation, and plausible state legislation as well as regulations are regarded as the key factors. On the other hand, value added and/or personalized services, which are reliable and compatible with the culture, as well as reaching a critical mass with the services are the key success factors for consumers (Muthaiyah, 2004). High initial and operational costs are also a critical factor to the adoption of 3G services.

Needless to say, factors listed above are important for accelerating the diffusion of m-commerce, it gives a highlight to application developers how to deploy a mobile application and to mobile services providers how release new mobile services. But most of the technical limitations, which currently influence the end user accessing mobile services, will be reduced with the availability of powerful and sophisticated communication technologies in the market. As (Kalakota & Robinson, 2001) point out that m-commerce is not about telecom infrastructure and software breakthroughs, but about applications and solutions for everyday users in various contexts and locations. The factors such as market segmentation, good financial situation, compatibility with the culture, lower initial and operational price, and reaching a critical mass of market are not monopolistic for m-commerce but for every new kind of application and service.

There are many different potential factors affecting the success of m-commerce. Recent studies mostly focus on the technical limitations of the mobile terminals, networks, and current mobile application systems; other researchers broadly explore the success factors from social, cultural, financial, market, and consumer viewpoint, respectively. But, despite the high penetration of mobile devices, and the hype of mobile industry, questions like “Why are the customers not willing to use the mobile services?“, “What are customers expecting?“ and “How can companies establish a new strategy of mobile commerce and successfully initiate a mobile application?“ are neither mentioned nor answered in the literature. In the following section, we want to fill this gap and to discuss which factors – also called Critical Success Factors (CSF) – can affect the success of m-commerce.

2.4 Identify the Critical Success Factors (CSF) for M-Commerce

The starting point of the CSF research was a paper of Daniel (1961) who analyzed some critical factors in context of management information systems. The concept itself can be defined as follows: A success factor is a factor which has a sustainable and positive effect on the success of a company. By using these factors a competitive advantage could be realized.

Because, however, there are many different potential success factors, the academic research in this field is only interested in the most critical ones. These factors are called CSF and can be classified in three groups (Hilbert, 2005): The first group is the subset of the so-called endogenous CSF which can be directly controlled by the business. The second class contains the so-called exogenous CSF which are not directly manageable. The third group is the class of moderator variables that have the task to mediate between the 'real' success factors and the success values. Consider all these groups of CSF, a very general model for the causal relationship within the CSF research was defined as illustrated in Figure 2-1.

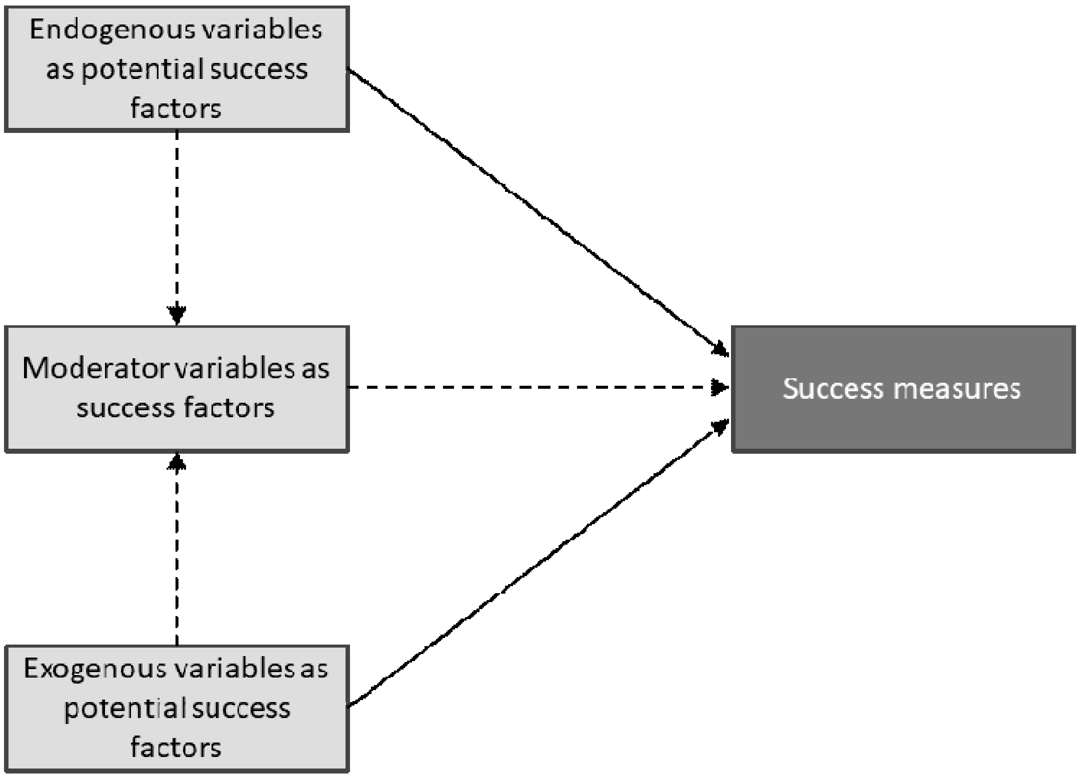

Figure 2-1: Basic framework for the CSF research (adapted from (Hilbert, 2005))

2.4.1 Attitude Towards the Use of Mobile Services: The End-Users' Perspective

Before exploring the success factors of m-commerce, it is important to understand the end-users' perspectives of mobile services. There is a clear need to know if consumers are contented to use their mobile devices to buy new services and to comprehend why and how individuals (potential m-commerce consumers) adopt them. A second, very important question is if there is a willingness to pay additionally for the mobile services. Reviewing the previous research efforts and its findings broadly in literature, we could generally assess the state of m-commerce and comprehend the attitude to m-commerce of the end-users.

Singh carried out an empirical investigation in graduate school of Kwa-Zulu Natal's (Singh I. K., 2003). The MBA students were purposively selected as they have the potential to implement m-commerce in business as future 'captain of industry' and would therefore be able to give valuable input on what m-commerce could offer companies and consumers. The study elicited that 62% of the respondents have phones with m-commerce capabilities. With regard to the reasons for not conducting mobile transactions, 62% of the respondents indicated they would not transact on their phones as it was too costly, followed by the facts that business does not require it (50%) or that the phone does not facilitate m-transactions (37%). The lack of skills or knowledge in transactions (17%), poor security (16%) and poor interface design (14%) were mentioned as reasons against m-commerce as well. As regards the incentives for conducting mobile transactions, 77% of the respondents indicated that they would transact on their mobile devices if business requires it or if it would be cheaper (59%). A survey conducted by Anckar and D´Incau also indicated a rather low willingness among the respondents to use most of the m-services subject of their investigation (Anckar & D'Incau, 2002).

Europe is reckoned as the high potential market of m-commerce as the very high penetration of mobile phone (cf. (Vrechopoulos, Constantiou, Mylonopoulos, & Sideris, 2002; Carlsson & Walden, 2003; Carlsson & Carlsson, 2005)). Findings from a Germany-, Greece and Finland-based consumer survey by Vrechopoulos et al. (2002) suggest that the majority of respondents do not use mobile phone for commerce, and the stated main reason for not doing that is they 'do not need it' (57% in Germany; 59% in Greece; 42% in Finland). The second most important reason for not using such kind of services was the high costs (25% in Germany; 9% in Greece; 27% in Finland) (ibidem). Further evaluation of m-services in these countries found that the most frequently used mobile services in Germany and Greece is 'information and news retrieval' and 'entertainment' in Finland.

Austria and Finland both have a large penetration of mobile phones and the telecommunications infrastructure in both countries is advanced. The 3G services were made available two years ago. Despite the fact that the consumers in both countries have a wide selection of mobile services available, they mainly use their devices for making phone calls and sending text messages (Carlsson & Carlsson, 2005). Draw on data collected through expert survey, C. Carlsson and J. Carlsson (2005) argue that one of the most critical barriers to the adoption of m-commerce in these two countries is the lack of mobile applications with real user value.

With aggressively upgrading its information infrastructure for e-commerce diffusion in recent years, China has become the world's biggest mobile phone market with more than 377 million mobile subscription in 2005 (IDC China, 2005). China's mobile value-added market began rapid development in 2002. In 2004 the total market scale reached 29.83 billion Yuan, which is predicted to reach 41 billion by the end of 2005 (Okokok, 2005). An empirical survey conducted in Zhongguancun Science Park, Beijing in 2005 shows that the majority of the respondents had used Internet via a computer (89%), but less than 9% are accessing the Internet via a mobile device. With regard to mobile services, the short message service (SMS) is the most basic and common mobile service, and almost all of the mobile phone users use SMS. Wireless music, wireless online game, ring tones have also taken the great share in the available mobile services, and mostly younger consumers use these services. The reasons the respondents gave for not using mobile commerce is show in Table 2-1.

Table 2-1: Reasons for not use mobile commerce (IDC China, 2005)

Reasons	Percentages
It is needless	79
Lack of value-added applications	71
Poor quality of the content	50
Too expensive	54
Poor security and privacy	40
Easy substituted by wired network	63

These findings generally show that m-commerce in China is in the initial stage. The current available services such as SMS, mobile phone ring tone have the inherit relationships to the mobile communication, could be viewed as the extending of the mobile communication.

2.4.2 Value-Added-Based Acceptance Model of m-Commerce

It is clear that the critical success factors for m-commerce are directly related to the reasons that consumer use or do not use m-commerce. Many factors positively or negatively influence users' adoption of m-commerce, and several variables could be derived from the users' perspectives. Davis has shown that the Technology Acceptance Model (TAM) can explain the usage of information technology (Davis F. D., 1989). Davis asserted that perceived usefulness and ease of use represent the beliefs that lead to acceptance. Perceived usefulness is the degree to which a person believes that a particular system would enhance his or her job performance; Perceived ease of use is the degree to which a person believes that using a particular system would be free of effort.

Although a large body of research supports the TAM as a pertinent model to explain the acceptance of IT, it is questionable whether the model is applicable to consumers' choice of commercial channels. Adoption decisions relating to m-commerce are likely to be very different from technology adoption decisions. (Anckar, Carlsson, & Walden, 2003) argued that what the consumer chooses to adopt in m-commerce is not merely a technology per se, but rather a new instrument of commerce. Furthermore, TAM is usually applied as if every situation would be a single target situation, building on the implicit assumption that only one specific technology is available for the potential users. It may be difficult to obtain valid predictions and explanations of technology acceptance with TAM when consumers actually are exposed to a multiple-choice situation or in this case alternative, transact in fixed or mobile, channels.

As argued above, consumers who adopt m-commerce are not merely based on perceived usefulness and perceived ease of use; perceived value added and perceived usability also affects the users beliefs. Based on this understanding, integrating theories and models of traditional IS adoption with findings from consumer investigations of m-commerce adoption, a general multi-dimensional value-added-based model for predicting and explaining the adoption of m-commerce and its potential determinants is illustrated in Figure 2-2.

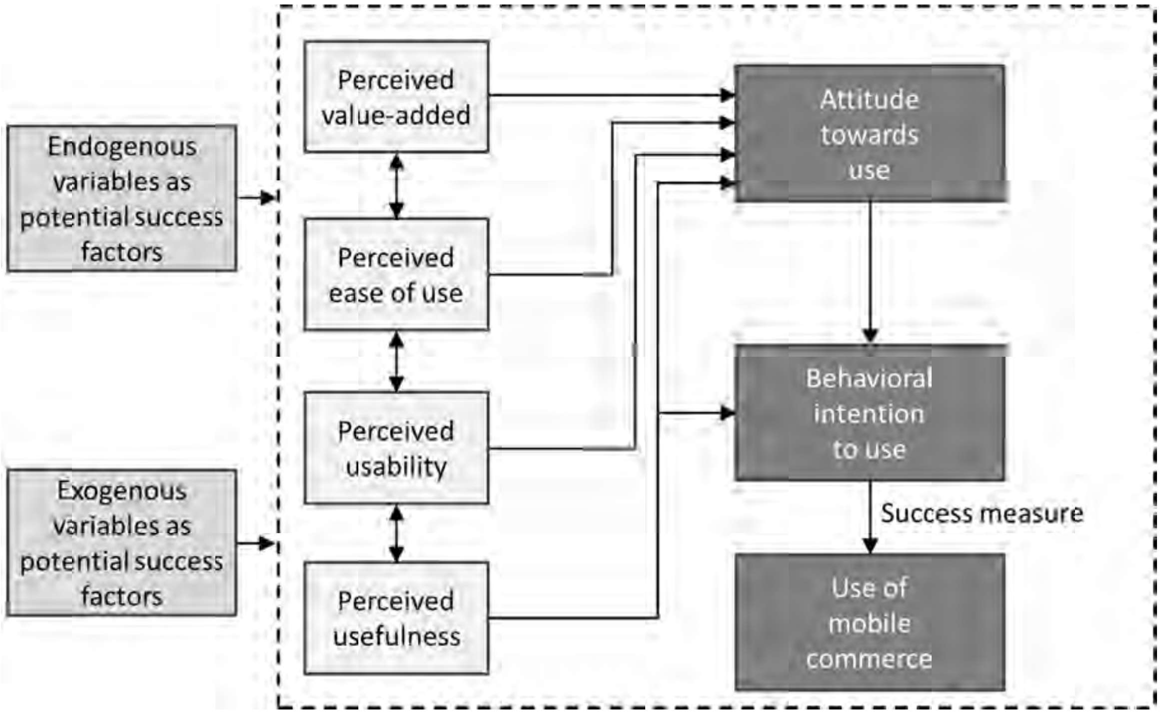

Figure 2-2: Adapted TAM model on the adoption of mobile services

At the following, we try to map the users' attitudes, which were discussed in section 2.4.1, into the proposed model. Additionally, we try to identify the potentially significant underlying variables that must be taken into consideration in order to design and deploy valuable m-commerce applications, and offer the consumers the value-added services.

2.4.3 Critical Success Factors for M-Commerce

2.4.3.1 The Facet of Perceived Value Added

M-commerce must add value for consumers. As long as the consumers have the feeling that what they receive is worth it, they are likely to accept and to pay for it. Findings from the different market surveys show that a great percentage of respondents has no intention to use mobile services as they 'do not need it' at the moment, the reason therefore is the lack of value-added services.

In the literature on m-commerce adoption, aggregated diffusion issues or technology issues are usually focused. However, a comparison of the slow adoption of m-commerce in Europe and Asian countries with the successful adoption of comparable I-mode services in Japan, suggests that aggregated and technology-based models are insufficient to explain the m-commerce adoption process. M-commerce is one kind of value-added service that can be accessed on user's mobile devices, the additive value of m-commerce roots in the innovative business model and contents.

Business models determine how the business transaction is specified and when and how the players interact with each other. We believe, a viable business model, where all players, including consumers, operators, content providers, terminal device manufacturers, portal providers, and distributors, cooperate to run a profitable business, is one of the dominant factors for the success of m-commerce.

F1:	*Business Model. Suitable and viable business model is one of the critical success factors.*

(F= factor)

The vitality of m-commerce rests with its differentiations, so the content is another important issue. A new business model can survive successfully only if it can fulfill preexisting needs and/or creating new needs. M-commerce must provide what conventional e-commerce difficult to or fail to serve. Implementing a differentiated service requires a new way of thinking about the content. Therefore we identify the content innovation as one critical factor.

F2:	*Content Innovation. Added value results from the distinctive content of m-commerce.*

The success of m-commerce has often come from the insightful innovations within the core business of the enterprise and innovative use of the existing technology to support, enhance, or extend its core business.

2.4.3.2 The Facet of Perceived Usefulness

Perceived usefulness is defined as the degree to which a person believes that using a particular system would enhance his or her job performance, i.e., by reducing the time to accomplish a task or providing timely information (Davis F. D., 1989). It is a response to user assessment of the extrinsic characteristic of IT. The TAM has been both extended and modified, and several hundred studies are found in literature applying one of these models to explain end-users' adoption and acceptance of different kinds of ICT-systems (Venkatesh & Davis, 2000). Doubtless, much of what has been learned from previous studies of the adoption of IT may be relevant to understanding the adoption of mobile services.

Traditional acceptance models mainly suggest the business purpose (cf. (Davis F. D., 1989), (Mathieson, Peacock, & Chin, 2001)), such as how IT can help users to improve the effectiveness and efficiency, and to achieve task-related objectives. Much of the research studying the use of mobile services in work contexts is interesting because it studies the functional reasons for adoption. However, little of research on mobile services in the leisure context and everyday contexts have either focused directly on the functional use of mobile services in leisure (Palen, Salzman, & Youngs, 2001), or on how the boundary between the work and leisure contexts is blurred by the use of such services (Gant & Kiesler, 2001). These studies indicate that there is a mix of work and leisure related functional reasons for adoption of mobile services.

The reasons for adoption of mobile services should not be confined to business purposes. Another important issue is how mobile services differ from traditional ICT-services in ways that affect users' adoption. For example, the personalization, location specificity and ubiquity of these services are suggested as important characteristics making their adoption different from other ICT-services. As thus, we identify the following determinant of the perceived facilitating the business and users' everyday life.

F3: Business Support. Improves business performance, enhances effectiveness and efficiency.

F4: Leisure Time Support. Ubiquitous use for entertainment, urgency, and special purpose such as location based services, etc.

2.4.3.3 The Facet of Perceived Usability

There is a big gap between what the technology can now do and what the consumer has been led to expect. According to the Boston Consulting, nearly one-third of the early users surveyed in Europe abandoned m-commerce after only a few tries (Boston Consulting Group, 2000). The utility, security and privacy of mobile applications are broadly concern of consumer. Success of m-commerce lies on the value and their usability. From the user's perspective these can be reduced to system quality, content quality, trust, and support that will greatly affect the usability of m-commerce.

F5: System and Content Quality. System quality includes 24-hour availability, online response time, page loading speed, and visual appearance, etc. Content quality includes up-to-datedness, understandability, timeliness, and preciseness, and so on.

F6: Trust. Trust includes security and privacy.

F7: Support. Status tracking, account maintenance, payment alternative, individual preference and FAQ support.

2.4.3.4 The Facet of Perceived Ease of Use

Mobile devices offer some novel features which make it possible to use anywhere at any time, however, its intrinsic limitations, such as the small size of display area, limited input or interaction capabilities, low speed of data transfer, etc. affect the adoption of m-commerce. Some limitations of mobile devices will be weakening the progress of technologies, for instance, 3G devices offer multimode interaction capabilities, and the 3G mobile networks will enhance the speed of data transfer; and others will not be expected to change dramatically. For example, it will also continue to shrink in size.

Empirical surveys show that a complex and ineffective user interface limits the usability of mobile devices and hinders the use of mobile devices for mobile transactions (cf. (Anckar & D'Incau, 2002; Singh I. K., 2003)). To improve the design of user interface of mobile applications, its usability must be enhanced and made simple and effort-free. Innovation overcoming barriers, smart design and presentation of the content, and the interface of the mobile application will facilitate its use. Thus, the better organization of content, the simple and effective design of presentation and the interface are seen as an important success factor. A higher degree of usability can be reached and enables users to reach their goals better and faster by an adapted user interface:

F8: User Interface Design. Innovative interface design will facilitate the adoption of m-commerce.

Pricing, finally, is another important factor which users consider when selecting mobile applications. Both initial costs and operating costs need to be in the right ratio to the value the user receives from a mobile application:

F9: Initial and Operating Costs. High initial and operating costs influence the adoption of m-commerce.

Beside these factors regarding the effects of endogenous variables one factor for an exogenous variable should be formulated. This factor considers the limitations of technology and the infrastructure of mobile communication, which cannot be controlled by the company, service provider and operator solely:

F10: Availability of Technology and Support of Infrastructure.

These basic factors are identified to potentially positively affect the success of m-commerce. We map them into the basic framework for the CSF research as shown in Figure 2-3.

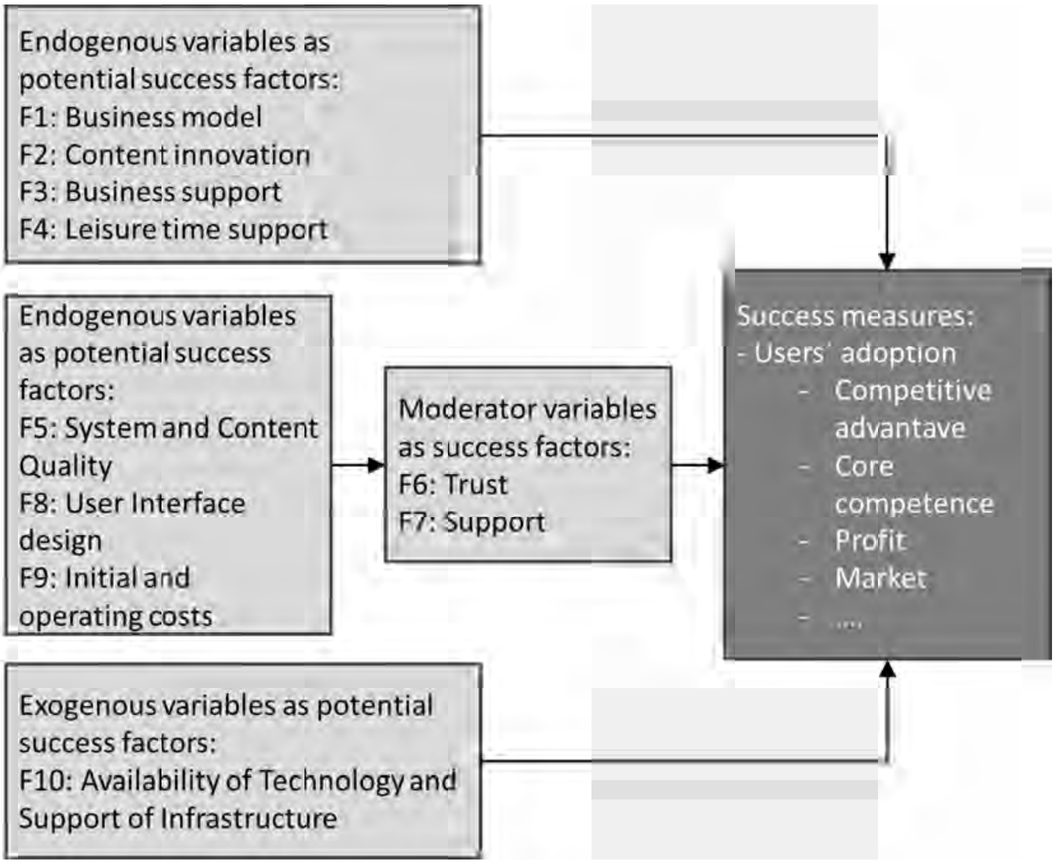

Figure 2-3: Framework for identifying CSF of mobile commerce

2.5 Conclusions

M-commerce offers a new business opportunity to enterprises and consumers, but before the opportunity become as an actual business, some barriers need to be overcome. A set of factors can potentially positively affect the success of m-commerce and should be taken into account by enterprises while adopting m-commerce. In this paper, we present a theoretical framework of CSF which will help companies to establish the m-commerce strategy and to implement the m-commerce applications.

3 Basis for the Evaluation of Mobile Systems

Abstract

Mobile computing offers new business opportunities to enterprises as it "emerged as a primary engine of economic growth […], profoundly changing daily lives – everywhere" (Bezerra, et al., 2015). Nevertheless, the implementation of new technologies does not mean that any business value for the enterprise is per se and automatically achieved. Quite the contrary: Many barriers need to be overcome in order to reach the objectives set. In this paper we first discuss the necessity of an integrative approach for mobile systems. To do so, we provide a general introduction into the main context of mobile computing, which is followed by an explanation of systems theory and business/IT alignment as applicable lenses for evaluating the business value of mobile systems. We define holistic principles as starting points for the development of an integrative framework for the evaluation of mobile systems. This research work closes with an analysis of existing approaches for evaluating ICS in general, taking into account the holistic principles, showing that additional research is well possible for the evaluating of ICS in general and mobile systems specifically.

3.1 Mobile Computing as the Overall Context of Mobile Systems

Mobile computing is perceived as an umbrella term to *'mobile business'* and *'mobile commerce'* and thus to all variations of the usage of mobile devices. Although a large number of definitions exists in research and practical literature (for example (Forman & Zahorjan, 1994; Lyytinen & Yoo, 2002; Satyanarayanan, 2011; Kaur, Saini, & Vashisht, 2013)) there is still disagreement regarding contents and boundaries of these concepts (cf. (Chlamtac & Redi, 1998; Magdic & Suman, 2003)). To discuss these definitions and their specific focus in detail would go beyond the scope of this work; nevertheless it is important to provide a short introduction into the field of mobile computing in order to enable the reader to better understand the necessity of an integrative approach. To do so, we start with exploring (in a very condensed way) an overall context for mobile computing.

Based on the definition provided by (Diehl & Held, 1995), we define mobile computing as

> *the usage of mobile devices – that can be connected wirelessly with the Internet or Intranet – in order to process data and to support improved business processes.*

At the beginning of 90´s and 2000´s, the terms *'ubiquitous'*[24], *'nomadic'*[25] and *'pervasive computing'*[26], as well as *'ambient intelligence'* – tightly associated with mobile computing, which provides the technical basis – were often applied in the context of or as synonyms of mobile computing[27]. These terms all deal with mobile access and processing of data, but differ slightly as regards to their specific focus.

As the scope of this work lies on the business usage of mobile devices, we focus on the subterms *'mobile business'* and *'mobile commerce'*. We therefore discount other, more technical areas of mobile computing.

In the broadest sense, mobile business can be seen as a variant of mobile computing, which specifically aims at supporting and enhancing business processes. Having a closer look at current literature, it becomes clear that even years after the first emergence of this topic, there is no agreement about what exactly is meant by the term *'mobile business'*[28] (cf. (Balasubramanian, Peterson, & Jarvenpaa, 2002; Mylonopoulos & Doukidis, 2003)). Many authors provide explanations and definitions of the term, but have their own priorities (cf. (Hartmann & Dirksen, 2001; Hribar & Lenart, 2004, p. 226f.)). As a discussion on details and nuances would lead too far, we refer to (Lehner, 2002, p. 6f.) who debates these definitions in detail.

We define with respect to (Lehner, 2002, p. 6f.) mobile business as

the entirety of all business processes in which mobile technologies are used in order to support the user in performing improved business processes.

Although a strict distinction is not always possible since in some cases boundaries overlap, Lehner differentiates between an *internal* and an *external* orientation of mobile business (Lehner, 2002, p. 2f.) (see Figure 3-1). The latter focuses on the market[29] or the business-to-consumer sector, which includes besides the traditional (private) customers also corporate

24 Ubiquity of processing information; *"ubiquitous computing strives at creating a completely new paradigm of computing environment"* (Bardram & Friday, 2010, p. 39). The term 'ubiquitous computing' was created by Mark Weiser (cf. (Weiser, 1991; 1993a; 1993b)).

25 Usage of mobile devices in connection to information and communication technologies.

26 *"Convenient access, through a new class of appliances, to relevant information with the ability to easily take action on it when and where you need to"* (IBM´s definition; in (Hansmann, Merk, Nicklous, & Stober, 2001, p. 11).

27 cf. (Want, 2010): *"[…] ubiquitous computing is characterized by the explosion of small networked portable computer products in the form of smart phones, personal digital assistants (PDAs), and embedded computers built into many of the devices we own […]".*

28 Budu and Boateng (2015) provide a good overview on the different concepts and definitions of the term mobile business.

29 From the supply and the customer side.

customers and business relationships respectively. In contrast to this external orientation, the internal orientation of mobile business is concerned with the support of employees and internal business processes through mobile technologies.

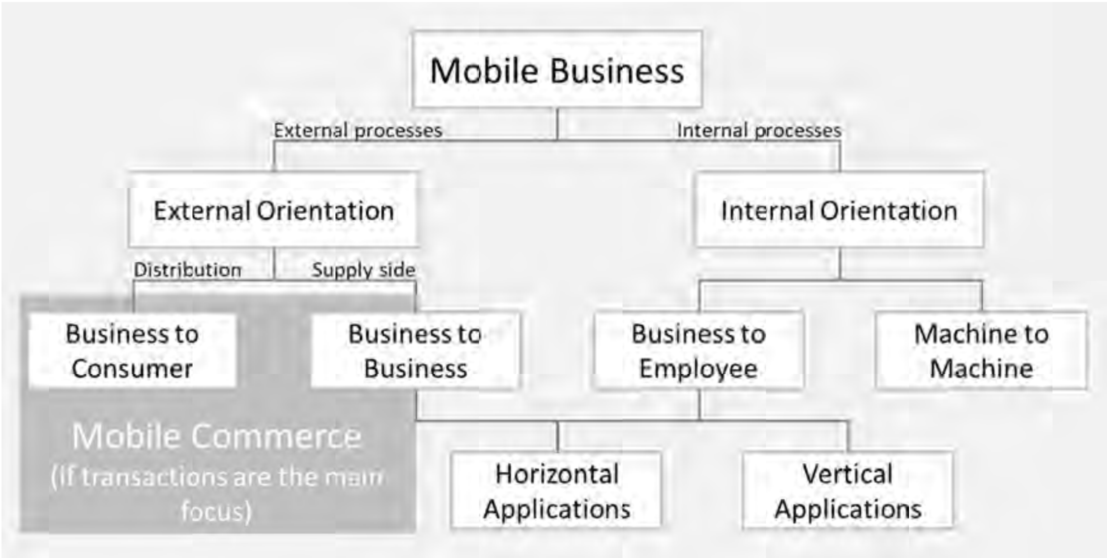

Figure 3-1: Mobile Business – external vs. internal orientation

Similar to the term mobile business, there is no standard definition of the term *'mobile commerce'* (cf. (Wirtz, 2001, p. 45)). To separate the two concepts, Turowski and Pousttchi define the term mobile commerce as

> *"[…] any kind of business transaction in which transaction partners use mobile electronic communication techniques (in conjunction with mobile devices) in the context of service initiation, performance agreement or service provision" (Turowski & Pousttchi, 2004, p. 1).*

Mobile commerce is, according to this definition, a part of mobile business. Having this in mind, we might generalize the findings from (Feng, Högler, & Stucky, 2006) to the generic mobile business context. Although addressing different users / customers, mobile commerce and mobile business face similar challenges, while in both orientations critical success factors and user-orientation contribute to their overall success.

To answer the research question *"How can mobile systems be evaluated in an integrative way?"* demarcating for manageability, we take the *internal* orientation of mobile business as starting point. This focus manifests itself particularly through the case studies (chapters 7-9) performed in our subsequent studies: Their scope is the internal organization leveraging of mobile technologies. Future research can then include the findings of this internal focus towards external process orientation.

3.2 Systems Theory and Business/IT Alignment as Basis for Evaluating Mobile Systems

A distinction between ICT, ICS and mobile systems is needed to better understand the context of this work. We start with systems theory which is a legitimate lens for ICS evaluation as the implementation of ICS is not only a technology-related task, but affects the organization as a whole (Bernsteiner, Kilian, & Ebersberger, 2016, p. 72). Thus an approach is proposed that considers different types of components of the organization itself (technology, people, and processes).

Systems theory is an approach that focuses on entities or elements (of a system) and that postulates that the system itself comes into existence by the relationships among the system elements and the resulting interactions (Goos & Zimmermann, 2005): A system is more than the sum of its components – it needs to be *"understood as an interconnected whole"* (Findlay & Straus, 2015, p. 476) whereas each element is connected directly or indirectly to every other element, having an effect on the behavior of the whole (Ackoff, 1971). Consequently, the *"system cannot be understood by studying the parts in isolation because it is only in combination that the unique properties exist"* (Matook & Brown, 2017, p. 314), (cf. (M'Pherson, 1974)).

As the *"behaviour of the elements, and their effects on the whole, are interdependent"* (Ceric, 2015, p. 20), the analysis of structures, reactions and functions allows certain predictions about the expected system behavior, whereas it does not focus on a separate consideration of each element, but on the overall system (Bertalanffy, General Systems Theory, 1976).

The perspective of the present work is based on the definition of the term *'system'* according to Goos and Zimmermann[30]:

> *A system is a collection of (system) components that are inherently related, including their relationships (translation, based on (Goos & Zimmermann, 2005, p. 18).*

In dependence on systems theory and to put more emphasis on the factors *'human being'* (human or social components) and *'delimitation of the environment'* we propose the following socio-technical definition of the term 'system':

> *A system is a set of technical and human (social) components[31], which are inherently related. Due to their interactions, the components form a unit that is earmarked or task-focused and thus differentiates itself in this respect from the surrounding environment.*

[30] A similar definition is provided by Elliott (2004, p. 49).

Having the above given considerations in mind, it becomes clear that in contrast to the term ICT that focuses on the technologies to support information exchange and communication, the term ICS encompasses all system components of technical and human nature (i.e. human beings), their relationships as well as their properties and their behavior (so called system parameters)[32]. This cognition is important as (business) value emerges as a result of complex interactions between the single components of an ICS.

Antweiler defines an ICS as (translation)

> *"[...] The totality of all system components (of technical and human nature), which aim to support information and communication exchange within its system components, including their properties and relations to each other" (Antweiler, 1995, p. 12)[33].*

In the present work, we focus on ICS in a mobile context and thus on so called *mobile systems*. According to Biljon and Kotzé, *"in the mobile context, the user and the equipment can be mobile and the surroundings may therefore change constantly"* (Biljon & Kotzé, 2007). In the context of mobile business, authors differentiate several aspects of mobility. Pandya (1999) and Roth (2002) for example identify following kinds of mobility:

- mobility of devices: portability of devices, relocation
- personal mobility: mobility of the user, access to services and applications can take place via different devices and at different locations (Wallbaum & Pils, 2002)
- mobility of applications / services: ability of networks to provide services and access to applications (e.g. via data synchronization) to users independently from their current location (cf. (Krannich, 2010, p. 24; Scherff, 2010))

Generally speaking, the main objective of deploying mobile technologies is exhausting added values that are facilitated by them, i.e. to increase the efficiency and effectiveness of business processes (Pilarski & Schumann, 2014) by redesigning them in a mobile way: bridging

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[31] Remark: In some, mainly older publications and thus sections of this work, we have used the terms 'elements' and 'components' synonymously, although they can be distinguished from our perspective: An element can be seen as a 'basic module' that functions also without having interdependencies with other elements whereas a 'component' can be seen as 'concerted / harmonized part' of the whole, which corresponds better to systems theory view – the theoretical basis of this work. As a consequence, as the importance of systems theory became more and more obvious during research and to emphasize the importance of interdependencies of the single system, the term 'component' replaced the term 'element' in the newer publicatations.

[32] Similar definitions can be found at Szyperski (1980), Krcmar (1990), Picot (1990, p. 132) and Peppard and Ward (2016).

[33] A similar definition as provided by Alter (1999), (2001), Krcmar (2015) and Withworth (2006) who define a socio-technical system as a general system that includes hardware, software, people, and business or community structures and processes.

geographical distances and providing required data and information at any time at any place (Scheer, Feld, & Goebl, 2001, p. 101ff.). These changes focus primarily on the improvement of time, quality and costs, and thus contribute to the valorization of many businesses (Schönberger, 2014).

We leverage the above given definitions of the terms *'system'* and '*ICS'* and define a mobile system as a

> *set of mobile technology and human (system) components, which are inherently related[34]. They form an entity due to their interactions that is task-related and that executes corresponding (mobile) business processes.*

Mobile systems appear in different forms; they have manifold characteristics, which make them specific as compared to stationary ICS (see also sections 1.4 and 4.4): Users are involved in mobile processes while they are using mobile technical components; they rely on wireless networks. This specific setting implies certain singularities to be considered while evaluating mobile systems. It becomes clear that the proper alignment between the single system components is of key importance when discussing the economic efficiency and business value of any ICS – and particularly of mobile systems due to their singularities that distinguish them from stationary systems.

So the implementation of mobile systems is not only a technical challenge. Next to also considering the human component it requires an alignment of mobile technologies and business processes as well (Henderson & Venkatraman, 1993) and should be accompanied by organizational changes (cf. (Robey & Boudraeu, 1999; Hong & Kim, 2002; Al-Mashari, Al-Mudimigh, & Zairi, 2003)) as *"alignment within the relationships may facilitate increased technology use; however, gaps in alignment may impede technology use and result in poor performance or system failure"* (Hester, 2014, p. 48) (see also section 7.1 for further details).

The usefulness of process and socio-technical systems theory perspectives has already been identified in the 90s e.g. by Hammer (1990), Orlikowski (1992), Hammer and Champy (1993) or Peppard and Ward (1999). Since then, many scholars have investigated the connection between alignment and organizational performance which follows the socio-technical perspective (e.g. Peppard and Ward (1999) and Cragg, King and Hussin (2002)). The aim of theories and studies focusing on *'alignment'* or '*fit'* is to reveal *"conditions that facilitate a positively interactive relationship among two or more entities"* (Hester, 2014, p. 51).

We summarize that the development of an integrative approach for evaluating the business value of mobile systems can be based on following three pillars:

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[34] cf. the discussion of Goos and Zimmermann (2005) concerning the term *'system'.*

1. Systems theory and
2. Business/IT-alignment,
3. Addressing the specificity of the mobile context by explicitly taking singularities of mobile systems into account.

In the following section we will present the process of solution finding towards an integrative framework. It starts with the definition of holistic principles which are in the subsequent section used for analyzing existing approaches.

3.3 Holistic Principles as Basis for Mobile Systems Evaluation

In the following we will shortly outline the development of the integrative approach for evaluating the business value of ICS in a mobile world. To do so, we leverage holistic principles as a *"holistic view observes the whole of a system and not just the parts in isolation without any recognition of the system´s purpose or goal"* (Elliott, 2004, p. 53). According to Elliott, *"the doctrine of general system theory states that a holistic system provides greater benefit than the component parts of a system all working independently. This provides the fundamental concept that underpins systems theory: that the whole*[35] *is greater than the sum of its parts"* (2004, p. 52). These statements confirm the necessity of considering

a) all components of a mobile system;
b) the interdependencies between the single components; and
c) the singularities of a mobile system.

Holistic Principles

Taking into account the described perspectives of systems theory and business/IT alignment we identify the following holistic principles in the evaluation of ICS in general (Figure 3-2) (Högler, 2012):

- Multi-dimensionality as regards to
  - Costs and benefits: Direct and indirect monetary as well as qualitative or strategic effects need to be considered as they highly contribute to the overall value of mobile systems.

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[35] Already Aristoteles stated that "the whole is more than then the sum of its parts".

  - Life cycle: The whole life cycle of the system has to be considered (cf. (Jaster, 1997; Wood & Hertwich, 2013)), including an *"extension of the time horizon of observation and the recording of effects as they occur"* (Högler, 2012, p. 26).
  - Process orientation[36]: All processes influenced or affected by the system need to be considered as they also indicate the singularities of mobile systems. This means that different process levels have to be evaluated: workplace, department / group, enterprise and market / society / environment level[37] (cf. (Forschner, 1998; Benson, Bugnitz, & Walton, 2004; Melville, Kraemer, & Gurbaxani, 2004)).
  - Interdependencies: The effects between all single system components need to be considered. Benson et al. confirm, that *"a complete, full-process, full life-cycle view of the relationship between business units and IT"* is needed (Benson, Bugnitz, & Walton, 2004, p. 86).
- Scalability: The holistic approach needs to be adaptable with regard to the requirements of a specific project like financial resources or time restrictions[38] (Kern, 1974).
- Consideration of success factors: The holistic approach needs to consider critical success factors as they highly impact the success of any IT projects (cf. (Gebauer & Shaw, 2004; Gichoya, 2005)), let alone for addressing the singularities inherited by the mobile context.
- Systematics: Results have to be reproducible, also if the approach was adapted to the specific needs or framework of a project. The comparison of different projects thus needs to be possible (Mutschler, 2005).

We adopt these holistic principles for the analysis of existing evaluation approaches and the development of the aimed integrative approach (see Figure 3-2).

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36 *"The process-orientation detaches itself from traditional territorial thinking and concentrates on relationships between process parts and people involved in the process, as well as between corporate divisions. […] The process orientation focuses on the relationships between processes, between people who participate on these processes as well as between different departments."* (Högler, 2012, p. 26).

37 Often strategic or long-term effects like image improvement.

38 According to Högler, the degree of completeness and accuracy of the integrative approach should depend on the investment level. Yet, it must be considered that omitting or simplifying single steps of the assessment procedure or reducing the so called dimension depth of the assessment can lower the accuracy of results. At the same time, *"with increasing dimension depth the proportion of concretely available data and facts decreases while estimations and assumptions and thus uncertainties in the calculation increase"* (Högler, 2012, p. 27).

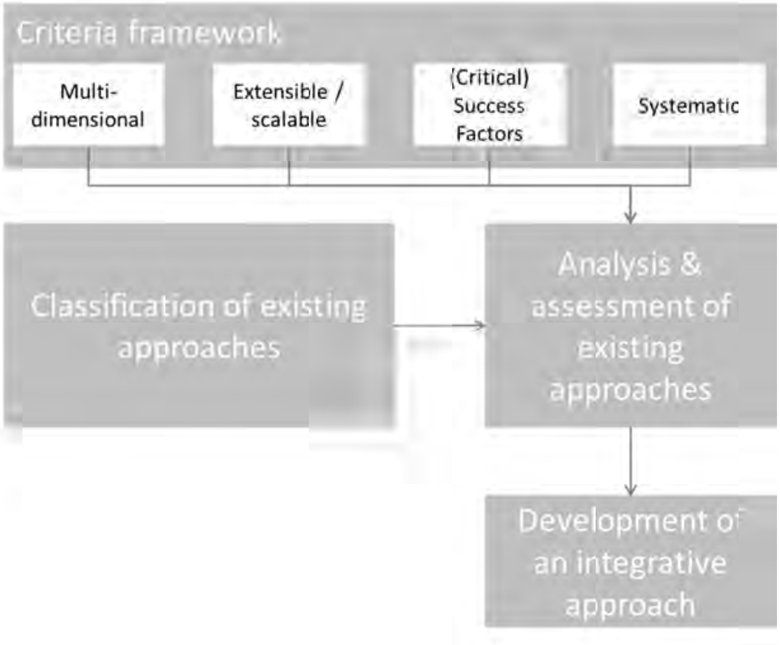

Figure 3-2: Method for finding a first version for the integrative approach, taking into account holistic principles (based on (Högler, 2012))

3.4 Summary of Existing Approaches

3.4.1 Classification and Main Characteristics of Existing Approaches

The following paragraphs explain the classification of approaches for the economic evaluation of investments as it is used in the present work and the main characteristics of each class of approaches.

Existing approaches can be coarsely categorized as follows (cf. (Högler, 2008; Högler, Versendaal, & Batenburg, 2015)): traditional or classic approaches and newer approaches. While traditional approaches have been developed since the early industrial era, newer approaches showed up during the last decades, often developed and established by business consulting companies and with less scientific background[39] (Wild & Herges, 2000, p. 1). Traditional approaches in turn are sub-classified into one- and multi-dimensional approaches (Ney, 2006, p. 17): While one-dimensional approaches focus only on monetary values and on a very narrow frame of reference (e.g. working place instead of whole enterprise), multi-dimensional approaches take in general a broader focus and often also consider non-monetary values of an investment (Pietsch, 1999).

[39] Examples are the Total Value of Ownership (TVO) and Total Cost of Ownership (TCO), developed by Gartner (Gartner Group, 1997), (Gartner Group, 2003).

One-dimensional approaches are further detailed into static and dynamic approaches. The joint characteristics of static approaches (Wöhe, 1990) like cost comparison (cf. (Buchner, 1972; Volz, 1989)), is that they do not consider the temporal occurrence of costs and benefits (Reichwald, 1987), like temporally retarded economic secondary effects (Berghout & Remenyi, 2005). Same is valid for the accumulation and discounting of monetary return flows (Zangemeister, 2000, p. 18). In contrast, dynamic approaches do consider such temporal effects and can be further detailed into dynamic present-value approaches like the Net Present Value (Dillerup & Albrecht, 2005) and accumulated value approaches like the Compound Value Method (Männel, 2004).

Multi-dimensional approaches were developed in the 70´s in order to gain a broader spectrum of evaluation criteria for the newly upcoming technologies and working systems (Zangemeister, 2000, p. 17). Such approaches represent the extension of one-dimensional approaches with regard to the scope of the consideration: the dimension of the costs and the organizational perspective[40]. They are often process-oriented and consider – besides directly and indirectly monetarily measurable effects – non-monetary or qualitative effects of an investment (Zangemeister, 2000) and by doing so try to overcome the main criticism of one-dimensional approaches. With reference to the numerous approaches for evaluating the economic performance / efficiency presented and discussed in economic and scientific literature, the explanations in this context are limited to approaches, which seem suitable in the context of this work. In contrast to the traditional approaches, which could still be discussed relatively completely, this is not possible for the large number of multi-dimensional and newer procedures, which often differ only in nuances.

There is no uniform, non-overlapping and consistent classification of multidimensional approaches in the literature. For this reason existing classifications were examined in the context of this work, compared with each other and brought to a common denominator. The result was a re-structuring and new classification of such approaches, which creates a clear overview of the area of research. Figures 3-3 and 3-4 show the coarse structuring of the multi-dimensional methods, which can be subdivided into *common* as well as *focus-oriented* methods.

Common approaches are generally distinguished according to whether they support the diagnosis or the decision-making during the system selection (alternative evaluation by priority ranking). Diagnosis-oriented approaches are either applied for analyzing already installed

[40] This shifts the perspective away from the object of investment or a single workplace to the organisation which seems to be necessray as IT-related costs are always *"part of something, being a project or a departmental unit. […]. There is little knowledge of the cost behaviour of information systems and few, if any tested methodologies or even theories to manage and control IT cost"* (Berghout & Remenyi, 2005, p. 85).

systems[41] or in order to deliver an intuitive preparation of all relevant information based on an argumentative balance (Ney, 2006, p. 35), cf. (Picot & Reichwald, 1987). One of the most well-known diagnosis-oriented approaches is the Four-Level-Model[42] by (Picot, Reichwald, & Behrbohm, 1985). As such approaches are not appropriate as stand-alone approaches for the economic and business value evaluation of investments, they are not described in detail.

Decision-oriented approaches try to condense all relevant information into one single cost-accounting aggregate value. They are either considering one-layer[43] or multi-layer criteria. Approaches with one-layer criteria are separated into approaches that detect qualitative or quantitative values. Approaches considering qualitative values represent so-called argumentative approaches, like the Value Benefit / Utility Analysis (cf. (Rürup, 1982; Zangemeister, 2000)) and which resemble to a great extent the diagnosis-oriented approaches. Main distinction between them is the fact that decision-oriented approaches with qualitative criteria require the transformation of all information and values into one single aggregate value while diagnosis-oriented approaches keep all relevant results in the way as they were obtained. Consequently, diagnosis-oriented approaches can be seen as aspects of decision-oriented approaches that preprocess information, but where the decision-maker has to condense the information into values that are useful for his decision (Ney, 2006, p. 35).

Approaches with focus on quantitative criteria are the so-called financial approaches, like the Cost-Benefit-Analysis in the Narrow Sense (cf. (Sassone & Schaffer, 1978; Sassone, 1987; Eichhorn, 2000; Zangemeister, 2000)). They differ from traditional investment calculations by taking into account the indirect and indirect effects of an investment and consequently broaden the perspective of the analysis and by their far-reaching monetization where appropriate and possible.

[41] Diagnosis-oriented approaches – tracing back to the work of Staudt (1981) – analyze an investment, but do not allow any decision support or evaluation of different alternatives (Zangemeister, 2000).

[42] Also known as the Multi-Level-Model or Four-ary-Economic-Analysis in its later version and as this classified by some authors as a decision-oriented, but one-layered qualitative approach. Some authors classify this model as focus-oriented approach. Our own analysis of this approach shows, that it also can be applied for decision-making support.

[43] Synonymously used: single-layered criteria.

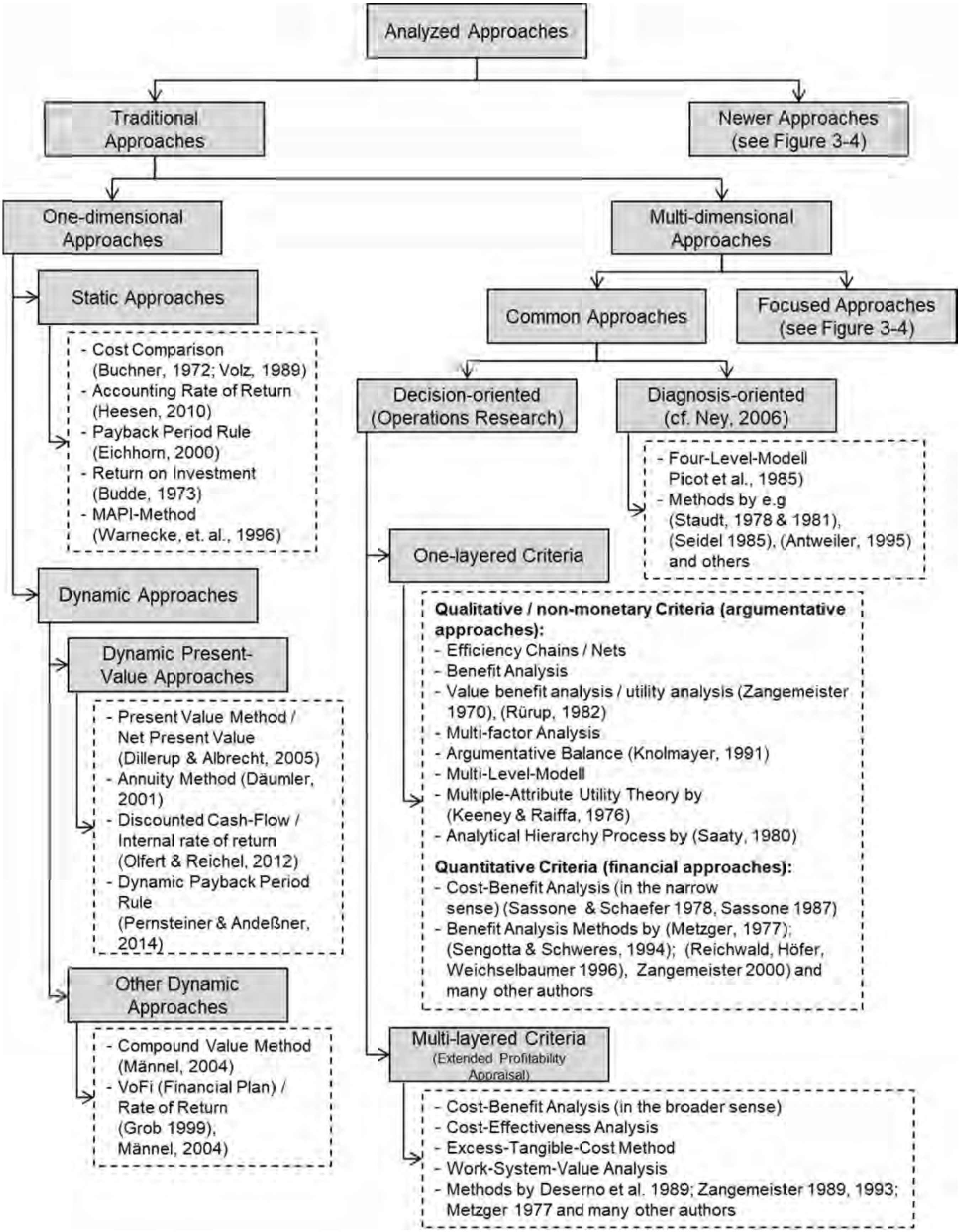

Figure 3-3: Classification of analyzed approaches I

Approaches with multi-layered criteria are also called extended profitability appraisals and capture monetary as well as qualitative effects. Most well-known approaches are: Cost-Benefit Analysis (in the broader sense, (Bottler, Horváth, & Kargl, 1972, p. 15)), Cost-Effectiveness Analysis and the Excess-Tangible-Cost Method.

Focus-oriented procedures focus e.g. on the areas of ICT, office communication, success factors, comparative values, competition / strategy, global target direction and customer business processes. From the large number of focus-oriented methods, those methods have been selected which focus on the economic analysis of IT or related systems; consequently, an in-depth analysis was only done for approaches that focus on ICT (like the Time-Savings-Times-Salary-Model, cf. (Sassone, 1987)) and office communication (like the Hedonic Wage Model by (Sassone & Schwartz, 1986)). Approaches which allow fewer statements about the profitability and business value of an investment than about the strategy of the company[44] were also identified but are not further considered due to their strongly divergent objectives in comparison to this research work. Approaches that were left unconsidered are shown in white in Figure 3-4.

Newer methods like Total Value/ Cost / Benefit of Ownership and Balanced Scorecard came up with the further development of information (and communication) technologies and systems. We classify them coarsely into cost-oriented, benefit-oriented and strategy-oriented approaches and other approaches. As indicated by their names, procedures with focus on costs or benefits cover only parts of a business value evaluation; consequently they cannot be applied as stand-alone procedures in order to evaluate the business value of any investment, though they can be part of integrative approach. We summarize their main characteristics per subcategory.

Cost-Oriented Newer Approaches

Activity-Based Costing[45] (ABC) was developed in 1985 and following years in the US as tool for the controlling of general and administrative costs. Its main characteristic is the orientation on business activities and processes to capture and structure general and administrative costs and to assign them to products and services. A few years later, in 1987, the Total Cost of Ownership TCO model was developed by Bill Kirwin, Research Director of the Gartner Group[46] for Microsoft. It tries to live up to the claims of traditional approaches by taking into

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44 These are: approaches with focus on success factors, comparative values, competition / strategy, global target direction and customer business processes.

45 cf. (Johnson & Kaplan, 1987; Drury, 1992; Kaplan & Cooper, 1998; Gunasekaran, Williams, & McGaughey, 2005; Thyssen & Jorgensen, 2006)

46 cf. Gartner (1997), (2003)

account besides direct also indirect costs (Wild & Herges, 2000). Meanwhile, more than 20[47] TCO models – developed by different authors, associations and consulting companies like Forrester – do exist and consider different types and levels of details of costs, resulting in incomparableness of results (Geissdörfer, Gleich, & Wald, 2009). Life Cycle Costing / Life Cycle Cost (LCC) resembles at first sight the TCO approach as it tries to capture costs of the entire life span of a product, starting with any initial costs (e.g. for the planning and design) to operating and maintenance costs to costs that occur when the product is disposed[48].

Planned or Standard Cost Calculation focuses – as its name already indicates – on future operating costs that are expected to occur in the context of an existing or a planned system (Gudehus & Kotzab, 2010, p. 132). A similar approach, also with focus on future costs, is Target Costing. Target costs are derived from a market analysis and include *"the currently foreseeable product costs and the established target costs [which] are continuously compared to actual and anticipated performance"* (Mörtl & Schmied, 2015, S. 380)[49].

Benefit-Oriented Newer Approaches

With the increasing awareness that the evaluation of benefits is the most difficult and challenging activity in evaluating the business value of ICS[50], newer approaches for analyzing benefits were developed.

The Total Benefit of Ownership (TBO) (Grossman & Hart, 1998) model represents a concept derived from the TCO model, which evaluates the overall benefit of an IT investment. The model provides a system for evaluating different benefit categories and considers all savings, optimization and benefit potentials in the context of a holistic approach (Gadatsch & Mayer, 2004). This includes recording the advantages achieved by cost savings as well as non-monetary or qualitative and strategic benefits that are not included in the traditional economic evaluation approaches. There is no – except very general literature – publically accessible, which defines the procedure of the TBO model explicitly. Similar to the TCO model, there is no generally accepted TBO model or procedure that would enable comparative results.

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47 Geissdörfer et al. (2009) compare these 20 TCO models, so that a detailed discussion on their differences and main characteristics can be omitted in the present work.

48 cf. (Asiedu & Gu, 1998; Dhillon, 2010)

49 cf. (Seidenschwarz, 1991; Nißl, 2005)

50 Complexity is given as ICS and consequently mobile systems have many benefits that are not directly measurable (e.g. as cost savings), but rather have a qualitative or strategic impact. In addition, they can occur with delay, which makes their allocation to a specific investment even more difficult.

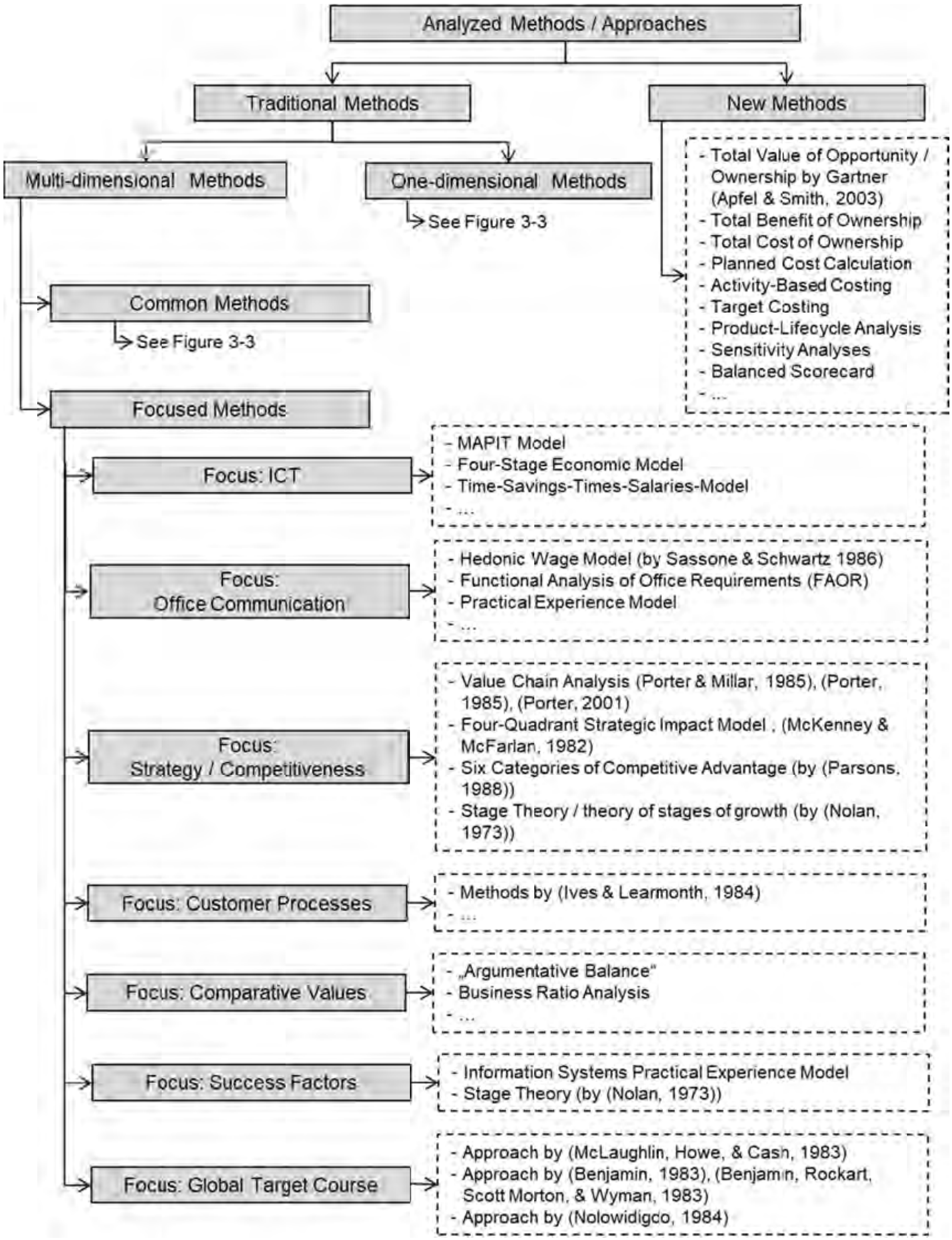

Figure 3-4: Classification of analyzed approaches II

Holistic / Complex Approaches

Meanwhile there are several approaches that take a more holistic view and do not only cover aspects of an investment evaluation. Rather they combine several methods to obtain a multilayer rating of the planned investment. They consider besides costs and benefits in some cases also risks or strategic alignment.

One approach identified that takes a more holistic or integrative perspective is the Total Value of Opportunity / Ownership (TVO) (cf. (Apfel A. , 2003; Apfel & Smith, 2003)). It includes several activities that can be applied as parts of the integrative framework, which are:

- organizational analysis including business process impacts (for the Business Process (Re-) Engineering)
- Total Cost of Ownership (for evaluating life-cycle costs)
- utility analysis (for evaluating benefits)
- risk assessment (for analyzing risks and volatility effects)
- sensitivity analysis (also for analyzing risks and volatility effects)
- examination of the *‘conversion effectiveness’* (analyzing potential target achievement rates)

Cranfield´s Benefits Management (CBM) assumes that benefits are not realized by the implementation of IT, but by the accompanying changes of organizational structures and processes. It applies cause-and-effect-chains to allow a better understanding of complex interrelationships. Consequently, it connects different management disciplines into a holistic approach.

The Total Economic Impact (TEI) approach was developed by the consulting company Giga Group in 1997. It was further elaborated by Forrester, also a consulting and research group, and focuses on the costs, benefits, risks and flexibility (Ramos, 2002) related to an investment. It is based on a traditional cost analysis (or TCO) which is extended by a benefit analysis. Besides quantitative effects also future potential benefits and associated risks are evaluated, accompanied by a sensitivity analysis (Mayor, 2002). The TEI is calculated by applying a scenario analysis, resulting in best, expected and worst cases of an investment (Ney, 2006, p. 67). Similar to the TVO, the TEI includes an organizational analysis that puts the investment into relation to the business strategy.

The Balanced Scorecard by Kaplan and Norton (1992) is a *“comprehensive framework that translates a company´s strategic objectives into a coherent set of performance measures”* (Kaplan & Norton, 1993, p. 134). Similarly to the integrative framework, it measures performance against business objectives (Ward & Peppard, 2002, p. 206). Its main objective is to provide a strategic management tool that transforms the mission and strategy of a company into precise KPIs in order to create a basis for the management for the generation of growth by customer-oriented products and services.

3.4.2 Analysis of the Existing Approaches

Analyzing[51] existing approaches shows that particularly one-dimensional profitability analyses (so called 'economic efficiency calculations') are not satisfactory as exclusive procedures for evaluating of impacts caused by ICS in general and mobile systems specifically (Horváth, 1988). One-dimensional profitability analyses do not regard ICS as an *"entity that unfolds its effects through the interaction of its individual components"* (Högler, 2012, p. 25). Instead, they evaluate only the single system components without considering their interdependencies and associated effects. This results in a disregard of many effects that contribute to the overall business value of such a system. Another reason for their insufficiency is that they use only one criterion – monetary effects – for the evaluation of the investment (cf. (Hemingway, 1999, p. 89)). This approach does not allow a thorough capture of the business value because many positive impacts remain unconsidered as they often cannot be monetized (Zahn, Schmid, & Dillerup, 1999), particularly strategic benefits like competition position, innovation and thus corporate strategy (Zahn, Schmid, & Dillerup, 1999).

Multi-dimensional profitability analyses (so called 'economic analyses') seem at first sight to be an appropriate approach for evaluating mobiles systems as they consider different types of effects – besides monetary also qualitative effects. Having a closer look it becomes clear that they were developed to consider mostly isolatable investment objects that have no extensive effects (Picot, Reichwald, & Wigand, 2003). Thus they do not consider ICS in general and mobile systems specifically as entities, but focus mainly on effects that can be directly and indirectly monetized. For example, cost-benefit analyses request monetary values for all criteria in order to ensure that the analysis is exhaustive. The disadvantage of the monetization is, that even if quantities exist that allow an approximately derivation of monetary values, *"the estimation will be a matter of judgement, the validity of which will always be open to question"* (Hemingway, 1999, p. 89; Nagel, 1990), potentially resulting in considerable errors of estimation that may fudge the overall results.

Multi-dimensional approaches neglect many positive effects of ICS and mobile systems. Qualitative effects, that cannot be monetized, or effects that cause structural changes and consequently have often temporally and spatially shifted effects, are discounted (Picot, Reichwald, & Wigand, 2003).

In most cases, it is not possible to detect *all* benefits of an ICS or mobile system (Draheim, 2010, p. 39), because its implementation depends on many unknown changes in specifications and thus requirements as well as conditions (Retter, 1996, p. 100). As a result, the identification of benefits might better be addressed in a situational, case- and company-

[51] As the results of this evaluation are shown in (Högler, Versendaal, & Batenburg, 2015) in detail, we will at this point summarize the main findings.

specific, way, which is not the case for the traditional approaches. From an integrative view this means, that for a systematic approach to identify the potential benefits of investments in ICS and mobile systems it is necessary to derive them from the company´s target system[52], which is mainly not done yet. To evaluate individual system alternatives it needs to be examined in each case, to which extent the defined business objectives are supported by the respective alternative (Adam, 1996, p. 100). None of the analyzed approaches follows this path, and none fulfills all holistic criteria.

Newer – so called combined – methods like Total Value of Ownership (Dempsey, Dvorak, Holen, Mark, & Meehan III, 1998)), Total Benefit of Ownership (Grossman & Hart, 1998), Total Impact of Ownership (Draheim, 2010), Total Cost of Ownership (cf. (Wild & Herges, 2000; Schwan, 2014; Krypzcyk & Bochkor, 2015)). Target Based Costing (Faraji & Reiszadeh, 2013), Activity Based Costing (ibidem) and Balanced Scorecard (Kaplan & Norton, 1992) combine two or more methods to receive more realistic results. Yet, they do not, per se, regard a system as an entity, which consists of single components that are influencing each other and which thus influence the overall result. Kaplan & Norton recognized already in 1995 that the identification of key success factors is an important issue (Kaplan & Norton, 1995, p. 71). Consequently, they suggested including them into their Balanced Scorecard (Kaplan & Norton, 1992). Also Ward and Peppard explicitly suggest to consolidate the Balanced Scorecard and Critical Success Factors (CFS) Analysis to *"provide a more comprehensive set of IS requirements"* as the *"Balanced Scorecard links measures to business objectives, while CSF analysis identifies what is critical to achieving results. Together, both techniques provide a rigorous assessment of prioritized IS opportunities, given the current business strategy"* (2002, p. 213). However, they do not explicitly link particular singularities of a mobile context with CSF.

Socio-technical approaches like the Task-Technology-Fit (Goodhue & Thompson, 1995) focus on interrelationships that are neglected by the discussed approaches, but do not regard costs and benefits and other effects of (mobile) systems. Consequently, also these methodologies do not, up front, offer an integrative approach.

The above discussion suggests that none of the analyzed approaches examines ICS in accordance to all proposed holistic principles. Particularly ICS are not considered as systems that consist of components that are inherently related and that influence each other. In addition, only a few procedures focus on business processes – a precondition for the evaluation of interdependencies between components and related effects. Effects that are spread

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[52] A target system is a collection oft he company´s objectives that need to be achieved (e.g. in a specific project). It can be either unstructured and contain all gathered objectives or structured. In the latter case the identified objectives are brought in a hierarchical relationship.

on business processes[53] are not taken into account, resulting in falsified outcomes of the analysis. Only a few of the examined approaches consider success factors or volatility effects of the investment.

3.5 Conclusions

In summary it can be stated that the evaluation of an ICS and mobile systems cannot be accomplished in line with the economic analysis of industrial goods and technologies that do not interfere much with their users. ICS in general and mobile systems specifically are much more complex than such technologies due to their singularities and as interactions between single system components are constantly influencing each other, instantiating interrelationships that do not occur in systems that are not that intensely interacting with users. Such interrelationships may seem of less importance for industrial goods like conveyors, yet they need to be considered in more complex contexts. Moreover, strategic, often non-monetary or qualitative effects are neglected by several of the existing evaluation approaches. These effects often mesh and are in many cases company- or industry-specific; the overall business value of mobile technologies need to be considered more explicitly (Vuolle, 2011) and require new ways of evaluating economic impacts of mobile technologies. It has to be emphasized that the focus of this research work is on the internal orientation of mobile business and consequently does not analyze the appropriateness of the elaborated framework for other cases like for machine-to-machine or embedded technologies. Yet, we are convinced that the framework can be applied also to such technologies as it allows that their specifics can be taken into consideration and respected in the overall evaluation of their business value.

Based on the considerations of this paper, a research agenda can be defined that is also pointing at the issues above and guiding the further research activities, which forms the basis for the development of the integrative framework for the evaluation of mobile systems.

[53] so called integrational aspects

4 Research Agenda

Abstract[54]

The present work shows the necessity of an economic evaluation model that is based on singularities of mobile systems and that takes into account the interdependencies of their individual components. A motivation for this approach is not only given by the continuing discussion on the economic efficiency of mobile systems, but also by the fact that appropriate methodologies for comprehensive evaluation still do not exist. Starting point for a research agenda is the definition of the term mobile system, followed by the explanation of the single components and singularities of such systems. The findings of the present work motivate the development of a generic model for economic evaluation. By defining the research agenda we provide guidance for constructing such a model.

4.1 Introduction

For nearly three decades, the debate about the cost-effectiveness of information and communication systems (ICS) is consistently resurrected. In the late 80´s Solow stated, that the effects of computers can be seen everywhere – except in the productivity statistics (Solow, 1987). Also Loveman had no doubt that *"IT capital had little, if any, marginal impact on output or labor productivity, whereas all the other inputs into production – including non-IT capital – had significant positive impact on output and labor productivity"* (Loveman, 1994). The current state of scientific knowledge though presents opposite results: The productivity paradox does not exist in praxis – it is caused by the lack of appropriate methodologies for the economic analysis of ICS (Brynjolfsson, Hitt, & Yang, 1998).

Information and communication technologies (ICT) are often implemented in order to conduct businesses as efficient as possible; the quantitatively definable monetary effects are considered the most important objectives when implementing such a system. For the economic evaluation mostly methodologies are applied that focus exactly on these effects. This approach may easily fudge the results due to the fact that the full benefits of the technologies are insufficiently reflected – and thus leads to the assumption that a productivity paradox exists.

Literature study shows that there is still a lack of appropriate evaluation methodologies (cf. (Ashurst, Doherty, & Peppard, 2008; Högler, 2012)). Especially integrative and qualitative effects of the systems are mostly not considered in the calculation (Pietsch, 1999) – one of the

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main benefits of ICS. This is even more important for mobile systems that represent a special 'mobile' form of ICS. It can be assumed that mobile systems face the same difficulties concerning the economic evaluation as stationary ICS. Additionally they are affected by challenges that result from the fact that mobile technologies are mostly used during 'mobile actions' like travelling or walking. Literature on the effectiveness of mobile systems is scarce; therefore, in this position paper, we explore the domain of mobile systems from an evaluation angle.

The term 'mobile system' is defined in section 4.2, and section 4.3 describes the single components of such systems. The unique singularities of mobile systems are elaborated in section 4.4. Section 4.5 will outline economic evaluation of mobile systems based on their singularities and main characteristics; for this we define a number of research questions. We finish our paper with conclusions.

4.2 How to Define Mobile Systems

Although often used synonymously in the literature, this work strictly distinguishes between ICT and ICS. Starting point for the elaboration of a definition is systems theory, an approach that focuses on entities and that postulates that the system itself comes into existence by the relationships among the system elements and the resulting interactions. This approach was chosen due to the fact that for an economic evaluation based on singularities of mobile systems the relationship of entities or components respectively is of key importance. The analysis of structures, reactions and functions of the entities allows certain predictions about the expected system behavior, whereas it does not focus on a separate consideration of each element (cf. (Boulding, 1956; Bertalanffy, 1976)).

Having the above given considerations in mind, it becomes clear that in contrast to ICT, the term ICS has to include also system-elements of human nature (human beings) besides technologies that support information exchange and communication (so called 'technical components') and thus takes into account the relationships between the single components, properties as well as their behavior (so called system parameters).

System parameters are variables, whose values characterize the behavior of the system with a given structure (DIN, 1995). Since the behavior of a system and therefore its cost-effectiveness are influenced by their interaction or controlling of system parameters, they play an important role for the evaluation of mobile systems. System parameters with the largest influence on a system are characterized in the present work as 'success factors'. The term success factor is used in the literature to characterize the cause of success. Corsten defines success factors as *"[...] factors that have a significant impact on the potential success of a strategic business area. While on the one hand it is emphasized that the individual factors [....] depend on the industrial sector in which the company operates, on the other hand a hypothesis is supported that there are so-called basic factors [....], that matter for the success* *or failure over all industries, i.e. it is assumed that the structure of the factors´ system is relatively constant, while the weighting of the individual factors is subjected to frequent changes"* (2000, p. 103f.). In dependence on Rockart (1979) and relating mobile systems, the current work defines critical success factors as technical as well as human system parameters that have a significant impact on the economics of the mobile system.

Relationships between the single components are represented by the processes that take place between them whereas the structure and organization of the ICS symbolize the characteristics of the elements. When reflecting on the given definition of the term ICS it becomes clear, that the human component is of key importance when discussing the profitability of ICS. Users are involved in all processes; they are using the technical components and determine the success factors for the (economic) efficiency of the whole system.

Within this research work, mobile systems are chosen as subject of investigation. Mobile systems can be regarded as ICS that are extended by mobile aspects. They exist in different forms and have a multiplicity of characteristics, aiming at integrating people, mobile processes and workstations into internal, mostly stationary corporate and enterprise-wide process chains and thus to overcome their spatial separation and accompanying information losses.

Basing on the general systems theory and following the above-given socio-technical definition of the term ICS, the present work defines a mobile system as a set of mobile technology and human (system) elements, which are inherently related (see also the discussion of (Goos & Zimmermann, 2005) concerning the term system). They form an entity due to their interactions that is task-related and that executes corresponding business processes. Mobile systems, as a unit, distinguish themselves in this respect from the surrounding environment by the relations between their components and the effects that take place between the single components. In the following sections the components as well as the singularities of a mobile system are discussed.

4.3 Components of Mobile Systems

A mobile system consists of two types of components: technical and non-technical components. The distinction of the components is important because the economy of mobile business processes is not only affected by technical, but particularly by the human system components (users).

Technical components comprise mobile hardware (e.g. Smartphones and Tablets), appropriate applications as well as mobile operating systems and middleware (if necessary). They include also wireless communication technologies like LTE, UMTS and WLAN (see Figure 4-1). The particular potential of mobile technologies lies primarily in the possibility of reorganizing processes and thus in the exhaustion of the value added that is facilitated by mobile technologies. Especially mobile ICT contributes to the efficient support of processes by bridging spatial and temporal distances (Schiller, 2000). Figure 4-1 shows technical as well as non-technical components of mobile systems. Security issues play an important role for mobile processes and thus can influence significantly the economic efficiency of such systems. The importance of security in the field of wireless and Internet-based systems is a key research topic of the project Be Wiser – Building Enterprises: Wireless and Internet Security in European Regions, funded by the European Commission under the 7th Framework Program (project reference FP7-REGIONS-2012-2013-1). It is expected that main findings of this project will be included in the author's further research.

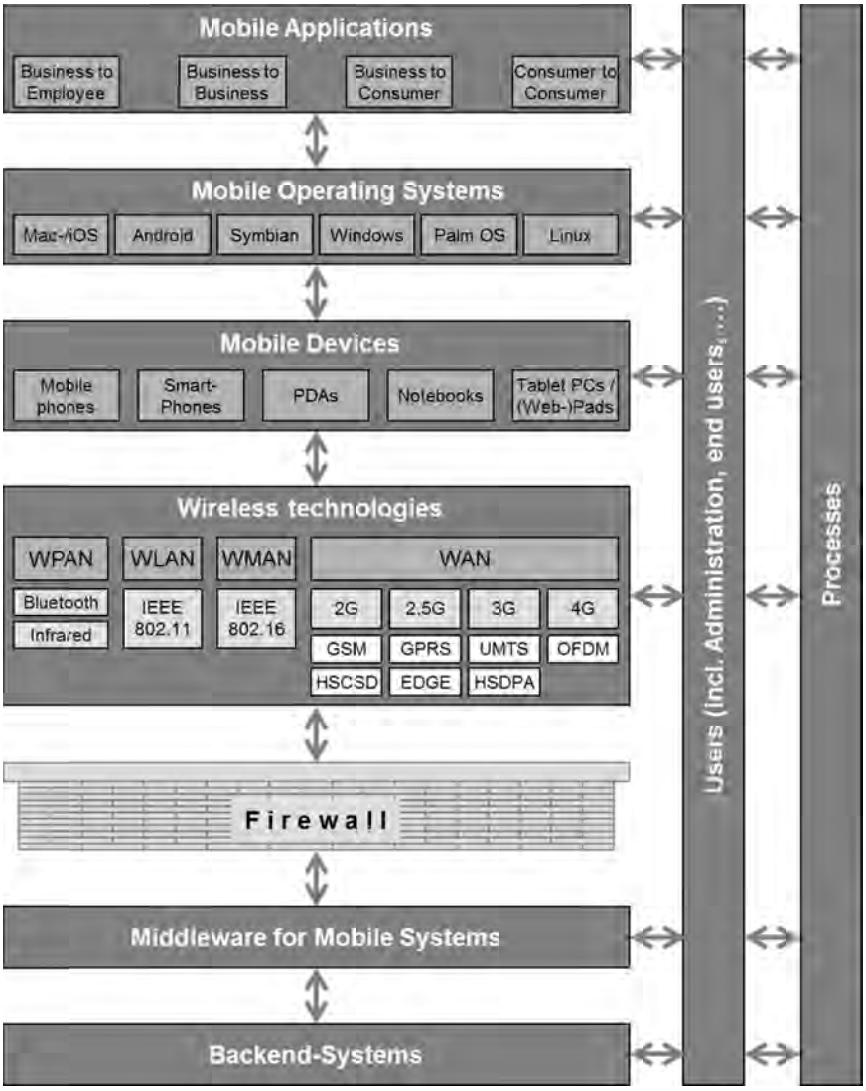

Figure 4-1: Components of a mobile system

Non-technical 'components' are users who use the technical components in order to perform their tasks. These can be for example employees who accomplish their jobs in a mobile way (means: not at a stationary workplace) either within or outside the enterprise (e.g. sales people, customer service and maintenance engineers). Human-Computer-Interactions (HCI) is a well investigated research field, thus this work refers to books and proceedings like 'Human-Computer Interaction – INTERACT' (Gross, et al., 2009), 'Digital Technology Research' (Price, Jewitt, & Brown, 2013) and articles within the IEEE-journal 'Pervasive Computing'. They explain the human-computer-interactions in detail. The effects of HCI on economic efficiency are still an open research topic and will be elaborated by the author to a later point.

Mobile processes differ from stationary processes primarily by its spatial distribution and the mobility of the persons who are involved in the process. Mobile processes can be characterized as follows: At their beginning it is often not exactly known where and when they will take place – many uncertainties can influence these processes and thus make them at least partly unpredictable. Example: Even if a sales man has an appointment with a customer at a defined location and at a defined time, there is still an uncertainty that he will not be able to attend this meeting: A strike, storm, breakdown or even an accident can foil his plans. Thus, following these explanations, distributed processes with a determined distribution structure are not mobile processes (Köhler & Gruhn, 2004a).

The evaluation of a mobile system has to take into account all interdependencies between the single components. In order to do so, e.g. following questions have to be answered: "How do technical components like mobile devices, applications and data transfer affect each other? And how can the most important component of the mobile system – the human being – be affected by the technical components or by the surroundings when proceeding tasks? How can the singularities of different working profiles (e.g. maintenance engineer, businessman) and their experience with mobile technologies be considered within the holistic profitability analysis?" In order to be able to answer these questions, it is necessary to understand the singularities of mobile systems that will be discussed in the following section.

4.4 Singularities of Mobile Systems

In an investigation we identified the following singularities, which are supported by argumentation as we present them. Note that not only literature study but also practical experience and observation have contributed to the identification of the singularities.

Mobile systems have many different forms and a multiplicity of characteristics and singularities in comparison with stationary ICS. These findings motivate the development of a profitability analysis that takes into account the singularities of mobile systems and that takes the human component as central hub and pivotal point when evaluating such a system.

The aim of mobile systems is to integrate mobile processes and workstations with internal, mostly stationary corporate and enterprise-wide process chains and thus to overcome their spatial separation and accompanying information losses. By the ubiquitous access to relevant information, mobile technologies promise an increased efficiency of business processes and enable new ways of working.

At the same time, mobile systems face many challenges and hurdles stationary ICS are not confronted with, like security issues or the absence of data networks. The following paragraphs will enlighten the most apparent singularities of mobile systems.

Mobile systems can be easily distinguished by stationary ICS due to their singularities. Starting with the technical components of a mobile system, it becomes clear that in contrast to desktop computers mobile devices are continuously transported. This in turn requires a minimum weight and a small size of the devices with maximum robustness.

According to Lonthoff and Ortner (2007), Schach, Scherer and Menzel (2007) and Högler and Versendaal (2014) mobile devices face many restrictions despite intensive research and technological progress of the past years. In contrast to ICT, mobile devices have – due to the low battery capacity – only a limited power supply and are seldom plugged in local area networks. This fact requires increased energy efficiency of mobile devices and corresponding applications and stable wireless Internet connection. With decreasing size of the devices, also the computing capacity becomes lower. In conjunction with inefficient main storage mobile devices have lower information processing capacities compared to the capacities of stationary ICT. This fact must be taken into account when developing mobile applications, which have to cope with the mentioned restrictions of mobile devices (see also (Kornmeier, 2009)). Also the input options of mobile devices offer only restricted possibilities: Most keyboards are missing or incomplete and in many cases unhandy, virtual keyboards still do not offer the same usability as standard ones. Additionally, in many cases the worker has not both hands free, which imposes additional usability requirements on the keyboards and the input methods respectively. Especially as regards to the writing speed, this kind of keyboards will not achieve the comfort and usability of traditional ones.

The output options hinder the usage of mobile devices due to the relatively small displays, which have limited facilities for the presentation of contents. Thus, special applications which take into account peculiarities of mobile devices are specifically designed and developed.

The distraction caused by the surroundings depicts also a singularity of mobile systems. In contrast to stationary working places, a mobile worker is distracted by his surroundings, e.g. by noise, incidents and weather. For example, mobile devices are hardly usable in rain or dusty areas, also ambient light is a real challenge: Images and texts are less visible than in closed rooms and thus exhaust the eyes of the users, although automatic recognition of ambient light and adjustment of the backlight is available for most devices.

Reliable data transmission is an unsolved field, too. Transmission problems can be caused by fluctuating bandwidth or insufficient network coverage and thus can hinder continuous work with mobile devices (cf. (Gerpott & Kornmeier, 2004; Princen & Schreurs, 2010)). Slow or interrupted connections represent disruptive factors and may not only reduce the quality of service, but also affect the efficiency of work: The accessibility of required data everywhere and anytime is of key importance in order to reach the maximum possible efficiency of mobile systems (Högler & Versendaal, 2014).

The relatively broad variety and fast enhancements of operating systems are still regarded as a challenge for the employment of mobile devices. Many mobile applications run only under one operating system and thus can cause synchronization problems. Additionally, the integration of applications into existing systems and their interoperability is not resolved satisfactorily in many cases. With the widespread adoption of cloud-based solutions these problems should become less important within the next few years.

Compared to stationary computers, data security in mobile applications and devices is low – although a broad variety of security mechanisms already exists. The main reason for this security problem is not technology, but the user of mobile devices who bypass security mechanisms for convenience or ignorance. As mobile devices are lost or stolen much more frequently than their stationary counterparts (cf. (Day, Daly, Sheedy, & Christiansen, 2000; Gluschke, 2001; Frolick & Chen, 2004)) and as many users log into unsecure wireless networks without taking into account all the risks they are facing, the security issue is not yet solved in the area of mobile technologies satisfactorily.

The last paragraphs have shown the most evident singularities of mobile systems. When evaluating such a system, it is necessary to take into account all these restrictions and particularities – they may not only affect the work but also the economic efficiency of mobile systems. For example, major security problems can decrease the monetarily quantifiable advantages of mobile systems. In order to benefit from the full potentials mobile systems bear, it is important to take into account not only the depicted singularities, but also to approve the human component as the most influencing (success) factor on the economic efficiency. This finding motivates the development of a research agenda that covers evaluation of mobile systems and that is based on the singularities of mobile systems.

4.5 A Research Agenda for Economic Evaluation of Mobile Systems

In order to plan research steps for mobile systems evaluation, based on the above considerations, we are now able to identify a number of research paths. We believe that once answers to related research questions are provided mobile systems productivity can be monitored and improved. Results pave a path in 1) creating more insight into the productivity of mobile ICT, 2) identifying possible areas of improvement for existing mobile systems, 3) managing running mobile system implementation projects, and 4) evaluating mobile system implementations. We identify the following research areas:

- generic identification and further validation of components of mobile systems and their relations as suggested in our Figure 4-1

- further confirmation, detailing and identification of singularities as touched upon in our section 4.4
- determination of success factors from singularities, system components behavior and interdependencies between components
- construction of a model or models for mobile systems evaluation taking into account success factors, components and interdependencies of components, leveraging system theory
- validation, case studies and more related to constructed mobile systems evaluation models

These areas can be step-wisely addressed in further maturing the knowledge base of research on mobile system evaluation.

4.6 Summary and Recommendations

The present work has shown the motivation for and necessity of economic evaluation models that address singularities of mobile systems. The current state of scientific knowledge has shown that the productivity paradox does not really exist in praxis. In fact, it is caused by the lack of appropriate methodologies for the economic analysis of ICS. Appropriate evaluation methodologies for ICS are still missing. None of existing methodologies takes into account all components, their interdependencies and singularities of these kinds of systems (section 4.1). This is even more important for mobile systems that represent a special 'mobile' form of ICS.

The present work takes the systems theory as starting point for the development of a definition for mobile systems (section 4.2). The reason for this approach lies in the fact, that systems theory focuses on entities and that postulates that the system itself comes into existence by the relationships among the system elements and the resulting interactions – the basis for the development of an economic evaluation model that is based on singularities of mobile systems. Section 4.3 has presented the single components of a mobile system and thus rounded off section 4.2.

Mobile systems, as seen in section 4.4, are affected by challenges stationary systems do not face. Their singularities result from the fact that mobile technologies are mostly used when the employee is working apart from a stationary workplace. It is these singularities that – in addition to the human component of a mobile system – decide about the success and thus about the economic efficiency of a mobile system. When evaluating such a system, it is of key importance to take into account all singularities and to analyze the interdependencies of the single system components; our section 4.5 provides a stepwise research agenda for this.

PART 2: FIRST STEPS TOWARDS THE MODEL

5 Integrating Success Factors into the Evaluation of Mobile Systems

Abstract[55]

Die rasante Entwicklung mobiler Technologien hat die Diskussion des Nutzens und der Wirtschaftlichkeit von Informations- und Kommunikationssystemen (IKS) neu entfacht. Eine Untersuchung bestehender Ansätze der Wirtschaftlichkeitsanalyse macht deutlich, dass bisher kein Ansatz existiert, der zum einen die Erfolgsfaktoren mobiler Systeme in die Wirtschaftlichkeitsanalyse einfließen lässt und zum anderen insbesondere kleine und mittelständische Unternehmen (KMU) durch die automatische Identifikation projektspezifischer, relevanter Erfolgsfaktoren mobiler Systeme bei der Wirtschaftlichkeitsanalyse unterstützt sowie Risiken ihrer Nicht-Beachtung aufzeigt.

5.1 Einleitung

Obwohl einer Studie der NOP Research zufolge bereits heute rund 40% der Mitarbeiter einen Tag pro Woche außerhalb des Unternehmens verbringen (Schönig, 2005), bringt eine aktuelle Umfrage von Techconsult zu Tage, dass rund 72% mittelständischer Unternehmen weder eine mobile IT-Lösung im Einsatz, noch in Planung haben (Witzki, 2005). Einer der Gründe für diese Zurückhaltung ist – neben knappen Budgets – die Angst vor unwirtschaftlichen Investitionen. Nach wie vor wird die Entscheidung für oder gegen eine IT-Investition *„auf der Basis weniger Informationen, intuitiv und durch das Anwenden von ‚Daumenregeln' getroffen"* (Pietsch, 1999, p. 12) und der eigentliche Wirtschaftlichkeitsnachweis der Investition oftmals vernachlässigt.

Diese Arbeit führt den Begriff mobiles System ein, welcher – im Gegensatz zum Begriff Mobile Business – weniger die Prozesse, als vielmehr den Anwender mobiler Technologien in den Mittelpunkt stellt und das mobile System als ein sozio-technisches System auffasst. Konkret wird unter einem mobilen System die Gesamtheit der mobilen Hard- und Software einschließlich der erforderlichen drahtlosen Übertragungstechnologien verstanden, welche Anwender eines Unternehmens bei der Ausführung von mobilen Geschäftsprozessen unterstützen.

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[55] This work was originally published as: Högler, T. (2006). Framework für eine holistische Wirtschaftlichkeitsanalyse mobiler Systeme. In T. Kirste, B. König-Ries, K. Pousttchi, & K. Turowski (Ed.), *Mobile Informationssysteme - Potentiale, Hindernisse, Einsatz. Proceedings der 1. Fachtagung Mobilität und Mobile Informationssysteme (MMS) im Rahmen der Multikonferenz Wirtschaftsinformatik (MKWI 2006). Passau / Germany, 20.-22.02.2006.* Bonn: Bonner Köllen Verlag.

Eine holistische Wirtschaftlichkeitsanalyse, welche nicht nur die Kosten und Nutzen eines mobilen Systems berücksichtigt, sondern auch die jeweiligen Erfolgsfaktoren automatisch identifiziert und somit zur Verringerung potenzieller subjektiver Fehleinschätzungen des Entscheidungsträgers beiträgt, könnte die Investitionszurückhaltung der KMU verringern. Die vorliegende Arbeit stellt ein entsprechendes Framework zur modular aufgebauten, holistischen Wirtschaftlichkeitsanalyse in ihren Einzelschritten vor.

5.2 Grundlagen und verwandte Arbeiten

Mobile Systeme können als eine Ausprägung von IKS betrachtet werden. Sie unterliegen denselben Schwierigkeiten, die mit der Durchführung einer Wirtschaftlichkeitsanalyse einhergehen und unter anderem von Dworatschek und Donike (1972) und Burger (1997) ausführlich behandelt werden.

Verfahren, die nicht nur die monetären Aspekte von IKS, sondern auch ihren Nutzen in die Wirtschaftlichkeitsbetrachtung einbeziehen, existieren zwar seit einiger Zeit (vgl. hierzu einen Überblick bei Kredel (1988), Nagel (1990), Holzapfel (1992), Schumann (1992) und Retter (1996); sie sind aufgrund ihrer Komplexität und der zur Berechnung benötigten umfangreichen Datenmaterials in der Praxis nicht sehr verbreitet. Die vorliegende Arbeit präsentiert das Framework für eine holistische Wirtschaftlichkeitsanalyse, welche aufgrund ihrer Modularität in ihrer Komplexität an die Bedürfnisse des Unternehmens angepasst werden kann. Zudem werden neben technisch orientierten Erfolgsfaktoren (Systemkomponenten) auch anwenderbezogene Erfolgsfaktoren auf ihren Einfluss auf die Wirtschaftlichkeit mobiler Systeme untersucht.

5.3 Framework für eine holistische Wirtschaftlichkeitsanalyse mobiler Systeme

Die im Folgenden vorgestellte holistische Wirtschaftlichkeitsanalyse mobiler Systeme zeichnet sich durch folgende charakteristische Schritte aus:

- Identifikation relevanter Erfolgsfaktoren in Abhängigkeit vom jeweiligen Projekt
- Gewichtung der Erfolgsfaktoren anhand ihrer Korrelationen untereinander
- Analyse des Risikos der Wirtschaftlichkeitsminderung durch Nicht-Berücksichtigung von Erfolgsfaktoren
- Integration bestehender Ansätze zu einem modular aufgebautem Gesamtkonzept

Die holistische Wirtschaftlichkeitsanalyse teilt in zwei Phasen auf: eine Analyse- und eine daran anschließende Bewertungsphase. Innerhalb der Analysephase wird zunächst das Zielsystem ermittelt, welches alle Ziele beinhaltet, die durch das mobile System erreicht werden sollen. Hierbei ist es wichtig, die Ziele soweit wie möglich derart zu definieren, dass eine Messung des Zielerfüllungsgrades nach Projektende möglich wird. Da unter realen Bedingungen bzw. aufgrund begrenzter Budgets in der Regel nicht alle Ziele erreichbar sind, muss im folgenden Schritt eine Priorisierung und Gewichtung der (Teil-)Ziele erfolgen. Da sich gewisse Ziele – positiv wie auch negativ – beeinflussen und ggf. sogar gegenseitig ausschließen können, ist eine Untersuchung ihrer Abhängigkeiten notwendig, welche unter Umständen die Streichung bestimmter Ziele aus dem Zielkatalog erfordert oder eine neue Priorisierung und Gewichtung der Ziele zur Folge hat. Dies ist insbesondere dann der Fall, wenn es sich um zwei ähnlich wichtige, aber konkurrierende Ziele handelt.

Da es in den wenigsten Fällen sinnvoll ist, alle potenziellen Maßnahmen umzusetzen, ist in folgenden Schritt die Ermittlung derjenigen Maßnahmen notwendig, die zur Zielerreichung maßgebend beitragen. Hier greift das Pareto-Prinzip, welches besagt, dass mit rund 20% der Maßnahmen 80% der Ziele erreicht werden können (Brugger, 2005).

Hierfür werden zunächst die IST-Prozesse analysiert und dabei auf ihr Mobilitäts- bzw. Optimierungspotenzial untersucht und anschließend modelliert. Innerhalb der Prozessanalyse können aktuelle Kennzahlen ermittelt werden, die in eine Prozesskostenrechnung und bei umfangreichen Analysen oder großen Investitionen, bei welchen sich der Aufwand lohnt, in eine anschließende Prozesssimulation einfließen können. Im Anschluss daran erfolgt die Modellierung der – durch das mobile System zu unterstützenden – SOLL-Prozesse, die eine Analyse der Wirkungszusammenhänge der einzelnen Maßnahmen sowie die Identifikation der Wirkungsketten erlaubt.

Für die beschriebenen Einzelschritte kann das Modul Mobile Process Landscaping (MPL) nach Köhler und Gruhn (2004a) zum Einsatz kommen, da anhand dieser Methode bzw. der ihr zugrunde liegenden Prozessmodellierung diejenigen Geschäftsprozesse und Aktivitäten identifiziert werden, die ein Mobilitätspotenzial aufweisen und somit durch mobile Systeme unterstützt werden können. Auch die weiteren genannten Analysen sind mit Hilfe des MPL möglich.

Die erwähnte Wirkungskette ermöglicht die Identifikation und Priorisierung der effektivsten Maßnahmen. Diejenigen Maßnahmen, welche einen positiven bzw. sich gegenseitig verstärkenden Einfluss auf weitere Maßnahmen oder Prozessschritte haben, können als besonders effektiv angesehen werden. Sobald alle Ziele und Maßnahmen ermittelt sind, ist eine grobe Auswahl der in Frage kommenden mobilen Systeme möglich.

Um den Analyseprozess zu vereinfachen und die Abhängigkeit vom Analytiker bzw. Entscheidungsträger zu minimieren, bietet die holistische Wirtschaftlichkeitsanalyse eine automatische Ermittlung und Gewichtung aller relevanten Erfolgsfaktoren an, die zur Wirtschaftlichkeit des mobilen Systems beitragen. Der für jedes Projekt abzuleitende Erfolgsfaktorenkatalog basiert auf den Ergebnissen der Expertenbefragung und bezieht die Abhängigkeiten der Erfolgsfaktoren von Kriterien wie der Zielsetzung, Branche und Größe des Unternehmens, von der Art der Anwendung (Mobiles Informationssystem, Mobile Customer Relation Management System, ...) und dem späteren Anwendertyp (Manager, Lagerist,....) ein.

Dieser Erfolgsfaktorenkatalog ergibt sich mit geringem Aufwand direkt aus der Angabe dieser Kriterien; die Auswertung, Ermittlung und Gewichtung der Erfolgsfaktoren erfolgt automatisch. Ein Vorteil dieser automatischen Erfolgsfaktorenanalyse ist die Aufdeckung der Korrelationen der Erfolgsfaktoren untereinander, da auf diese Weise bestimmte Erfolgsfaktoren eine höhere oder geringere Gewichtung erhalten können, als ihnen z.B. aufgrund der Unter-nehmensgröße zusteht. Gleichzeitig zeigt diese Analyse potenzielle Risiken auf, da die Nicht-Berücksichtigung von sehr wichtigen Erfolgsfaktoren eine weitaus größere Auswirkung auf die Wirtschaftlichkeit des mobilen Systems zur Folge hat, als dies bei unbedeutenden Erfolgsfaktoren der Fall ist.

In der nun anschließenden Bewertungsphase werden zunächst die Kosten des Gesamtsystems beispielsweise über das Modul ‚lebenszyklusabhängige Total Cost of Ownership' (L-TCO) ermittelt, die nicht nur die diversen Kosten aufaddiert, sondern auch ihr zeitliches Auftreten festhält. Dies erleichtert die monetäre Bewertung des Systems über die dynamische Investitionsrechnung erheblich, da hier die zeitlichen Abfolgen der Ausgaben strukturiert vorliegen. Die Ermittlung des Nutzens sollte unter Berücksichtigung der jeweiligen Wirkungszusammenhänge (Ziele, Maßnahmen, Erfolgsfaktoren) z.B. mit Hilfe einer entsprechend modifizierten Nutzwertanalyse erfolgen. Die aufgezeigten Wirkungszusammenhänge erlauben zudem, die durch die Erfolgsfaktoren beeinflussbaren Risiken besser einschätzen zu können. Die Ergebnisse der L-TCO, der modifizierten Nutzwertanalyse sowie der Risikoabschätzung werden in eine dreidimensionale Matrix übertragen, welche das Gesamtergebnis grafisch darstellt.

In Abhängigkeit vom Investitionsumfang und dem Analyseaufwand, den das Unternehmen bereit ist, für die Wirtschaftlichkeitsanalyse aufzubringen, sind die einzelnen Module (wie z.B. Nutzwertanalyse, dynamische Investitionsrechnung) durch einfachere oder aufwändigere Verfahren realisierbar, was die Anpassung des Frameworks an die Bedürfnisse des Unternehmens ermöglicht. Aufgrund der Modularität der holistischen Wirtschaftlichkeitsanalyse ergeben sich weitere Fragestellungen, zu denen zwar eine ausführliche Diskussion existiert, diese aber den Rahmen des vorliegenden Artikels jedoch sprengen würde.

5.4 Zusammenfassung und Ausblick

In der vorliegenden Arbeit wurde ein Framework zur holistischen Wirtschaftlichkeitsanalyse mobiler Systeme dargestellt, welches sich insbesondere durch die automatische Ermittlung relevanter Erfolgsfaktoren sowie einen modularen Aufbau auszeichnet. Durch den modularen Aufbau ist die holistische Wirtschaftlichkeitsanalyse in Bezug auf Aufwand und Genauigkeit an die jeweiligen Bedürfnisse des vor der Investitionsentscheidung stehenden

Unternehmens anpassbar. Als gegenüber Daumenregeln verlässliches, umfassendes und transparentes Instrument erleichtert sie die Entscheidungsvorbereitung bei Investitionen. Doch erst der Einsatz in der Praxis und die Auswertung von durch die Analyse ermittelten und den tatsächlich erreichten Ergebnissen werden die holistische Wirtschaftlichkeitsanalyse auf ihre Praxisnähe hin evaluieren und die notwendigen Modifikationen offen legen – eine entsprechende Finalisierung und Evaluierung des Frameworks wird derzeit vorbereitet.

6 Framework for a Holistic Profitability Analysis for Mobile Systems

Abstract[56]

Mobile systems, a special kind of information and communication technologies, promise to increase efficiency of business processes by uncoupling communication processes as well as information flows from space and time. The ubiquitous access to relevant information via mobile devices allows new forms of working, as for example unused time (e.g. waiting at the airport) can be converted into productive working time. Although a multiplicity of different forms of economic analyses exists, the proof of economy for these systems is still neglected. This is due to the existence of uncertainties concerning the potential economic effects of such systems as well as their measurement. This work introduces a holistic approach for evaluating economic effects of mobile systems that enlightens these effects from a novel viewpoint.

6.1 Introduction

Almost three decades ago, the discussion about the efficiency of information and communication technologies (ICT) started and it is still up to date. In contrast to traditional profitability analyses that consider only one dimension (that means only monetary measurable cost and benefits); newer approaches try to integrate long-term as well as strategic benefits. When evaluating ICT and especially mobile systems as a special form of ICT it is very important to consider these benefits that are 'only' qualitative or at least difficult to quantify or even to monetarize. Compared to industrial goods as e.g. production machines the impacts and benefits of mobile systems are rarely easy to measure. Fact is that mobile systems have numerous impacts that do not only affect the processes in which mobile technologies are used but they affect also processes that are only secondarily linked to the latter ones. Here we speak of the interdependence of or between effects. To realize the maximum efficiency of a mobile system, a variety of success factors has to be identified. These can be e.g. usability, user acceptance and social as well as security aspects.

The following sections describe a framework for a holistic profitability analysis for mobile systems. Section 6.2 defines important terms and evaluates briefly profitability analyses that are currently used for the assessment of ICT. The results of this analysis motivate the devel-

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[56] This work was originally published as: Högler, T. (2008). Framework for a Holistic Profitability Analysis for Mobile Systems. *Proceedings of the 1st International Conference on Mobile Society (mSociety 2008) in combination with 3rd European Conference on Mobile Government (EURO mGOV 2008). Antalya / Turkey, 15.-19.09.2008.* Kushchu, Ibrahim.

opment of the holistic approach. The framework itself is described in section 6.3 whereas section 6.4 summarizes the findings gained within this research work.

6.2 General Definitions and Evaluation of Traditional Profitability Analyses

Section 6.2.1 defines the most important terms used in this research work. Especially the terms 'mobile system' and 'mobile application' have to be explained and distinguished from related terms like 'mobile business' and 'mobile services'. In section 6.2.2 the author defines the terms 'framework' and 'holistic approach' and evaluates traditional profitability analyses in terms of a holistic approach.

6.2.1 General Definitions

In contrast to the term 'mobile business' which focuses strongly on mobile business processes, the term 'mobile system' aims at the relations between the components of the system as well as at their effects among affected by technical, but by all components of the mobile system, particularly by the human system components (users). All components of the mobile system are taken into account within the holistic framework.

Mobile systems exist in different forms and have a multiplicity of characteristics. They can be seen as ICT that are extended by mobile aspects. The goal of mobile systems is to integrate mobile processes into internal, mostly stationary business processes and thus to overcome their spatial separation and accompanying information losses.

The author defines a mobile system as an assortment of mobile technical as well as human system components that have an interrelationship between each other and that aim to perform business tasks. Technical components of mobile systems compass mobile hardware (e.g. PDAs and Tablet PCs), the appropriate applications as well as mobile operating systems and middleware (if necessary). Additionally, they include wireless communication technologies like UMTS, GPRS and WLAN.

As mentioned before, this work distinguishes between mobile applications and mobile services. According to Haeckelmann, Petzold and Strahinger (2000), Schiller (2000) and Lehner (2002), a mobile application is a software that is customized to the characteristics of mobile devices and that is installed on them. Mobile applications are adapted to the potentials and disadvantages of mobility (Turowski & Pousttchi, 2004) in order to amend the productivity of mobile workers as well as the economy of mobile systems. Mobile applications are employed in environments that are bulk-headed by other events and thus require the full attention of the user. Therefore they have to be as simple as possible to use. In this context simplicity represents the 'reflection of the users´ expectation' (Wenzek, 2002). The term wireless refers to the cordless data exchange, that is to say the data exchange accomplished without any physical connection and/or by means of radio or infrared. The term mobility describes the possibility for progressive movement and/or position change.

Contrary to mobile applications we define mobile services as applications that are available via mobile devices, but need not to be installed on them. They are made available via a stationary backend system (e.g. of a mobile network operator or a mobile application provider) and can be accessed by using an Internet browser that is installed on the mobile device. In this example, the Internet browser is a mobile application and only a means to an end whereas the service that is accessed via this browser is a mobile service. Typical examples for mobile services are the so called location based services such as passenger information for the public suburban traffic or financial services like mobile payment. This work focuses on mobile applications because they are more often used for the support of mobile business processes than mobile services are.

Non-technical components of a mobile system are beside of mobile (business) processes users who use the mobile technical components in order to perform their tasks. These can be for example executives (especially the upper management) or employees who accomplish their job mobile either within or outside the enterprise (e.g. sales people, customer service and warehouse clerks). Mobile processes differ from stationary processes primarily by their spatial distribution and mobility of the persons who take part in the process. They are characterized by the fact that at their beginning it is not exactly known where they will take place. Thus, distributed processes with a determined distribution structure are not mobile processes (Köhler & Gruhn, 2004a).

Having a closer look at mobile business processes it becomes clear that the potential of mobile technologies lies primarily in the possibility of reorganizing processes and thus in the exhaustion of the value added that is facilitated by mobile technologies. Particularly mobile ICT contribute to the efficient support of processes by bridging spatial distances (Schiller, 2000).

6.2.2 Evaluation of Traditional Profitability Analyses

As mentioned before, mobile systems represent a special, mobile kind of ICT. Thus it can be assumed that they are subject to the same difficulties concerning their profitability analyses as stationary ICT. Evaluation problems as well as the examination of widespread profitability analyses evince the absence of a holistic approach, which permits a comprehensive analysis of costs and impacts caused by ICT. The definition for a holistic approach is discussed in section three in detail; therefore it will be only sketched in this section.

A holistic approach is defined as an approach that has following characteristics:

- orientation on the lifecycle of the system as well as on business processes
- multi-dimensionality
- extensibility and scalability in order to be adopted to the needs of each project

- consideration of the interdependence of effects
- consideration of critical success factors in respect of the investment´s volatility effects
- systematic (of the) method

This work defines a framework as an abstract and scalable method as well as a guideline for the enforcement of a holistic profitability analysis. It contains a systematic collection of profitability analysis methods and allows the combination of these methods in order to evaluate the profitability of a mobile system.

During her research work, the author examined more than twenty-five acknowledged profitability analyses in terms of their holism. In summary it can be stated that the profitability analysis of a mobile system cannot be accomplished in line with the profitability analysis of industrial goods. On the one hand ICT and especially mobile systems have shorter innovation periods; on the other hand they are characterized less by their monetary benefits than rather by non-monetary or qualitative benefits, which are neglected by most procedures. Besides, due to their high complexity ICT have different (quantitative as well as qualitative) effects on enterprises that mesh and that are often company or industry specific. It is to be stated that ICT are often used with the goal of rationalizing processes and thus the quantitatively definable monetary effects are of central concern. This quite short-sighted approach leads finally to the fact that benefits are not or at least not sufficiently reflected in the assessment. For example, integrative effects of the systems are not considered in the calculation due to missing evaluation equipment´s (Pietsch, 1999).

As Horváth determined, especially one-dimensional profitability analyses (so called 'economy calculations') are not suitable as exclusive procedures for the verification of economic impacts caused by ICT (1988, p. 3): They have got only one criterion for the evaluation of the investment and thus do not fulfil an important characteristic of the holistic approach – the multi-dimensionality. Focusing on monetary and thus neglecting qualitative effects is not appropriate for the evaluation of mobile systems. Besides competition position, innovation and thus the corporate strategy as well as high-quality services gain in importance. Values like e.g. flexibility, customer satisfaction or personnel competence – factors that are not considered by one-dimensional profitability analyses – cannot be monetized (Zahn, Schmid, & Dillerup, 1999). For consequence, these calculations are not sufficient for the evaluation of investments in ICT. They have to be extended to multi-dimensional calculations or even replaced by completely new approaches. Multi-dimensional profitability analyses (so called 'economic analyses') represent an appropriate approach; however they do not suffice neither in order to seize all facets of the potential benefits of ICT nor to allow a holistic approach. Multi-dimensional profitability analyses put several criteria into account when evaluating a system. Nevertheless they are limited in most cases to effects that can be directly and indirectly monetized. In particular procedures, which require an evaluation of all benefits as monetary dimensions, disregard the majority of benefits caused by ICT, especially by mobile systems. Qualitative effects, that cannot be monetized, remain mostly unconsidered.

Thus investments in ICT are not evaluated profoundly enough. This is also because of the fact that economic analyses regard mostly isolatable investment objects that have no extensive effects. Thus they are not appropriate for investments that cause structural changes of the enterprise. Exactly these objects are characterized by retarded temporally and spatially shifted economy effects (Picot, Reichwald, & Wigand, 2003) that can be captured only by an approach that has a process as well as a lifecycle orientation.

The research results make clear, that none of the analyzed procedures examines effects as well as their interdependences. This is accompanied by the fact that only a few procedures are oriented on business processes – a precondition for the evaluation of interdependences between effects. Therefore these analyses do not consider effects that spread business processes (so called integrational aspects), which falsifies the results of these analyses usually derogatorily. Only few of the examined procedures consider success factors or volatility effects of the investment. All these research results motivate the approach of a framework for a holistic profitability analysis for mobile systems, which is introduced in section three.

6.3 Framework for a Holistic Profitability Analysis for Mobile Systems

The starting point of this research is the statement that none of the evaluated procedures is sufficient for the comprehensive evaluation of the economy of ICT, especially of mobile systems. As we have seen in section two, there is no procedure for measuring the economic efficiency that takes all characteristics of a holistic approach into account. These procedures regard only sub-ranges of the effects that are caused by ICT and thus ignore a holistic perception. This holistic perception is however necessary in order to detect monetary, qualitative and strategic benefits as well as their interdependences. For this reason the author developed a framework for a holistic profitability analysis for mobile systems. This framework contains beside an extended time horizon also a support for a comprehensive, systematic evaluation of costs and benefits including strategic benefits that cannot be monetized. Additionally, it takes into account interdependences between the different positive as well as negative effects that are examined on the basis of business processes which are affected by the mobile system. Moreover, this approach allows considering volatility effects in particular on the basis of critical success factors and thus allows a kind of prognosis support. Since the focus of this work is on mobile systems and almost no critical success factors could be identified within literature, these factors were determined in the context of a study (expert questioning) and are integrated into the approach of the framework. Even if some of the assessed profitability analyses cover one or several aspects of the holistic approach, there exists no approach that covers all aspects. Therefore the framework for a holistic profitability analysis is a novelty. The following sections describe the characteristics of the holistic approach.

6.3.1 The Holistic Approach

The following paragraphs describe the characteristics of a holistic approach. In section 6.3.2 the holistic profitability analysis for mobile systems will be introduced.

Orientation on the Lifecycle of the System

The holistic approach presupposes the analysis of the entire life cycle of the system in its individual phases. In fact, this means that the timeframe of the analysis is extended and effects are gathered at the point of time when they occur. This procedure has the advantage to allow a comprehensive and detailed evaluation of costs, benefits as well as of risk factors. The reason for this is that effects are analyzed and evaluated not according to the point of time when they occur, but according to the space of time they take effect. Discounting permits their comparison, even if they have different weight within the life cycle phases (Horváth, 1988).

Orientation on the Business Processes

The process orientation plays an outstanding role within the framework of the holistic approach, since it does not only supply valuable data for the evaluation of the ICT but allows also the investigation of interdependences between the effects caused by the ICT on different process levels that are changed and/or affected by the system. Business process models facilitate the analysis of the effects as well as of their interdependencies.

The process orientation focuses on the relationships between processes, between people who participate on these processes as well as between different departments. This is in particular of importance for processes that have a division of labor, since the effects within these processes have not only temporal delays but they also arise spatially distributed. Therefore they can be only identified if the timeframe of the analysis is extended and all processes are analyzed in detail. The systematic consideration of interdependences between effects within a profitability analysis during the entire life cycle of the system is one of the innovations the holistic approach delivers.

Multi-Dimensionality

A further characteristic of a holistic approach is its multi-dimensionality. This does not concern only costs and benefits that are monetary measurable, but also the depth of the analysis. The multi-dimensionality of the holistic approach is closely connected to the process orientation mentioned in the last paragraph. It is necessary since ICT are used in the rarest cases as isolated solutions. For this reason different effects on preceding and subsequent processes occur. ICT and particularly mobile systems achieve most improvements when integrated into existing or planned systems or system structures. If we speak about multi-dimensional effects we include beside monetary and quantitative also qualitative as well as indirect effects, since these can be relevant in particular for innovations where no empirical values concerning their effects exist.

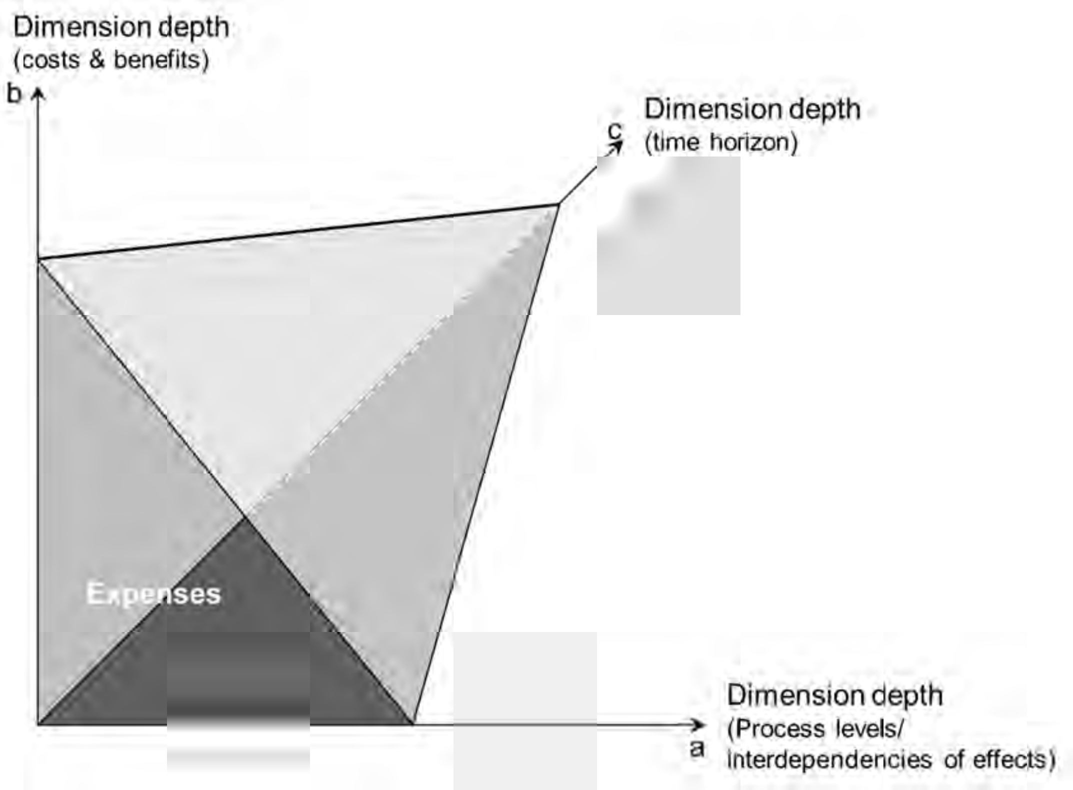

Figure 6-1: Levels of the dimension depth and expenses

Extensibility and Scalability

The multi-dimensionality mentioned in the last paragraph enables the extensibility and in particular scalability of the profitability analysis, since the dimension depth can be adopted to the project conditions and/or the project budget. This is necessary in order to limit the expenditures for the analysis and thus make the analysis suitable for smaller projects (see Figure 6-1: The volume of the pyramid reflects the total expenditure for the profitability analysis). For this reason the degree of the completeness and accuracy of the analysis should depend on the investment level (Kern, 1974). Before the analysis starts, a financial critical value should be defined. This critical value borders the investment level of a project and makes a maximum dimension depth of the analysis necessary regarding time, business process levels as well as effects and the interdependencies between them. Thus the critical value is needed because the profitability analysis – just as the mobile system – is subject to the principles of economy. It must be considered that omitting or simplifying individual steps and/or reducing the dimension depth can reduce the accuracy of the results. Generally speaking, with increasing dimension depth the proportion of concretely available data and facts decreases while estimations and assumptions and thus uncertainties in the calculation increase.

Consideration of the Interdependence of Effects

The consideration of interdependences between effects is a further characteristic of the holistic approach. All effects as well as their interdependences and influences on each other are analyzed and evaluated within all affected business processes as well as during the entire life cycle of the system. This comprehensive analysis of the interdependences between effects uncovers not only the effects but also their strength and their direction. For the representation of the interdependences between effects so called effect chains or effect matrixes are suitable.

Consideration of Critical Success Factors in Respect of Volatility Effects of the Investment

The introduction of new technologies is accompanied by numerous risks. These risks can be strengthened if critical success factors are ignored. This is due to the fact that critical success factors contribute essentially to the achievement of the optimal benefit of a system. In contrast, ignoring these factors can cause disadvantages like e.g. that the benefit occurs later than expected or is minimized and thus the efficiency of the system is not as high as it could be. For this reason the analysis of volatility effects has to be completed by the analysis of critical success factors.

As a novelty the holistic approach offers an equipment that extends a traditional risk analysis by integrating critical success factors. The combination of analyzing volatility effects as well as critical success factors has the advantage to allow more realistic forecasts about the potential efficiency of the system. Although this approach does not supply accurate results, it is helpful in decision making: Both pointing out interrelations between critical success factors and the analysis of their influence on the economic efficiency permit an improved evaluation of the ICT.

Systematic

The systematic of a profitability analysis is a criterion that intensively affects the handling of the analysis. This approach has the advantage that the statements concerning costs and benefits and thus the results of the analysis are the more transparent the more structured the analysis is. In particular, if complex processes affect many other processes it is of major significance to have a structured procedure.

6.3.2 The Holistic Profitability Analysis

The following paragraphs introduce the holistic profitability analysis that fulfils all holistic characteristics. Its development is based on the criticism of the profitability analyses presented in section two. The holistic profitability analysis is a generic model, which describes the economic analysis of ICT by the example of mobile systems. Figure 6-2 shows the structure of the holistic profitability analysis:

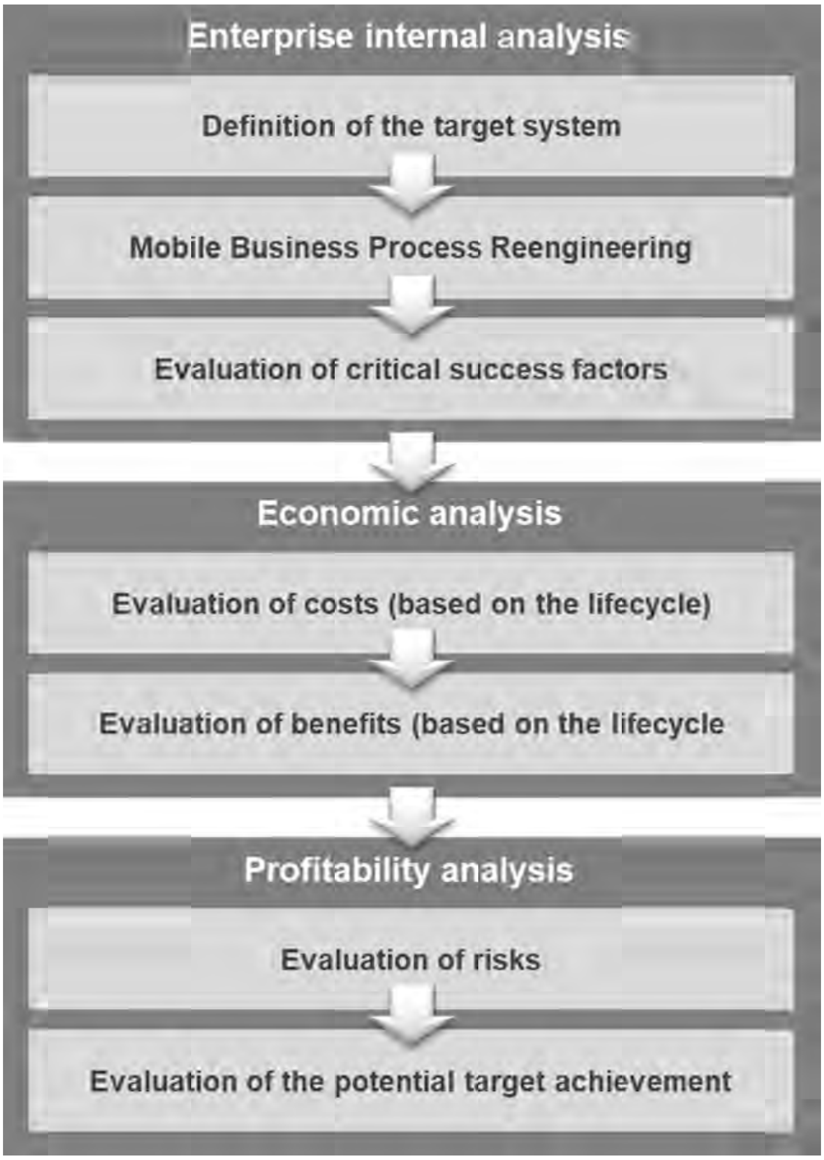

Figure 6-2: Phases of the holistic profitability analysis

The holistic profitability analysis consists of three main phases: the enterprise-internal analysis phase, the economic analysis phase and the profitability analysis phase. Within the enterprise-internal analysis phase the target system is defined. Here, all targets are identified, categorized and evaluated. Additionally, the author proposes the analysis of interdependencies between the targets. This procedure has the advantage, that all targets can be valuated regarding their effects on other targets. Targets that have positive effects on other targets get a higher weight than targets that have no or even negative effects on other targets. The result of this analysis is a matrix that contains all effects, their strengths as well as the likelihood of their appearance.

The following analysis of business processes is compellingly necessary, since the holistic profitability analysis is based on the process orientation. Additionally, this analysis gives input for the economic as well as the profitability analysis. In the context of the so called Mobile Business Process Reengineering (mBPR) the current state of the business processes is evaluated, the mobility potential of the business processes is highlighted and the target processes are identified (so called Business Process Redesign). mBPR is the necessary basis for the economic analysis, because in this sub-phase nearly all data that are needed for the economic analysis are collected. Within this enterprise-internal analysis phase also all critical success factors are identified. These can be human factors like motivation, incentives as well as technical success factors like security, data transfer rate or size and weight of mobile devices.

The second phase of the holistic profitability analysis is the economic analysis. Within this phase costs and benefits of the system that has to be implemented are identified. As previously mentioned the data that were collected within the enterprise-internal analysis phase are prepared systematically and compared. Within this phase existing models and approaches like e.g. Total Cost of Ownership, Cost-Effectiveness-Analysis or different kinds of benefit analyses can be used to analyze the economic impacts of a mobile system.

The profitability analysis of an ICT takes place in the last phase of the holistic profitability analysis: Here the evaluation of the determined results gained within the first two phases is carried out regarding the goals set in the first phase (so called determination of the potential achievement of the target system). Volatility effects as well as success factors are taken into account within this phase. Targets defined in the first phase are related to the results of the economic analysis (phase two), that means each alternative is evaluated in regard to its costs and benefits as well as in the probability to reach the defined results. For the latter it is necessary to evaluate all success factors and to analyze which of these success factors are taken into account by each alternative. The consideration of the volatility effects has the advantage to act out best cases as well as worst cases of the project. So the result of this last phase of the holistic profitability analysis is not a concrete account for the profitability but a frame within the profitability of a system can vary.

6.4 Conclusions

This article shows the importance of a holistic approach for a profitability analysis for mobile systems. The development of such an approach is motivated by the fact that traditional economic analyses do not consider all aspects of mobile systems. In particular they do consider neither critical success factor nor interdependencies between effects, especially between benefits. During her research work the author has developed a novel, so called holistic profitability analysis that takes into account all characteristics of a holistic approach. This paper presents very briefly the holistic profitability analysis in its main phases.

PART 3: MODEL DETAILING AND APPLICATION IN PRACTICE

7 Evaluating Mobile Systems in Practice

Abstract[57]

This work presents an integrative framework for the evaluation of mobile systems. In comparison to stationary systems, mobile systems have a bundle of specific singularities that should be considered for evaluation. Further analysis of existing approaches clarifies that an integrative approach for mobile systems is needed considering, besides 1) monetary and 2) qualitative effects, also 3) interdependencies as well as 4) singularities of mobile systems and 5) critical success factors in order to predict the potential system performance. In the construction of the integrative framework we take 1) business/IT-alignment theory, 2) systems theory and 3) identified singularities as starting points, while taking a behavioral science research approach. The resulting framework consists of three main principles (detailed organization-internal evaluation, detailed economic evaluation, integrative evaluation) for a mobile system at hand. We validate the framework by successfully applying it in practical cases. The paper ends with conclusions and implications for further research.

7.1 Introduction: Need for an Integrative Mobile Systems Evaluation

Since the eighties, the debate about cost-effectiveness of Information Technologies (IT) – as parts of Enterprise Systems (ES) – is consistently resurrected. Many scholars have recognized the contradictory effects of IT. E.g., (Solow, 1987) stated that the computer age could be seen everywhere except in productivity statistics and Loveman had no doubt that *"IT capital had little, if any, marginal impact on output or labour productivity, whereas all the other inputs into production – including non-IT capital – had significant positive impact on output and labour productivity"* (Loveman, 1994, p. 85). By the current state of scientific knowledge it is recognized that IT investments should be accompanied by complementary investments, like improved business processes (cf. (Brynjolfsson, 1993; Brynjolfsson & Hitt, 1995; Brynjolfsson & Hitt, 1998, p. 50ff.; Robey & Boudraeu, 1999; Hong & Kim, 2002; Al-Mashari, Al-Mudimigh, & Zairi, 2003)). The implementation of ES represents not only a major technical challenge, but requires new ways of thinking about business processes and organizational changes, system alignment, and enterprise architecture. Still, success factors for optimal Enterprise Architecting and maximized effect of IT implementation and thus organizational success need to be investigated more explicitly (Niehaves, Poeppelbuss, Plattfaut, & Becker, 2014). This also holds for mobile IT, applications in a mobile context. Still there is little development towards an integrative framework for performance measurement of mobile

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systems that takes into account principles of aligning IT with associated investments like process improvement.

In this paper we aim to develop such an integrative framework, by merging different models and perspectives. The first is Henderson and Venkatraman´s model of business/IT-alignment (Henderson & Venkatraman, 1993) that has been hardly applied to the domain of mobile IT and its productivity potential so far. We apply their model using systems theory which postulates that a system comes into existence by the relationships among system elements and resulting interactions (Goos & Zimmermann, 2005). The analysis of structures, reactions and functions allows certain predictions about the expected system behavior, whereas it does not focus on a separate consideration of each element (Bertalanffy, 1976). In addition, we apply insight from the field of Information and Communication Systems (ICS). ICS comprehends, besides technological elements, system elements of human (social) nature, their relationships (represented by processes) and their properties (Högler, 2012, p. 21). This can be applied to mobile systems as a special type of ICS, aiming at integrating mobile processes and devices into internal, mostly stationary corporate and enterprise-wide process chains and hence overcoming their spatial separation and accompanying information losses – information becomes available any time at any place (cf. (Schiller, 2000; Isaac & Leclercq, 2006)). Mobile systems exist in different forms and have a multiplicity of characteristics, which make them specific as compared to stationary ICS. This specific setting implies certain singularities to be taken into account on evaluation. A detailed list of singularities of mobile systems has already been identified by (Högler & Versendaal, 2014).

Finally, we apply behavioral science in the context of design science research (Hevner, March, Park, & Ram, 2004). Behavioral science (in this context) is defined as follows: *"The behavioural science paradigm seeks to develop and verify theories that explain or predict human or organizational behaviour [...]. [It] seeks to develop and justify theories (principles and laws) that explain or predict organizational and human phenomena surrounding the analysis, design implementation, management and use of information systems."* (Hevner, March, Park, & Ram, 2004, p. 75), cf., (March & Smith, 1995). *"Such theories ultimately inform researchers and practitioners of the interactions among people, technology, and organizations that must be managed if an information system is to achieve its stated purpose, namely improving the effectiveness and efficiency of an organization."* (Hevner, March, Park, & Ram, 2004, p. 76).

Based on the above, we define following research question:

How can a framework be developed for the evaluation of mobile systems and their productivity and process improvements, taking into account special characteristics of mobile systems, and applying an integrative perspective using systems theory, business/IT alignment, behavioral and design science?

To answer this research question, we analyze existing evaluations of ICS to find an approach that considers all particularities of mobile systems, their critical success factors and overall business/IT-alignment, and that can be defined as integrative. To focus our research on organizational processes, we consider mobile business-to-employee processes.

In the following section we explore literature on the evaluation of ICS and mobile systems respectively. In the next section we take a behavioral science approach and build our integrative framework for the evaluation of mobile systems, further operationalizing it through the identification of success factors in the subsequent section. Through case studies we have judged the validity of our framework and present one of them as example. We end our paper with summarizing the results, and providing implications and anticipated further research.

7.2 A Review of ICS Evaluations

In literature a plethora of methods and technologies for evaluating investments in ICS exists (Figure 7-1 and Figure 7-2). To get an overview they have been divided according to their criteria (see also (Högler, 2012) for details): traditional one-dimensional analyses, including only monetary effects; traditional multi-dimensional analyses, including also qualitative effects – which mostly have to be transformed into monetary effects; and new methods that combine several methods to cover the whole spectrum of effects. According to Renkema and Berghout, existing qualitative or non-monetary evaluation methods mostly lack a theoretical basis (cf. (Renkema & Berghout, 1997; Berghout & Remenyi, 2005)).

Acknowledged traditional profitability analyses (one dimensional methods) have been examined in terms of their integrative aspects (Figure 7-1). In summary, these methods have been mostly developed for assessing industrial goods and focus only on monetary effects of an ICS investment. Non-monetary or qualitative benefits, characterizing mobile systems profoundly, are neglected by these procedures (cf. (Horváth, 1988; Zahn, Schmid, & Dillerup, 1999; Ney, 2006)) and thus lack an integrative view. Many multi-dimensional methods have been developed for the profitability analysis of ICS since the first computers came up (Figure 7-1). They put besides monetary also qualitative criteria into account. Nevertheless, many of these procedures demand evaluating all benefits in monetary dimensions which requires a transformation of qualitative into monetary effects – resulting in uncertainties in regards of the height of monetary value which is estimated by subjective perception.

The examination of widespread profitability analyses shows, that by focusing only on monetary effects many positive impacts of ICS and mobile technologies respectively are ignored leading to worse results than previously expected. This is due to the fact that economic analyses regard mostly isolatable investment objects (not systems) that have no extensive effects. Thus they are not appropriate for investments that cause primarily structural and organizational changes of an enterprise which are characterized by retarded, temporally and spatially shifted economy effects (cf. (Applin & Fischer, 2011, p. 288; Picot, Reichwald, & Wigand, 2003, p. 6)). Such effects can be captured only by an approach that has a process (business/IT) alignment as well as a socio-technical orientation based on behavioral and design science.

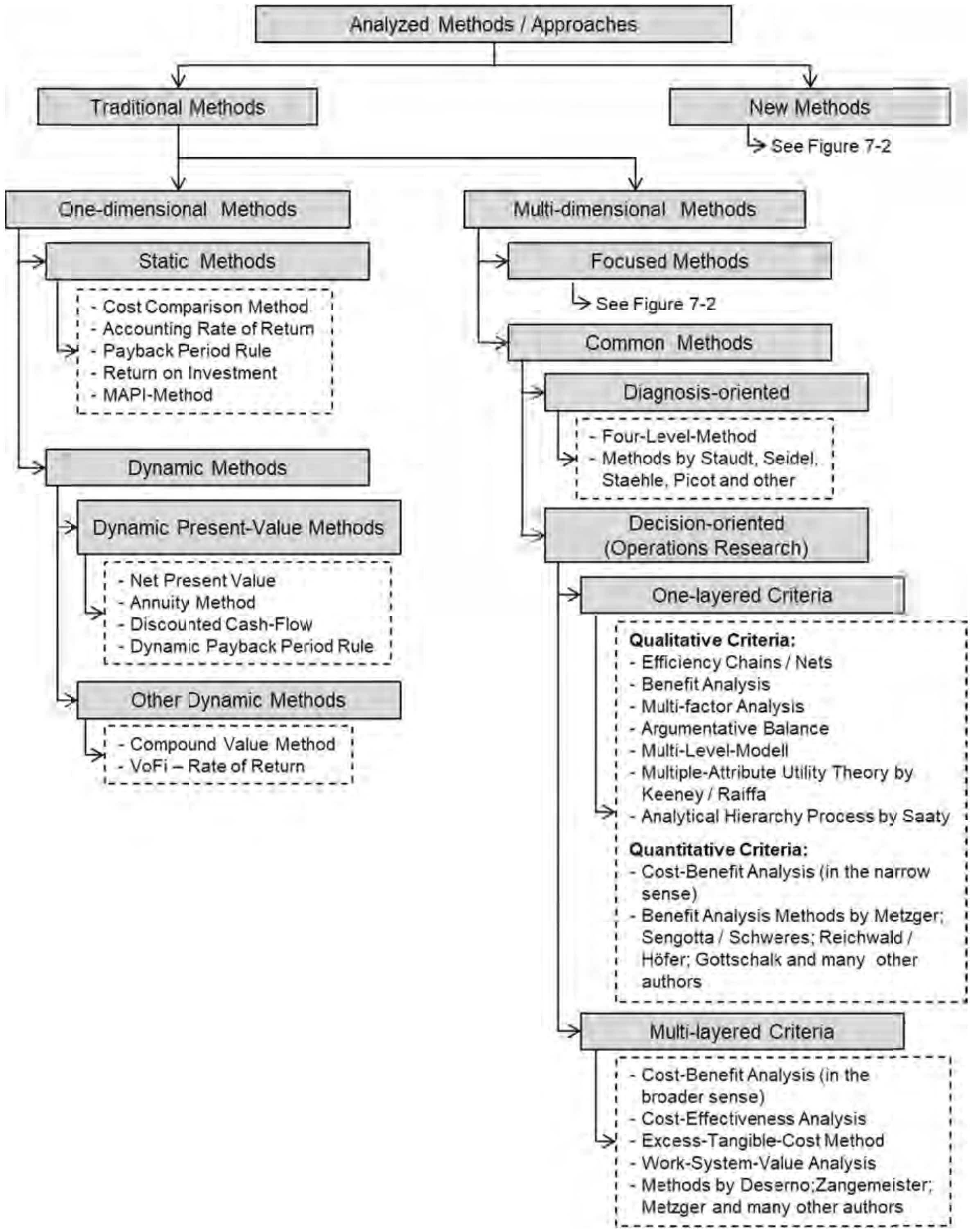

Figure 7-1: One-dimensional and multi-dimensional, common profitability analyses from literature (Högler, 2012)

Combined approaches evolved during the last decades, like Total Value / Benefit / Cost of Ownership and Target / Activity Based Costing (Figure 7-2). They combine two or more methods to get best possible and most realistic results, considering both quantitative and qualitative effects of ICS. Their analysis shows that even these methods do not cover all aspects of an integrative approach: First, they still do not regard mobile systems as entities consisting of single elements influencing each other and thus affecting the overall result. Second, many of these approaches do not consider users as system elements. Hence, success factors are mostly limited to technical attributes of a system; a socio-technical view is still missing (Orlikowski, 2000). Last but not least, business/IT-alignment is not considered by most of these methods.

The need for a process-oriented approach has already been recognized in the 90s e.g. by Hammer and Champy (2006) and Peppard and Ward (1999). Henderson and Venkatraman (1993) developed the Strategic Alignment Model which included the alignment of processes and IT. Since then, many scholars have fine-tuned and operationalized the connection between alignment and organizational performance (e.g. (Peppard & Ward, 1999; Cragg, King, & Hussin, 2002; Versendaal, Akker, Xing, & Bevere, 2013)), which is a mandatory prerequisite for an integrative approach. This approach is motivated also by the fact that an interdependency among system elements always exists (cf. (Bostrom & Heinen, 1977; Giddens, 1989; Orlikowski, 2000)) and has to be considered within a performance or profitability analysis.

The aim of theories and studies focusing on 'alignment' or 'fit' is to reveal *"conditions that facilitate a positively interactive relationship among two or more entities."* (Hester, 2014, p. 51). An example for such a theory is the Task-Technology-Fit (TTF) model. Gebauer, Shaw and Gribbins (2005) defined the TTF in a mobile context as *"a three-way match between the profiles of managerial tasks (operationalized by difficulty, interdependence and time-criticality), mobile information systems (operationalized by functionality as notification, communication, information access, and data processing, form factors, and location-awareness), and individual use context (operationalized by distraction, movement, quality of network connection, and previous experience)"* (Gebauer, Shaw, & Gribbins, 2005, p. 1). Following Goodhue and Thompson (1995), Gebauer et al. consider following elements when evaluating the TTF: tasks of corporate governance, mobile technology to be used and individual context of users. The disadvantage of such models is that they can only be used as a part of an integrative approach – as isolated methodologies they do not allow any forecasts on costs or benefits of mobile systems´ implementation. In addition, they neither identify success factors nor risks that have to be considered when implementing such a system.

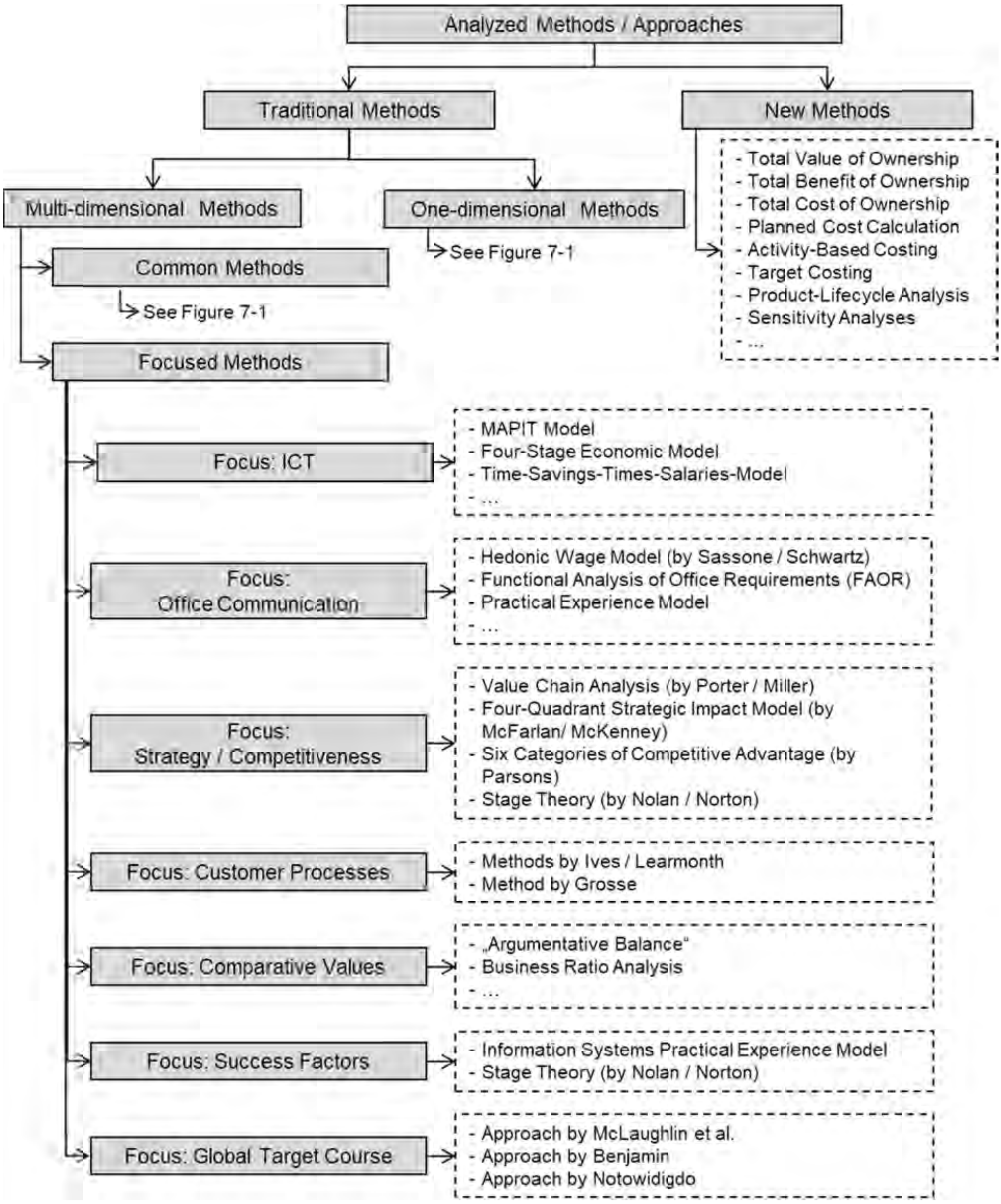

Figure 7-2: Multi-dimensional, focused profitability analyses and newer approaches (Högler, 2012)

Summarizing these findings, none of the analyzed methods offers an integrative view. One-dimensional methods focus only on monetary effects and ignore qualitative effects like structural impacts (i.e. intangible effects, cf. (Berghout & Remenyi, 2005)), which are characteristic for mobile systems. Multi-dimensional methods require the monetization of qualitative effects and thus may fudge results due to uncertainties occurring during this process. Newer, combined methods like TCO also lack an integrative view as they do not consider interdependencies of single elements of a (mobile) system. They merely neglect effects that can be caused by these interdependencies. Socio-technical approaches like the Task-Technology-Fit on the other side focus on exactly these interrelationships, but are not applicable to define effects, costs and benefits of mobile systems.

7.3 Integrative Framework for the Evaluation of Mobile Systems

The outcomes of the previous section lead to define three principles that are, in our view, essential to develop an integrative framework for the assessment of mobile systems:

1. For an integrative evaluation of mobile systems a detailed internal (intra-company) analysis has to take place, including business process reengineering.
2. A detailed economic analysis is necessary to perform an integrative evaluation of mobile systems. It considers all life-cycle costs as well as quantitative, qualitative and integrative benefits of mobile systems.
3. For an integrative evaluation of a mobile system as a whole, potential success factors and risks of implementing such a system have to be analyzed.

Systems theory is an important perspective to achieve integration of concepts and methods. From this approach, system parameters are variables, whose values characterize the behavior of a system with a given structure (see also (DIN, 1995)). Since the behavior of a system and therefore its performance are influenced by interaction or controlling of system parameters, they play an important role in matters of the integrative framework for evaluating mobile systems. System parameters with the largest influence on a system are characterized as ‘critical success factors’ (CSF). CSFs are a limited number of system properties that particularly contribute to achieving objectives set by the company (Rockart, 1979, p. 85). Relating to mobile systems, the current work defines CSFs as technical as well as social system parameters that have a significant impact on the performance of a mobile system.

Regarding ICS as systems of technical as well as social elements, that have relationships and that influence each other, system theory implies that neither singularities and success factors should be ignored nor risks that can occur if success factors are neglected. Next, systems theory enables the development of an integrative framework for the evaluation of mobile systems by further specifying our three principles into several activities that are connected and depicted in Figure 7-3:

- Principle 1 (Ward & Peppard, 2002, p. 206ff.): To adhere to this principle, following activities are considered necessary: definition of a target system (activity 1), defining monetary and qualitative effects to be achieved by the implementation of a mobile system (output 1 / O1) as well as requirements (O2). These outputs are inputs for the Mobile Business Process Reengineering (mBPR, activity 2). Singularities (O3), interdependencies (O4) as well as success factors (O5) of the mobile system are derived from activity 2 and flow as inputs into activity 3, the definition of CSF of mobile systems.

- Principle 2: In order to achieve integrative results, following activities are considered necessary: evaluation of life cycle costs of the planned mobile system (activity 4, (Unhelkar, 2009)), based on outputs from activity 1 (intended effects (O1)) and activity 2 (potential effects (O1_1)). Singularities (O3), interdependencies (O4) and intended effects (O1) are used as inputs for the evaluation of benefits (activity 5, (Högler & Versendaal, 2014)) that follows activity 4. The outputs of these activities (expected life-cycle costs (O7) and potential benefits (O8)) are used as inputs for principle 3.
- Principle 3: The analysis of risks and volatility effects (activity 6, (Kronsteiner & Thurnher, 2009)) is considered an explicit activity. The final assembly of these outputs (risks (O9) and volatility effects (O10)) leads to the assessment of potential target achievement rates (activity 7), which is – in addition to the constellation of all other activities within the three pillars – one of the scientific contributions of this paper.

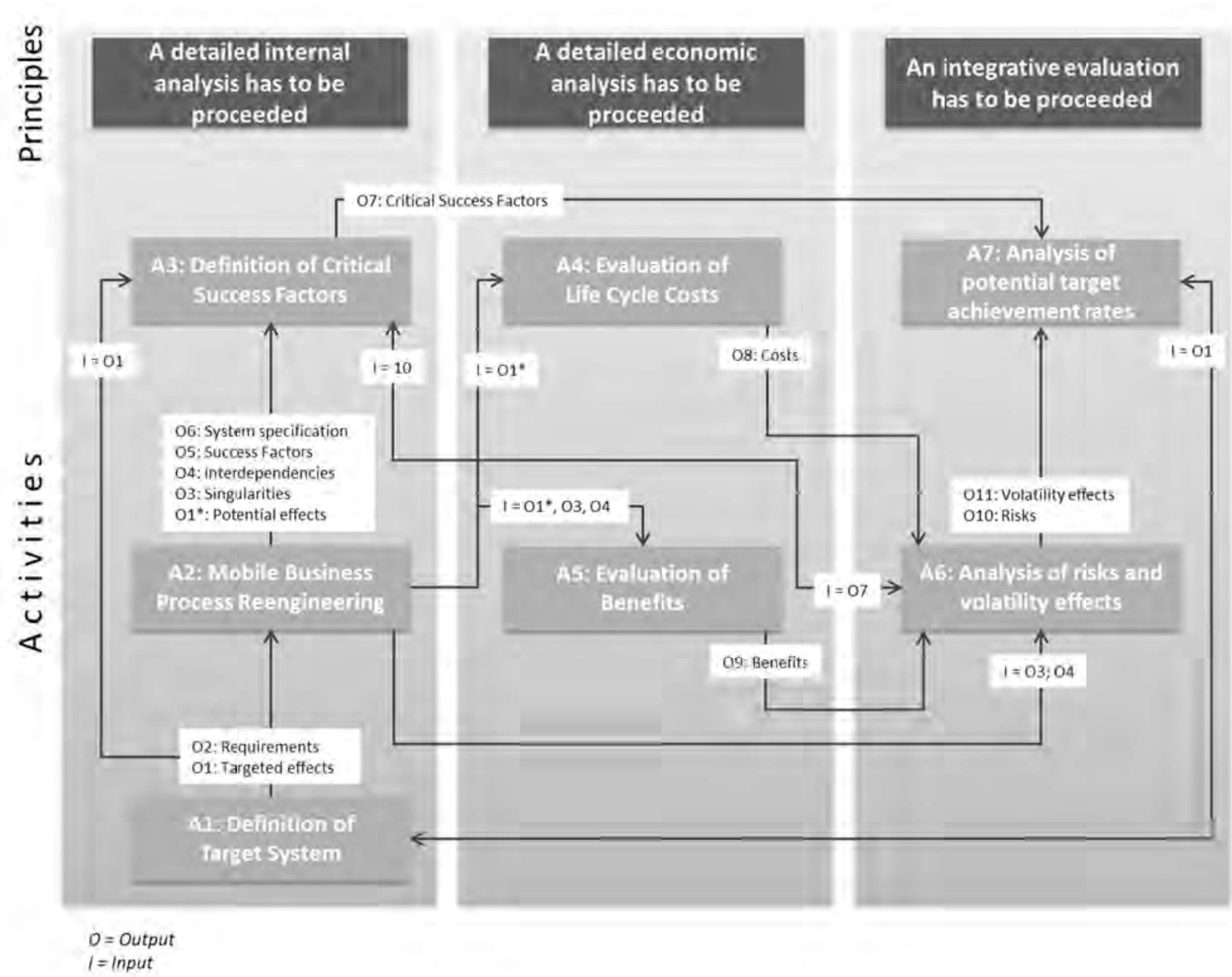

Figure 7-3: The integrative evaluation framework

The three pillars of the framework are:

1. Systems theory (particularly activity 2 and 4),
2. Business/IT-alignment, through activity 1 (the identification of goals – see Henderson & Venkatraman´s (1993) internal perspective of their strategic alignment model), activity 2 (including the process perspective), activity 5 (detailed external economic benefits) and activity 7 (overall target achievement rates) and
3. Singularities of mobile ICS, which can especially be found in activity 3 and 6.

The evaluation framework provides activities and principles for proper evaluation, leaving room for particular instantiation. A number of case studies have been performed with the framework, of which we show a particular one in the next section.

7.4 Validation Through a Case

As validation case the implementation of a mobile maintenance system was chosen due to its high complexity and consequential plethora of requirements defined by different employee groups. Maintenance processes are characterized by large percentages of mobile processes taking place remote from desktops. Therefore, maintenance engineers depend on the overall availability of required data and the reliability of mobile technologies like mobile devices and wireless networks. Only a perfect interplay between all components of the mobile system – social as well as technical ones – leads to the achievement of objectives set by the upper management. The implementation of a mobile maintenance system bears many risks, not only from technical side (e.g. transmission or (data) security problems) but also from the users´ side: Deficient acceptance and boycott by employees or the unwillingness to get used to new technologies can scupper the implementation in early stages. Thus it is notably important to include business/IT-alignment and to define success factors. These considerations have motivated the authors to choose the implementation of a mobile maintenance management system as validation case.

The company to operationalize and test the presented integrative framework was a German manufacturer for synthetic resin, involving more than 500 employees. The evaluation process took place in connection with the implementation of a mobile maintenance system. Two groups of persons were involved in the implementation process and the evaluation: (1) the business group of managers of the maintenance processes, carrying the overall responsibility for the planning / management of maintenance processes, the reliability of the plant and reporting to the top management, and (2) the group of maintenance engineers, carrying out the maintenance processes. All involved participants (5 in total) had many years of experience in the field of maintenance and the corresponding processes. The evaluation process took approximately 4 weeks, including several workshops with the mentioned groups and analyzing gathered data. The evaluation study was partly explorative and inductive, as no clear objectives and metrics were available to test or pre-test the case as by traditional evaluation methods.

Activity 1: Definition of the target system

The first workshop aimed at defining the target system and proceeding a requirements analysis. In a first step, objectives that had to be achieved by the implementation of the mobile maintenance management system were defined during a brainstorming process. As many of these objectives influence each other, in either positive or negative way, defining these interdependencies was part of the workshop as well. Positive influence means, that an objective supports the achievement of another objective, a negative influence means, that it hinders the achievement.

To investigate conflicting objectives, every objective was analyzed by letting the participants answer the following questions (see Table 7-1):

- Question 1: How does objective 1 influence objective 2? (no influence (white fields), positive (light fields) / negative influence (dark fields)
- Question 2: How strong is the influence? (+/-1 = slight, +/-2 = medium, +/-3 = strong influence)
- Question 3: What is the incidence rate? (1 = interdependency of effects unlikely, 2 = likely, 3 = expected)

Table 7-1: Calculation of preference-neutral weighting factors (example)

	Objective 1	Objective 2	Objective 3	Objective 4	Objective 5	Objective 6	Objective …	Objective n	**Active valence ∑**
Objective 1		2	0	2	6	2	0	0	**12**
Objective 2	6		6	-2	0	0	1	0	**11**
Objective 3	-1	-3		0	3	0	0	-4	**-5**
Objective 4	0	6	9		-2	0	0	-6	**7**
Objective 5	0	0	4	-2		0	-2	1	**1**
Objective 6	0	6	0	0	0		9	0	**15**
Objective …	-3	1	3	0	0	0		0	**1**
Objective n	0	4	0	0	2	-9	0		**-3**
Passive valence ∑	**2**	**16**	**22**	**-2**	**9**	**-7**	**8**	**-9**	

The scale for estimating the influences´ strength is arbitrary, but should not be too fine-grained, since these are pure estimates by people involved in the target system definition process (maintenance manager and consultant). To avoid pseudo-accuracy due to excessive fine granularity, scores were classified into a three-point scale. This coarse scale was chosen due to the fact that in practice the estimation of effects differed between the workshop participants. Every single workshop participant had to fill in his personal estimation of values in a table. Due to the fact that the scale was quite coarse, in most of the cases a consensus between all workshop participants (same single values). In order to reduce the single results to a common denominator, the mean value was calculated after answers of all workshop participants were received. The result was a preference-neutral target system as shown in Table 7-1.

On the basis of the prospect theory by Kahneman & Tversky (1979), (Kahneman, 2011) the values of the expected strength of the influence were multiplied with the values of the expected incidence rate. For example, if objective 2 will have a medium influence on objective 1 and it is expected that this influence will occur, then the value of this effect is 6 (2*3).

The active valence of an objective is the horizontal sum of the calculated values and means. The objective with the highest active valence influences the most other objective in a positive way. This implies that this objective is allocated a relative high weight due to the fact that (a) its own likelihood (or odds) and (b) that by achieving this objective many other objective will be achieved.

The passive valence is the vertical sum of the values of a single objective and shows how much an objective is affected by other objectives. Objectives holding a high passive valence will be reached by achieving the other objectives, thus they are not high priority candidates. This so-called preference-neutral prioritizing of objectives is presented in Figure 7-4. Boundary values were defined in order to focus only on objectives with the highest priority – in our case objectives with an active or passive valence lower than 5 would be regarded as priority C. In the given example, objectives no. 1, 4 and 6 received priority A, objective 2 priority B and the other objectives received priority C.

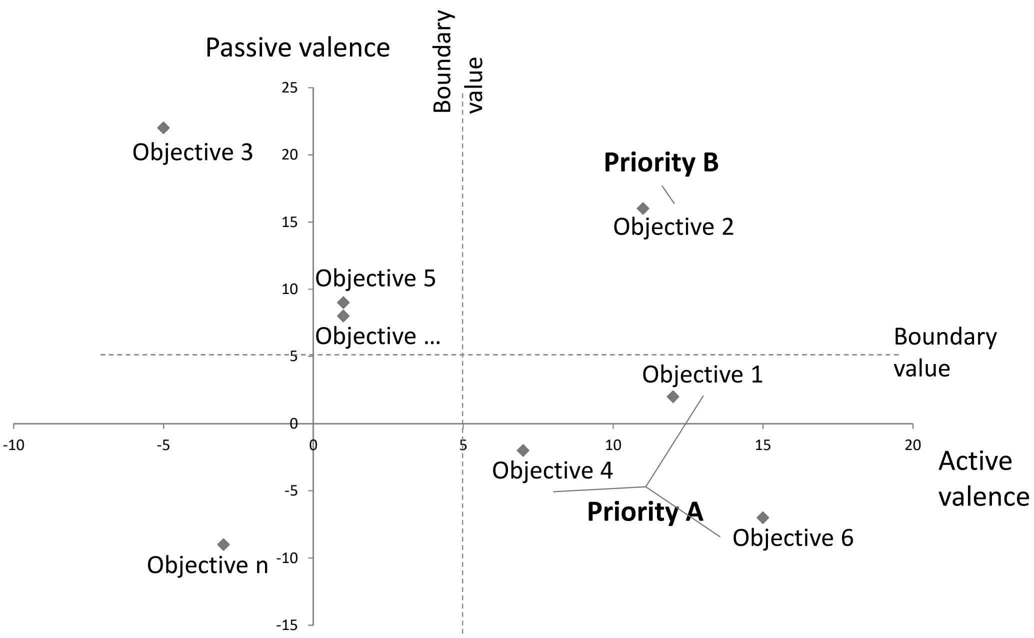

Figure 7-4: Preference-neutral prioritizing of objectives (example)

Activity 2: Mobile Business Process Reengineering

The second workshop held during the evaluation process was aimed at analyzing and documenting existing maintenance processes. The aim of the documentation of business processes is the (value-neutral) recording of all process-descriptive data. It is the basis for any process analysis, reengineering and optimization as well as performance measurement. Here, the processes affected by the planned transformation are identified and all relevant indicators are recorded, i.e. potential effects that are further specified by Key Performance Indicators (KPIs). Moreover, the information needs are determined. The primary goal of the information needs analysis is therefore to determine information-related requirements for ICS. For this purpose

1. the subjective (the ‘perceived information needs of the user’)

as well as

2. the objective (really required information and data in order to proceed a task) information needs

have to be analyzed and defined user-specifically. In the validation case we propose methodologies for the analysis of the as-is state of information flows. This is a so-called deductive approach that focuses on the determination of information needs of the focused groups, and an inductive approach that analyses the existing offer of information. For the deductive approach, the task analysis was chosen. For the inductive approach, a document analysis as well as employee interviews were selected due to time-constraints.

The as-is state of often occurring and continuous process types was assessed and the mobile parts of the processes were identified by using the Mobile Process Landscaping model (Köhler & Gruhn, 2004a). On this basis, mobile Business Process Reengineering was processed in accordance with the target system. During this process, besides the potential effects also singularities of the planned system, the expected interdependencies between single system elements and success factors were determined (see Table 7-2).

Activity 3: Definition of critical success factors

Success factors of all system elements that have to be taken into account have been derived from the requirements and interdependencies that resulted from activity 1 and 2. Critical success factors are – in the present work – deduced from requirements. Requirements – as defined in activity 1 – represent ‘can’ / ‘nice to have’ properties of a system. At that stage it is not clear how important they are. In activity 2 – mBPR – it becomes clear, which of these requirements are important for the success of the mobile system. These requirements are defined as success factors. A deeper analysis of the success factors allows conclusions on critical success factors. As already described, critical success factors are requirements that are indispensable.

Table 7-2: Identified requirements (examples)

Tasks	System-related requirements
Management and documentation of tasks & activities	**Mobile device** - Minimum size & weight of device - Ease of use of device & programs (usability, usefulness) - Ruggedized device (1,5m drop, dust, splash water) - Barcode (1/2D) or RFID tag reader - Smartphone or tablet; NEVER both devices at the same time **Application** - No additional work for users - Ease of finding documents / tasks / other information - Start-stop-function (-> duration of work) - Standard documents / information directly accessible in / linked to tasks - Processes easily to adapt **Network** - Always-on connectivity (3G or WLAN) / availability of data & information anywhere, anytime
Analysis of data (management level)	**Mobile device** - Speed of processing data - High resultion / big display -> Tablet Existence of well-usable keyboard **Application** - Application has to have an analysis module (no analysis with ACCESS / Excel or similar tools) - Graphical illlustration of results - Automatic tracking of activities (time needed, responsibility (done by...) must NOT be possible (due to internal regulations / work council) **Network** - Data bas to be accessible online, but also offline -> storage of data on device needed, not only "cloud-based" access

An example from our case study: As a technical requirement the existence of a 3G module in the mobile devices was identified due to the fact that not all parts of the single plants were covered by WLAN. Success factors that come along with this requirement are a) plant-wide coverage by WLAN and / or mobile devices with a 3G module and b) (as indirect requirement) plant-wide availability of data and information. Investigations of the usage and acceptance of new technologies were mainly based on the Technology Acceptance Model (TAM) by Davis (1985) (cf. (Davis, Bagozzi, & Warshaw, 1989; Venkatesh, Morris, Davis, & Davis, 2003)). This model argues that the easier a technical system is to use and the more useful it is, the more a user is likely to use it. Thus, the authors identified the users´ prerequisites for the technical system elements that were related to the singularities of mobile systems and interviewed them in order to find out how the processes have to be changed in order not to fit only the objectives set by the management but also to achieve the best possible usefulness for the maintenance engineers – in accordance with the TAM. In addition, also a Task-Technology-Fit analysis was proceeded to figure out how the technologies could best support the users. By doing so, the identification of critical success factors was possible.

Activity 4: Evaluation of life-cycle costs

Taking the above mentioned intended and potential effects into account, the authors were able to propose several combinations of technical elements (mobile devices, appropriate maintenance applications and wireless networks) and to calculate the expected costs for the equipment by applying the life-cycle oriented Total Cost of Ownership approach. This approach takes all costs into account that occur during the lifetime of a mobile system, including costs that occur in other departments that are directly or indirectly affected by the implementation of a mobile system.

Activity 5: Evaluation of benefits

Taking the results of the mBPR, the identified potential effects and the respective KPIs into account, a first evaluation and estimation of the potential benefits of each combination (e.g. cost savings, quality improvement) was possible. For this purpose in the workshops, for each combination the following question was proposed to be answered:

> *How does the process change / improve optimally by using mobile technologies (potential qualitative effects like quality of the documentation of every task; potential quantitative effects like duration of tasks)?*

In order to answer this question, the Mobile Process Landscaping model was examined, potential benefits identified and the best possible processes and combinations of elements (systems) were taken as basis for further consideration.

Activity 6: Analysis of risks and volatility effects

In order to analyze risks and volatility effects, following questions were suggested to be answered for every single combination of mobile technologies or systems, respectively:

- Question 1: How do singularities of the system and interdependencies between the elements affect the planned processes?
- Question 2: What happens, if critical success factors are not considered?
- Question 3: How does this affect the processes in terms of expected costs and potential benefits?

Discussing and answering these questions led to the identification of risks. For their assessment (e.g. insufficient network coverage, refusal of the technical components by employees, errors occurring during processes due to knowledge gaps of the workers) the same procedure as described for the calculation of preference-neutral weighting factors was applied. As a result, the authors received a table in accordance to Table 7-1 that identified risks, their value and their likelihood. This allowed a prediction concerning the volatility effects of the potential benefit achievement caused by the risks.

Activity 7: Analysis of the potential target achievement rates

The last step was the analysis of the potential target achievement rates. For this, it was analyzed which of the given combinations considers most of the system-related requirements (see Table 7-3) – for every single maintenance process. The requirements with the highest negative impact on the performance of the system were defined as critical success factors (CSF). For example, tablet PCs were identified as CSFs for processes that required wiring diagrams. In the next step, it was analyzed how much CSFs can contribute preventing risks; also here, the procedure as described for the calculation of preference-neutral weighting factors was applied. By doing so, an estimation of the potential target achievement of every single combination was possible.

Table 7-3: Influence of critical success factors on the likelihood of risks (example)

	Risk 1	Risk 2	Risk 3	Risk 4	Risk 5	Risk 6	Risk …	Risk n	Influence Value
Critical Success Factor 1		2	0	2	6	2	0	0	**12**
Critical Success Factor 2	6		6	-2	0	0	1	0	**11**
Critical Success Factor 3	-1	-3		0	3	0	0	-4	**-5**
Critical Success Factor 4	0	6	9		-2	0	0	-6	**7**
Critical Success Factor 5	0	0	4	-2		0	-2	1	**1**
Critical Success Factor 6	0	6	0	0	0		9	0	**15**
Critical Success Factor …	-3	1	3	0	0	0		0	**1**
Critical Success Factor n	0	4	0	0	2	-9	0		**-3**

The combination of technical elements of the mobile system was chosen as follows: The highest weighting factor was given to the consideration of critical success factors and thus to the potential achievement of the set objectives. Costs have been also taken into account, but received a much smaller weighting factor. It became quickly clear, that two types of mobile devices were needed: ruggedized smartphones for the regular daily work and – if necessary – tablets for special cases, e.g. if wiring diagrams or similar large documents were needed, or, e.g. if new wiring was needed that had to be immediately documented due to law or security reasons. It was decided to deploy only ruggedized Smartphones in the first step in order to minimize financial risks and to allow employees to first get used with a smaller part of the application. The choice of the maintenance management system fell on the system with the best usability and highest user acceptance (GS Service by Greengate): The graphical user interface was very similar to Microsoft Outlook, so the workers felt very comfortable with it during a testing phase. Additionally, the administration of the system was very easy and could be processed without any help of IT-specialists.

7.5 Conclusions and Implications

In this paper an integrative framework for the evaluation of mobile systems as a kind of Enterprise Systems is developed and applied.

The literature review showed that none of the existing methods offers an integrative view. Consequently, we were motivated to construct an integrative framework for the evaluation of mobile systems as part of Enterprise Architecting, which includes insights from system theory, business/IT-alignment, and which also considers singularities of mobile ICS. The framework is based on three main principles (a detailed internal analysis, a detailed economic analysis, and an integrative evaluation of mobile ICS), and is detailed by seven main activities.

The framework that results from this study is not only meant to 'predict' the potential target achievement of mobile ICS and organizational success, but can also help to monitor the implementation. Hence, in line with the business/IT-alignment insights, it does not only consider the singularities of mobile systems, but especially the interdependencies, relations and interactions of the single system elements. Several case studies – of which one was presented in this paper – support the correctness of Figure 7-3 including the completeness of the activities of the framework.

In order to further prove the practical application of the framework, further implementations in practice are necessary. This can be achieved in many other branches and for different kinds of tasks. The case in this paper 'only' concerned the maintenance management field, and only the stage of decision making including the first steps of implementation. The authors are aware that to validate the framework from the very beginning of a project until the first monitoring stage (e.g. after 2 years after implementation), a much more extended case study and longitudinal data collection is needed.

8 Determining the Target System

Abstract[58]

Mobile technologies are reshaping the global economic landscape, enhancing speed and comfort of communication and information exchange. Existing studies on the economic impact of mobile technologies taking a socio-technical system perspective are scarce. Our study shortly describes an integrative approach for such systems, which is in detail described in (Högler, Versendaal, & Batenburg, 2015), and specifically constructs the first activity in the integrative approach, i.e. defining the target objectives of the mobile system; it provides a case study at an SME to show this step´s applicability and validity. In defining the target system the Analytical Hierarchy Processing technique is extended. It encompasses a) the identification of objectives, and b) the determination of the hierarchy of objectives, c) the determination of the dependencies between objectives, d) the identification of strengths of the dependencies, and e) their likeliness of appearance, a f) prioritization and g) a consolidation of all previous sub-steps. The case study confirms the validity and applicability and provides reasons for generalization.

8.1 Introduction

We are living in a digital world that is directed increasingly by mobile technologies. These have *"emerged as a primary engine of economic growth […]"* (Bezerra, et al., 2015), becoming *"the fastest adopted technology of all time"* (ibidem). According to e.g. West (2014), mobile technologies have enabled new forms of communication, interaction and work; by doing so they have revolutionized business practices in all ranks. Nevertheless, when it comes to investigating the economic impact of mobile technologies in companies, particularly SMEs, little research work is done yet. In an in-depth analysis of existing economic analysis approaches (Högler, 2012) the author concludes that still methodologies are prevalent that only focus on monetary effects and thus neglect many aspects of mobile technologies – i.e. qualitative effects like impacts on employees or structural and organizational changes. These effects as well as the strategic alignment of mobile technologies and thus their overall organizational success need to be considered more explicitly (Vuolle, 2011). An approach is required that allows new ways of assessing and evaluating economic impacts of mobile technologies which have to be considered as parts of socio-technical systems.

A socio-technical system includes hardware, software, people, and business or community structures and processes (cf. (Alter, 1999; Alter, 2001; Whitworth, 2006)). In the context of mobile technologies, the authors define a mobile system as a set of mobile technologies and

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human (system) elements, which are inherently related by structures and processes (Goos & Zimmermann, 2005). They aim at integrating people, processes and mobile devices into internal, mostly stationary corporate and enterprise-wide process chains. Hence, they may overcome spatial separation and information losses (cf. (Schiller, 2000; Isaac & Leclercq, 2006)). Mobile systems exist in different forms and have a multiplicity of characteristics, which make them specific compared to stationary Information and Communication Systems (ICS). This specific setting implies certain singularities to be considered for their implementation and evaluation.

These considerations have encouraged the development of an integrative approach, which is shortly described in section 2. In this paper we specify the integrative framework of Högler, Versendaal and Batenburg (2015) by constructing the details of its first activity: the definition of the target system. The definition of the target system is of high importance as it is not only the basis for all further activities of the integrative approach, but also for any requirements definition. In contrast to objectives that are defined as a *"specific result that a person or system aims to achieve within a time frame and with available resources"* (Business Dictionary, 2016), requirements are *"(1) a condition or capability needed by a user to solve a problem or achieve an objective […]"* (CMMI, 2006, p. 553) and are derived from objectives. An improper requirement definition (Davis, Dieste, Hickey, Juristo, & Moreno, 2006) is according to many researchers and consulting companies, the most-cited reason for implementation failures and represents *"the lack of clear understanding of what the company wants to achieve"* (IMG, 2015).

The goal of this work is to present and validate the proposed definition of the target system by a case study at an SME. The case study research design was chosen as it is a useful tool for testing theoretical models by applying them in real world situations (Yin, 2013). In our case we apply the first activity of the integrative framework in a practical case in the building industry.

In the next section we will first re-address Högler et al. (2015) the integrative framework and define its first activity in detail. In section 3 the case study is described and analyzed. We end this paper with conclusions, impact and discussion.

8.2 The Integrative Framework – A Socio-Technical Approach for the Evaluation of Mobile Systems

The analysis of existing approaches shows that an integrative approach for the evaluation of information and communication systems (ICS) needs to consider, besides monetary and qualitative effects, also interdependencies between the systems´ elements as well as singularities and related critical success factors of ICS to predict the potential system performance (Högler, Versendaal, & Batenburg, 2015). Following these specifications, it becomes clear, that research on ICS evaluation taking an integrative view is scarce. Mobile systems, a form of ICS, have been chosen as object of investigation as they are more complex than stationary ICS and have specific singularities that need special attention. The assumption is that if the integrative framework works well for mobile systems, then it can be used for any kind of ICS.

The integrative framework for mobile systems as proposed by Högler et al. (2015) builds on following principles (Figure 8-1):

1. For an integrative evaluation a detailed internal (intra-company) analysis and design has to take place, including business process reengineering.
2. A detailed economic analysis is necessary which considers all life-cycle costs as well as quantitative, qualitative and integrative benefits of mobile systems.
3. A sensitivity analysis has to be proceeded that surveys in which way success factors and risks affect the potential target achievement when implementing mobile systems.

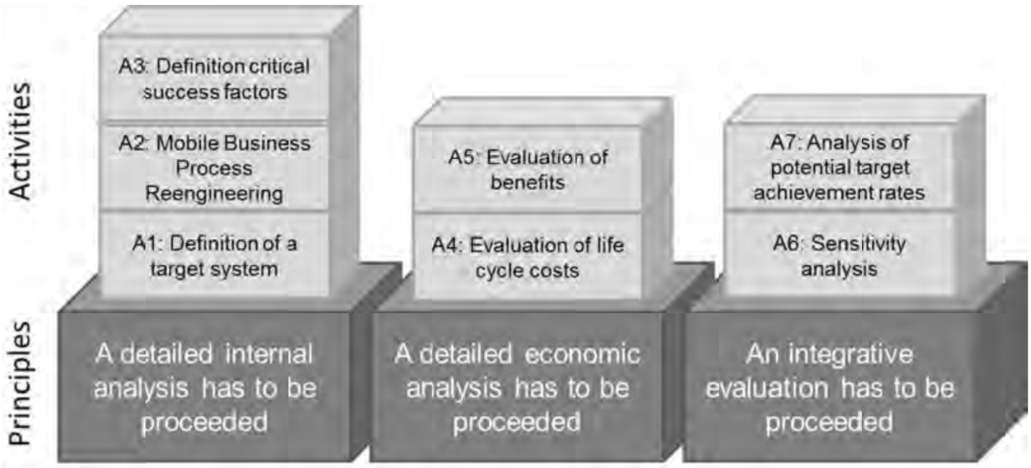

Figure 8-1: The integrative framework

These principles are covered by the seven activities of the framework (see Figure 8-1):

1. Activity 1: Definition of the target system by following the multi-attribute decision making (Hwang & Yoon, 1981). This activity outlines a new procedure for defining the target system leveraging the Analytical Hierarchy Process (AHP) (Saaty, 1996). The main contribution of this paper is that the AHP is extended and applied in the context of an integrative approach for evaluating the economic efficiency of mobile systems in order to determine objectives for such a system. The uniqueness of the extended AHP is that the determination of priorities is not based on subjective assessment, but on the following steps (see Figure 8-2), differing from previous approaches:
    - interdependence analysis between individual objectives (cf. (Kirchmer, 1999; Drews & Hillebrand, 2002; Rückle & Behn, 2007));

- consideration of the effective strength of the objectives and the probability of occurrence of interdependencies (cf. (Charette, 1991; Klabon, 2007)) and thus their respective value; and
- preference-neutral weighting of objectives in the context of these latter two aspects.

By following such a preference-neutral weighting and prioritization of objectives, a consistency test becomes unnecessary and is thus omitted in the proposed procedure.

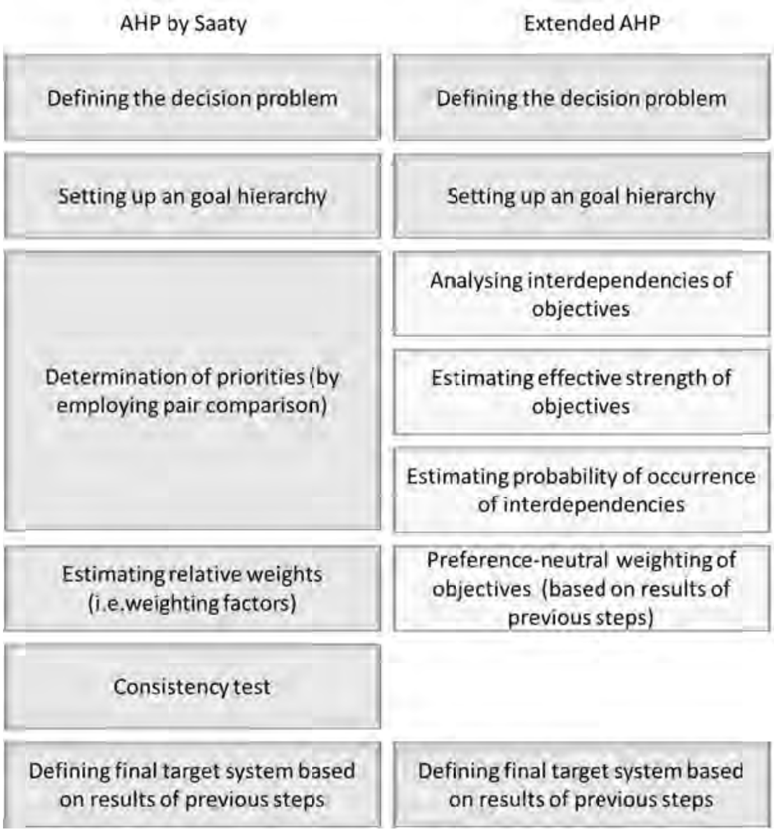

Figure 8-2: Comparison of original and our extended AHP

The validity of this activity is the main focus and contribution of this research paper and will be described in section 8.2 in detail. Agile methodologies like SCRUM are considered not appropriate for the definition of the target system as they focus on defining and managing *requirements*, which are derived from *objectives*. As such methodologies are process models that focus on project and product management, they are used in a later stage of implementing a system than the definition of the target system.

2. Activity 2: Mobile Business Process Reengineering as proposed by the authors builds upon Mobile Process Landscaping (cf. (Gruhn & Wellen, 2001; Köhler & Gruhn, 2004)).

3. Activity 3: Definition of critical success factors, their interdependencies, correlation analysis and weighting (cf. (Hway-Boon & Yu, 2003; Iqbal, Nadeem, & Zahee, 2015; Nysveen, Pedersen, & Skard, 2015)).
4. Activity 4: Evaluation of life cycle costs (cf. (Wild & Herges, 2000; Berghout, Nijland, & Powell, 2011)), performed by identifying costs during the whole lifecycle of mobile systems including the preliminary phase, utilization phase and disposal phase.
5. Activity 5: The evaluation of benefits, based on the total benefit of ownership model (Gadatsch & Mayer, 2004), involves the capture of cost savings and non-monetary benefits or qualitative and strategic variables which are not considered in the traditional approaches of economic evaluation.
6. Activity 6: Sensitivity analysis: As an uncertainty of the results achieved in the previous steps remains, a sensitivity analysis is conducted to check the stability of results. Particularly the variables *success factors* (cf. (Rockart, 1979; Corsten, 2000)), *risks* (Kronsteiner & Thurnher, 2009) and the accompanying volatility effects (cf. (Kulk & Verhoef, 2008; Singh & Vyas, 2012)) are analyzed.
7. Activity 7: Analysis of potential target achievement rates: Based on the results of the sensitivity analysis, the potential achievement rates can be determined. To do so, results of activity 1 (target system), activity 2 (current and target processes incl. key (performance) indicators) and activity 6 (volatility effects) are merged.

Definition of the Target System

The definition of the target system is the first activity of the integrative framework. Figure 8-3 depicts the single steps:

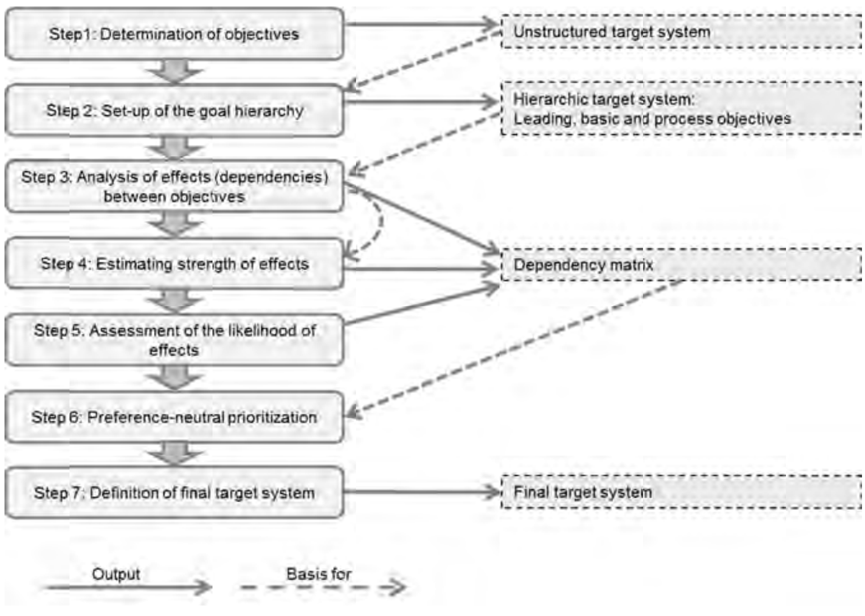

Figure 8-3: Steps in the definition of the target system

First, objectives are determined e.g. by task observation, in a workshop or from interviews with the help of a questionnaire. An unstructured target system contains all gathered objectives. In step 2, the identified objectives are brought in a hierarchical relationship (goal hierarchy; what we define in levels 'key objectives', 'basic objectives' and 'process objectives'). A goal hierarchy is only complete if *"each element of a hierarchy level has a direct relationship to the next higher element [...]"* (Ahlert, 2003, p. 37) (Figure 8-4).

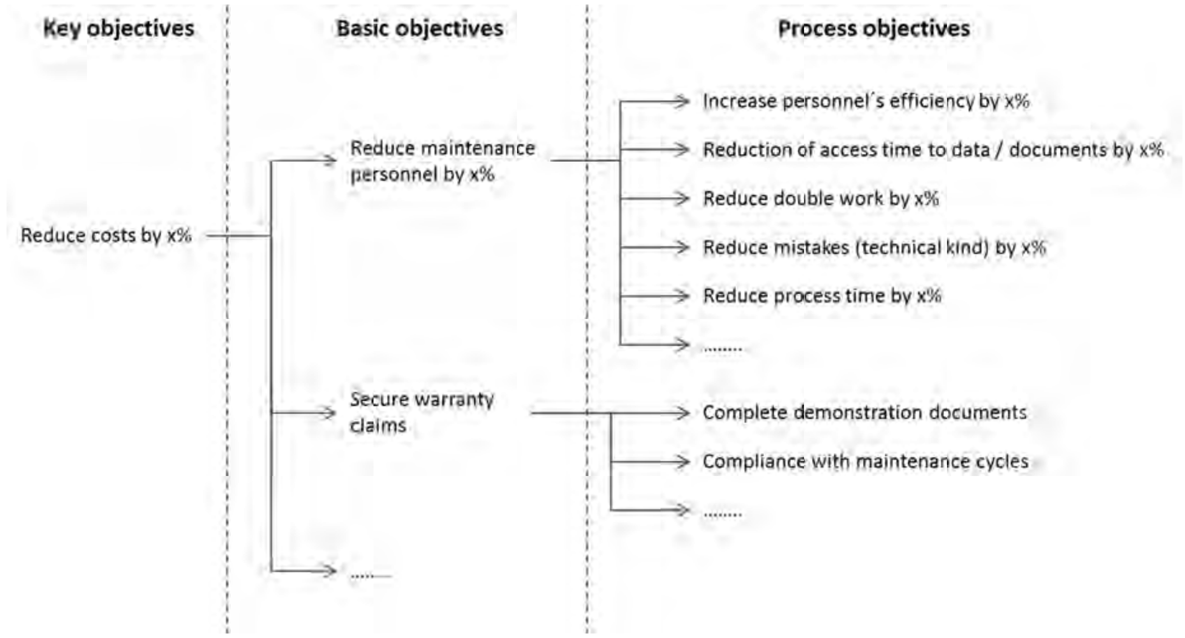

Figure 8-4: Example for a goal hierarchy

In the 3rd step, the identified process objectives are evaluated in a paired comparison concerning their mutual, direct interdependencies. The aim of this comparison is to identify particularly competing objectives, as setting priorities among them reduces inconsistencies in the target system.

The strength of interdependencies is estimated in step 4, which is largely subjective and based on experience of the involved interviewees. The scale for the estimation can be chosen freely, but it should not be too fine-grained, since this would cause pseudo-accuracies (Meixner & Haas, 2012, p. 202). Thus, the authors propose a three-level scale (low (value 1), medium (value 2), strong effects (value 3)).

Next the estimation of their likelihood (probability) is needed (step 5). It is methodologically based on risk management (e.g. (NIST, 2012, p. 23)) and in practice on the experience of the involved individuals. Again a three-level scale is proposed to estimate the likelihood of effects: effect is possible, but improbable (value 1); effect is probable (value 2); effect will occur with the utmost probability (value 3).

It is necessary that the interviewees agree internally on the nature of the effects – but not necessarily on their effective strength and likelihood, since without such an agreement, the target-relation-matrix cannot be installed. The individual effects between objectives should not be regarded as absolute and as in all circumstances occurring, but rather they indicate general trends which may be reinforced, mitigated or neutralized under certain circumstances, or by the use of respective (appropriate or inappropriate) systems.

To ensure that mainly high priority objectives are pursued, which have the greatest benefit, competing relations between objectives must be detected. This is done in the 6th step, where the objective priorities are determined. Based on the prospect theory by (Kahneman & Tversky, 1979), a preference-neutral weighting assumes that the weight of an objective can be determined by its active and passive value. To receive these values, for each objective its strength of effects is multiplied with the likelihood of its occurrence. The resulting (mathematical) products are subsequently summed up for each objective in both the horizontal (so-called 'active value') as well as in the vertical ('passive value') axis of the table. This procedure is legitimate insofar as the value of an effect can be defined as the product of strength of effects and their likelihood of occurrence (see also (Kahneman & Tversky, 1979)). A threshold should be defined by a decision maker which allows the classification of objectives in different priorities. As there is no standardized procedure for defining a threshold, the authors propose to choose a threshold that divides the objectives 'on sight'.

In the last step (7) the final target system is defined by consolidating the earlier steps and assigning final priorities to objectives.

8.3 Definition of the Target System in an SME of the Building Industry

We validate the first activity of the integrative framework in practice. We do so by operationalizing it at an SME in the building industry, where the definition of the target system was applied in the field of resource planning processes for workers who spend most of their working time outside of the company´s industrial premises (e.g. truck drivers, operators). An earlier version of the integrative framework, including the activity for defining the target system, has been applied to a large company (Högler, Versendaal, & Batenburg, 2015). From this experience we were able to fine-tune the first step, and prepare optimally for our SME.

In contrast to most of the available research literature, which focuses on large companies, the authors have chosen an SME as they have typically fewer financial resources and lower IT expertise (cf. (Huin, 2004; Forsman, 2008; Andersson & Tell, 2009; Haug, Pedersen, & and Arlbjørn, 2011)), in comparison to larger companies. At the same time, SMEs are the economic backbone of many countries in Europe, representing 99.8% of companies, whereas 89.3% are companies with less than 10 employees (IfM, 2013). Particularly for these micro companies a proper definition of the target system is of key importance in this context as they need to increase their digitalization level to increase their efficiency and to develop new products and services (cf. (BMWi, 2018)).

According to the Annual Report on SMEs of the European Commission (Muller, Gagliardi, Caliandro, Bohn, & Klitou, 2014), the building industry is one of the five most important SME sectors in the EU28, but is facing since the economic crisis still many challenges. One of the challenges is the fact that the building industry lags significantly behind other sectors in terms of ICT adaption (Hosseini, Chileshe, Zuo, & Baroudi, 2013). As different kinds of vehicles are used for the transport of construction material, their reliability and disposability is of high importance; resource planning and maintenance management systems help to keep track of (maintenance) schedules and thus to increase availability and service life of vehicles and machines. Bearing these facts in mind, we think that our case study organization, which is providing mainly mobile services for the building and construction industry in Germany, is appropriate. Moreover, as many German construction logistics companies, the case study SME faces competition from eastern European countries and has to optimize processes to increase efficiency of staff and to become more competitive. The particular SME was also selected due to already existing contacts of the authors with the organization, allowing easy access to management and operational employees.

8.3.1 Description of the Case Study

The case study company is located in Rhineland-Palatinate, Germany, and has six employees; two in management (CEOs) and four operational workers (truck drivers). Main activities of the company are excavation and earthwork, supplying of building material, pavement and demolition works and garden design within a range of 100 km around their offices. The fleet of cars encompasses 15 vehicles, among excavators, wheel loaders, caterpillars and trucks that have to be maintained regularly and that form the backbone of the daily business. As all processes rely on the availability and reliability of the cars, their maintenance is of key importance.

The application of the first activity of the integrative framework to a real case study followed the recommendation of Yin (2013, p. 84) and Maimbo and Pervan (2005), resembles the approach of Miles, Huberman and Saldana (2013), and had four stages:

1. Designing the case study protocol (section 8.3.2),
2. Conducting the case study (section 8.3.3),
3. Analyzing the case study evidence (section 8.3.4) and
4. Developing the conclusions, recommendations and implications based on the evidence (section 8.4).

The single stages – used to validate the theoretical construct of the framework – are described in detail in the following sections. We end our paper with a discussion on the validity of our integrative framework based on its partly operationalization.

8.3.2 Designing the Case Study Protocol

The research methodology integrates a structured case study protocol that guides in conducting the case study (Yin, 2013) and supports to address issues of both rigor and validity in the data collection process. The protocol was upfront designed following the procedure proposed by Maimbo and Pervan (2005) (see annex 1). While the case study was conducted, the proposed protocol was followed. The following subsections describe the case study´s process and results in detail. The procedure follows the seven sub-steps (see section 0) of activity 1 of our Integrative Framework.

8.3.3 Conducting the Case Study

To get a first impression on the daily work, a task observation and analysis (Kosiol, 1976) was proceeded; for this, one of the authors was accompanying a truck driver for 4 days. The a-priori categories of objectives contained in this questionnaire were the result of:

- main literature on business process (re-)engineering and management (e.g. (Staudt, 1996; Aichele, 1997; Darnton & Darnton, 1997; Harrington, Esseling, & Nimwegen, 1997; Gruhn & Wellen, 2001; Turowski & Pousttchi, 2004; Hammer & Champy, 2006)) and mobile business (e.g. (Schiller, 2000; Lehner, 2002; Köhler & Gruhn, 2004), (Lehner, 2002), (Köhler & Gruhn, 2004)) and
- former analyses proceeded in the timeframe 2006-2009 at several German companies, mainly of the chemical industry and the public sector, when one of the authors was working as a product manager at Rösberg Engineering Ingenieurgesellschaft mbH für Automation for mobile maintenance management systems at several German companies in the chemical industry.

These objectives were completed with objectives that were identified during the task observation and its analysis. For the final questionnaire, their hierarchy was constructed (also based on literature review, see a)), leaving room for additional objectives in the semi-structured interviews (see excerpt in Table 8-1 for the constructed questionnaire; full questionnaire in annex 2).

Two workshops were subsequently held, executing steps 1-6 with the participants, using the constructed questionnaire. During the workshops no additional objectives were mentioned by the participants, indicating that the literature, working experience and task observation and analysis proved to be appropriate preparation for building the questionnaire. The scheduling of workshops was in all cases spontaneous with a lead time of one or two days as a longer lead time led to postponements due to unscheduled workload. The workshops were conducted in separate groups – one with the management (2 CEOs) and one with a worker (truck driver). The visits took place early 2016; the workshops had an average duration of 2 hours.

Table 8-1: Excerpt of the questionnaire

Key objective 1	**Profit maximization**
Basic objective 1.1	**Cost reduction**
Process objectives:	
	Savings on machines by
	Savings on personnell costs by
	Savings on (maintenance)processes by
	Savings on repairs by
	Savings on material consumption by
	Increasing availability of own machines by
	Securing warranty claims
	Other process objectives
Basic objective 1.2:	**Increasing plant availability by x%**
Process objectives:	
	Reduction of troubles by %
	Reduction of system failures by
	Other process objectives

For step 7 a third workshop with the company´s management and an external financial advisor was performed. By this, the separate results from the two different groups were consolidated and eventually agreed upon. During this workshop one of the authors presented the determination of objectives in every single step. Objectives with high priority were discussed in detail with the CEOs and the financial advisor. Objectives with low priority were omitted as the CEOs and the financial advisor wanted to focus on objectives with the highest positive impact. The advisor, although not involved in the process, confirmed the transparency of the procedure as well as the achieved results, which accord with his findings to a great extent.

8.3.4 Results and Analysis

The outcomes of the semi-structured interviews with CEOs and worker can be summarized and processed as follows.

8.3.4.1 Step 1-2: Determination and Structuring of Objectives

Table 8-2 shows the results of the two workshops for the determination of objectives. The worker identified more process objectives than the CEOs. This implies that he sees more need for optimization than the CEOs. Here, the worker sees much more need for action than the CEOs. The reason for this could be a constant information loss between the CEOs and the workers, which is either not recognized by the CEOs or not always reported / confirmed by the workers. In contrast, the CEOs identified the key objective ‘enhancing (the company) image’ which was not chosen by the worker.

Also the percentages for the quantitative objectives differed in some cases, but only to a limited extent. Summarizing the findings, the worker saw less potential in cost savings regarding repairs than the CEOs. At the same time, he has identified additional cost saving potential by enhancing the availability of machines, at maintenance processes and for the material consumption. In contrast, the worker saw less potential to reduce the workload (20% in comparison to 40% desired by the CEOs). In terms of the key objective 'enhancing process quality', the worker generally saw a higher need for optimization than the CEOs, although there are only slight differences for most process objectives. Note the difference in the process objectives 'efficiency of machines' (worker: 50%, CEOs: 30%) and 'improving the planning ability (calculability) of tasks', where the worker sees a higher need for improvement (100% in comparison to 70% mentioned by the CEOs). Also this difference indicates the different view on current processes and related deficiencies. It seems that the worker sees himself strongly affected by the unpredictable nature of task allocation.

Table 8-2: Management (CEOs) objectives and worker (truck driver) objectives

		CEOs		Worker	
		%			%
Key objective 1	**Profit maximization**		x	x	
Basic objective 1.1	**Cost reduction**		x	x	
Process objectives:					
	Savings on machines by	30	x	x	25
	Savings on personnell costs by				
	Savings on (maintenance)processes by			x	10
	Savings on repairs by	50	x	x	30
	Savings on material consumption by			x	20
	Increasing availability of own machines by			x	50
	Securing warranty claims		x	x	
Key objective 2	**Increased process quality**		x	x	
Basic objective 2.1	General support of processes			x	
Process objectives:					
	Enhanced task overview		x	x	
	Reduction of information losses by	90	x	x	100
	Prevention of entry errors (validation documentation)			x	
	Secure available knowledge		x	x	
	Overview on "who, what, when"			x	
	Predictive Maintenance		x	x	
	Optimization of maintenance intervals		x	x	
Basic objective 2.2	**Enhanced Controlling /Monitoring**		x	x	
Process objectives:					
	Problems / troubles with machines		x	x	
	Problems / troubles within processes		x	x	
	Condition of machines			x	
	Repairs of machines		x	x	
	Tracking of tasks / processes		x	x	
	Efficiency of employees		x	x	
	Efficiency of machines		x	x	
	Material consumption		x	x	
	Inventory / stock			x	
	Costs of machines		x	x	
	Costs of employees			x	
	Costs of processes		x	x	
	Costs of material		x	x	
Basic objective 2.3	**Enhanced working conditions**			x	
Process objectives:					
	Reduction workload of personnel by	40	x	x	20
	Compliance with regulations		x	x	
	Increased work safety		x	x	
Basic objective 2.4	Enhanced data availability			x	
Process objectives:					
	Ubiquitous data availability			x	
	Seamless collection of data / information			x	
Basic objective 2.5	**Support of decision processes**		x	x	
Process objectives:					
	Enabling data analysis			x	
	Fast access to (all) necessary documents			x	
	Complete verification documentation		x	x	
Basic objective 2.6	**Minimization of environmental effects**		x	x	
Process objectives:					
	Compliance with environmental protection requirements		x	x	
Key objective 3	**Reaching production targets**		x	x	
Basic objective 3.1	**Optimisation of processes**		x	x	
Process objectives:					
	Increased utilization of machines by	30	x	x	50
	Reduction of downtime of personnel by			x	100
	Reduction of downtime of machines by			x	100
	Reduction of process interruptions by	80	x	x	100
	Reduction of unnecessary work by	90	x	x	100
	Reduction of follow-up work by	90	x	x	100
	Reduction of duplication of work by	90	x	x	100
	Reduction of false tasks by	90	x	x	100
	Unambiguousness of tasks		x	x	
	Increased predictability of tasks by	70	x	x	100
	Enhanced task planning		x	x	
	Enhanced resources planning		x	x	
	Enhanced coordination of personnel	50	x	x	40
	Increased productivity of employees by			x	
	General improvement of operational procedures		x	x	
	Reduction of paperbased documentation by			x	
Key objective 4	**Improved Image**		x		
Basic objective 4.1	Increased quality of processed tasks			x	
Process objectives					
	Increased process quality		x	x	
	Enhanced working conditions			x	
	Minimised environmental impacts		x	x	

Legend:
X: Objective identified by participant as relevant

%: numeric description of the quantitative objective (best-case scenario)

8.3.4.2 Steps 3-5: Analyzing Effects between Objectives

In the next step, the effects or dependencies between process objectives were analyzed as described in section 8.2. As key and basic objectives are used only for structuring process objectives, they have been omitted during the analysis. For each objective its strength of effects is multiplied with the likelihood of its occurrence. The resulting (mathematical) products are subsequently summed up for each objective in both the horizontal (so-called ‘active value’) as well as in the vertical (‘passive value’) axis of the table.

The results of the steps 3-5 were two tables: One contains estimations of the CEOs and the other estimations of the worker. As the interviews were proceeded separately and the different participant groups (2 CEOs, 1 worker) had no possibility to discuss their assumptions and estimations, the authors propose to keep the different target systems until step 7, where the resulting target systems are merged. The resulting target-relation-matrices document the effects between individual objectives (step 3).

Table 8-3: Results of steps 3-5, CEOs´ view

			Profit maximization			Increased process quality																				Reaching production targets												Improved Image		
			Cost reduction			General support of processes					Enhanced Controlling /Monitoring										Enhanced working conditions			Sup port of deci	Mini miz atio n of	Optimisation of processes												Increased quality of processed tasks		
			Savings on machines by	Savings on repairs by	Securing warranty claims	Enhanced task overview	Reduction of information losses by	Secure available knowledge	Predictive Maintenance	Optimization of maintenance intervals	Problems / troubles with machines	Problems / troubles within processes	Repairs of machines	Tracking of tasks / processes	Efficiency of employees	Efficiency of machines	Material consumption	Costs of machines	Costs of processes	Costs of material	Reduction workload of personnel by	Compliance with regulations	Increased work safety	Complete verification documentation	Compliance with environmental protection r	Increased utilization of machines by	Reduction of process interruptions by	Reduction of unnecessary work by	Reduction of follow-up work by	Reduction of duplication of work by	Reduction of false tasks by	Unambiguousness of tasks	Increased predictability of tasks by	Enhanced task planning	Enhanced resources planning	Enhanced coordination of personnel	General improvement of operational procedures	Increased process quality	Minimised environmental impacts	Active values
Profit maxi	Cost reducti	Savings on machines by			-2																					-1							-1	-1	-1		-1	-1		-8
		Savings on repairs by	6													-1																								5
		Securing warranty claims	9	9																																				18
Increased process quality	General support of processes	Enhanced task overview											1	4	9	9	1	1	1	1							6	6		3			9	9	9	9	2			80
		Reduction of information losses by	1					6	1	1	6	6	1	4	2	2	2	4	4	4	2						3	9	6	9	9	3	1	9	2		9	6		112
		Secure available knowledge		1					4													2	2		2			2			2						9	9		33
		Predictive Maintenance	4	4						9								1		1						3	6	3			1		2	4	4		2	4		48
		Optimization of maintenance intervals	6	4	1																	1				6							2	1	1		2	1		25
	Enhanced Controlling /Monitoring	Problems / troubles with machines	6	2	1		1		6			2	1			9		9	9		1					3	6	2		1	2		4	6	4	4	4			83
		Problems / troubles within processes	1	1			1								6	6		1	9				1			1	9	2					9	9	6	6	6			74
		Repairs of machines	4	2	6		1		9		3	2				3		3	3	1							1	1	1	3	1		1	1	1		1			48
		Tracking of tasks / processes	1	2	9		3		1		6	6	1		6	6		2	2	2				9		1		9	2	6	1		3	6	3	2	6			95
		Efficiency of employees					1					6							6		4												9	9	9	4	2			50
		Efficiency of machines	9	1			1				3	3						3	2							3							3	6	6	4	2			46
		Material consumption	1	1			1				1	1							4	9													1							19
		Costs of machines	6	4			2				3	3							3																					21
		Costs of processes	2	1			2				6	6																												17
		Costs of material	2	2			2						3				9		4																					22
	Enhanced working conditions	Reduction workload of personnel by																				1	4																	5
		Compliance with regulations			9																		3		2													9	9	32
		Increased work safety																				9																9		18
	Su pp ort of	Complete verification documentation			9	1	9	2	1	1	6	6	3	9	3	3	3	6	6	6		3	1				2	6	4	9	3	6	2	2	1	3		6		122
	Mi ni mi zat	Compliance w. environ. protection require.																				6																	9	15
Reaching production targets	Optimisation of processes	Increased utilization of machines by	1	-9																																	2			-6
		Reduction of process interruptions by																								4							6	1	1	1	9			22
		Reduction of unnecessary work by	4																		9																3	9		25
		Reduction of follow-up work by	2																		9																3	6		20
		Reduction of duplication of work by	4																		6																3	9		22
		Reduction of false tasks by	4																		6																3	6		19
		Unambiguousness of tasks		2			6														9						3	9	9	9	9		2	2			9	9		78
		Increased predictability of tasks by	2								1	1	1		2	2	1	1	1	1	4					6	9	1		1				6	9	9	2	9		69
		Enhanced task planning																			2					6	9	3	1	3	1		3		6	3	9	9		55
		Enhanced resources planning	2								2		1	1		2		1	1	1						9	6						6	9			2	9		52
		Enhanced coordination of personnel												1							2		1			1	6		1	1	2		6	9	6		6	6		48
		General improvement of operat. procedures																			9					4	3	1	2	1	1					1		9		31
Improv ed Image	Increa sed quality of	Increased process quality	2				4				1	1	1	1	1	1	1	1	1	1	6		2			2	1	3	4	6	2					3				45
		Minimised environmental impacts																					2		9															11
		Passive Values	*79*	*27*	*33*	*1*	*34*	*8*	*22*	*11*	*38*	*43*	*13*	*20*	*29*	*42*	*17*	*33*	*56*	*27*	*69*	*22*	*16*	*9*	*13*	*48*	*70*	*57*	*30*	*52*	*34*	*9*	*68*	*88*	*67*	*49*	*95*	*124*	*18*	

Legend: Yellow marked fields: Objectives that were identified as relevant by management, but not by the worker
Green marked fields: Positive effects
Red marked fields: Negative effects

Table 8-4: Results of steps 3-5, worker´s view

	Savings on machines	Savings on (maintenance)processes	Savings on repairs	Savings on material consumption	Increasing availability of own machines	Securing warranty claims	Enhanced task overview	Reduction of information losses	Prevention of entry errors	Secure available knowledge	Overview on "who, what, when"	Predictive Maintenance	Optimization of maintenance intervals	Problems / troubles with machines	Problems / troubles within processes	Condition of machines	Repairs of machines	Tracking of tasks / processes	Efficiency of employees	Efficiency of machines	Material consumption	Inventory / stock	Costs of machines	Costs of employees	Costs of processes	Costs of material	Reduction workload of personnel	Compliance with regulations	Increased work safety	Ubiquitous data availability	Seamless collection of data / information	Enabling data analysis	Fast access to (all) necessary documents	Complete verification documentation	Compliance w. environm. protection requirem	Increased utilization of machines	Reduction of downtime of personnel	Reduction of downtime of machines	Reduction of process interruptions	Reduction of unnecessary work	Reduction of follow-up work	Reduction of duplication of work	Reduction of false tasks	Unambiguousness of tasks	Increased predictability of tasks	Enhanced task planning	Enhanced resources planning	Enhanced coordination of personnel	Increased productivity of employees	General improvement of operational procedures	Reduction of administrative tasks	Increased process quality	Enhanced working conditions	Minimised environmental impacts	Active Value
Savings on machines		1	1		-9																																1	-9	1															-14
Savings on (maintenance)processes	2		-9	2	-9	-9																									-9									-9	-9															-50
Savings on repairs	2				-9	-6																							-6	-9											-9															-9		-46
Savings on material consumption																																																							0
Increasing availability of own machines	2		1																																			9	9												6					27
Securing warranty claims	9	3	9												1	1																																						23
Enhanced task overview	1			1					1		9							9		9	9				3	3								3				9	6	9	6	3	6	6	3	9		9	9	6	9			3		141
Reduction of information losses	3		1	1							6		9				6	3			6		3	3	3	3												4	3		6	4	4	3	9					9					89
documentation)	1	1	1	1	1								1	6			2	2																				1				3	3	3	1	1	1					9	9			47
Secure available knowledge								9						2	2	6	3																						1	2	1	3	2	2	6	1						6					46
Overview on "who, what, when"	1																				9			3	3	3	3	1	1	2								9	9	9	6	6	1	6	1	1		9	9	9	9	9		9			128
Predictive Maintenance					9	9										6																								9	6	9	9	9										9		9			84
Optimization of maintenance intervals	9	9	9		9	2										1	1											2	6	6									6	6	3	1															70
Problems / troubles with machines	9		4			3		9				9			6		2			9				3		3													9			6	6		2	6		9	9	9	9		6					128
Problems / troubles within processes	1		2					9												6	9			3		3				3								9			9	6					9	9	3	3		6					90
Condition of machines			9		9							9	9	9	9		9							3						9							6	9	6	9	6							9			6		3	9		138
Repairs of machines	2		9			3		3				9		9	9					9			3		1	1													9			1	2	1	6	2		1	1	1			1					83
Tracking of tasks / processes	1		2			9		9				3		9	9		9		9	3			3		3	2									3		3				9	3	9	3		6	2	2	6		6					123
Efficiency of employees							9					9				2			2							9	9		1												6									9	9	3	6	6		6	-6		80
Efficiency of machines	3							3							3		3							3		3														9									9	9	9	9		4					67
Material consumption	1		1					6							1		3									3	3																								6										24
Inventory / stock																																							9																9
Costs of machines	2		1					2						9	9										3																																		26
Costs of employees																									9																														9
Costs of processes	2		1					2						6	9																																										20
Costs of material	1		1					2									3				9				2																																	18
Reduction workload of personnel																													4	9																											13
Compliance with regulations						6																							9								9																	9			33
Increased work safety																													9																									9			18
Ubiquitous data availability							3	9			9	1	1					1		3												3	9	1										1	9	6	9	9	9	9					92
Seamless collection of data / information							3	9																			9			9		9		3																			9			51
Enabling data analysis		1	1		-9																																1	-9	1															-14
Fast access to (all) necessary documents							2	3			9																9				1								9	4	2	4	6	9	3	1	1	3	9	9		9			93
Complete verification documentation						9	2	3				9	9	9	9		9	9	6	6	6		9		9	9		9	2											2	6	2	9	3	3	1	1	1	1				9			162
Compliance w. environ. Protect. Require.																												9																										9
Increased utilization of machines	9		-9																		1																														1					2
Reduction of downtime of personnel																											-9	-4	-4							6		9	1																-1
Reduction of downtime of machines			-9		9																															9			6																15
Reduction of process interruptions																																				9									6	1	4	2		9		9			40
Reduction of unnecessary work	6		3												1	1	1	1										9															3				1	1	1			9		9			46
Reduction of follow-up work	6						1																			9																					1			9		9			35
Reduction of duplication of work	6																											9													9	1				1					9		9			44
Reduction of false tasks by	6																											9												2	9	9	6								9		9			59
Unambiguousness of tasks	3		9				1	9												1							9		2											9	9	6	1	9		6	2				9		9			94
Increased predictability of tasks	2						1	1	1	1									6	1							2											6			9	1		1				9	9	9		9		9			77
Enhanced task planning	3		2	1	3	1	3	2	1	1							1	1	2	1							4		2	1	1	1	1	1	1	9			9	9	9	2	2		9		9	9		9		9			119
Enhanced resources planning	6														1			1	1		1																9			9						9	9				9		9			64
Enhanced coordination of personnel	2						1							1						9	1							4		2								2			9		2	4	1		9	9	9			9		9			83
Increased productivity of employees																																																							0
Gen. improvement of oper. procedures	9					3		3						2	2		2	3	6	3	3					1	1	6	6	6					3	9			9	9	9	9	6			9	9					9			137
Reduction of administrative tasks																													9						9																	1			19
Increased process quality	9					3		3						2	2		2	3	6	3	3					1	1	6	6	6					3	9			9	9	9	9	6			9	9								6	134
Enhanced working conditions	-3																											9	6	9																								4			25
Minimised environmental impacts																												9							9																			6			24
Passive Value	116	15	40	6	4	33	26	96	3	2	42	40	30	65	73	15	58	34	50	69	36	0	33	15	59	26	89	64	45	10	2	13	13	8	40	143	44	56	124	115	71	83	64	22	113	88	122	99	39	192	9	191	-3	6	

Legend: Yellow marked fields: Objectives that were identified as relevant by worker but not by the management
Green marked fields: Positive effects
Red marked fields: Negative effects

8.3.4.3 Step 6: Preference-Neutral Prioritization

For the preference-neutral prioritization, the active and passive values have been calculated as described in section 8.2 for each interview group. The CEOs and the worker were asked to insert a vertical and a horizontal line that divides the identified objectives into four priorities (A-D). To do so, they were asked to compare two objectives that are near to the center of the figure and to decide which of these objectives is more important than the other and then to decide which priority the more important objective should get. Within three iterations (management) and two iterations respectively (worker) the thresholds were defined.

The resulting dependency matrix of each interview group is shown in Figure 8-5 and Figure 8-6:

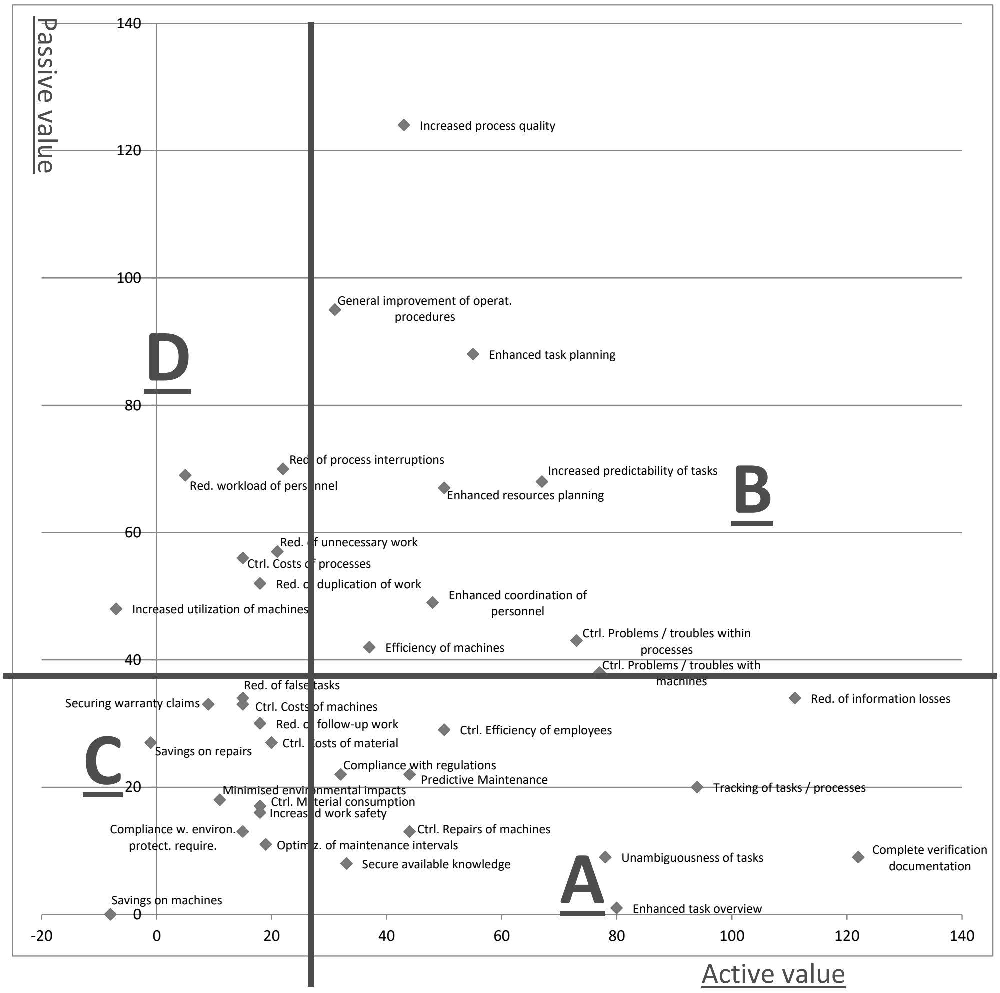

Figure 8-5: Objectives and their preference-neutral priorities (CEOs)

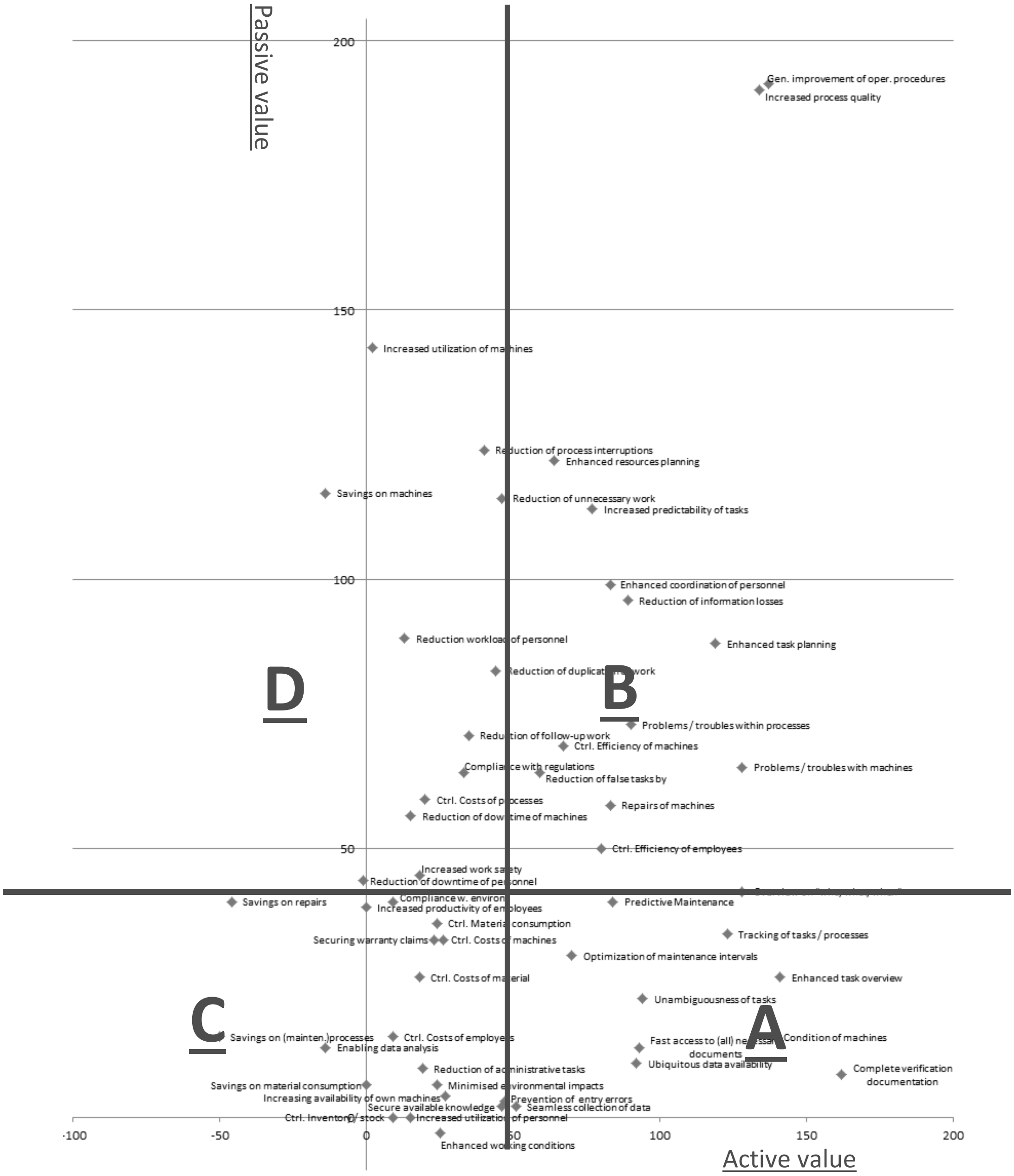

Figure 8-6: Objectives and their preference-neutral priorities (worker)

8.3.4.4 Step 7: Definition of the Final Target System

In the last step the final target system is defined by merging the existing target system of CEOs and the interviewed worker and assigning final weightings to objectives. Table 8-5 gives an overview on the objectives and their preference-neutral prioritization (result of step 6). The main focus of the discussion was put on Figure 8-5 and Figure 8-6 as well as on Table 8-5, which was the basis for merging and consolidating the two target systems.

A comparison of objectives shows that prioritization of CEOs and the worker correspond to a great extent. It is obvious, that a complete documentation is a very important objective as the preference-neutral prioritization (Table 8-5). The objectives 'tracking of tasks & processes', 'enhanced task overview' and 'unambiguousness of tasks' have also been identified for both groups as of high relevance and received very similar weightings.

Table 8-5: Comparison of results (preference-neutral prioritization)

	CEOs					**Worker**	
	Objectives	Active Value	Weighting	Weighting	Active Value	Objectives	
Priority A	Complete verification documentation	122	15%	17%	162	Complete verification documentation	**Priority A**
	Reduction information losses	112	13%	15%	141	Enhanced task overview	
	Tracking tasks / processes	95	11%	14%	138	Ctrl. condition of machines	
	Ctrl. problems / troubles machines	83	10%	13%	128	Overview on "who, what, when"	
	Enhanced task overview	80	10%	13%	123	Tracking tasks / processes	
	Unambiguousness of tasks	78	9%	10%	94	Unambiguousness of tasks	
	Ctrl. problems / troubles within process	74	9%	10%	93	Fast access to documents	
	Ctrl. efficiency of employees	50	6%	9%	92	Ubiquitous data availability	
	Predictive Maintenance	48	6%	20%	137	General impr. of operat. procedures	**Priority B**
	Ctrl. repairs machines	48	6%	19%	134	Increased process quality	
	Enhanced coordination of personnel	48	6%	18%	128	Ctrl. problems / troubles machines	
Priority B	Increased predictability of tasks	69	39%	17%	119	Enhanced task planning	
	Enhanced task planning	55	31%	13%	90	Ctrl. problems / troubles within processe	
	Enhanced resources planning	52	30%	13%	89	Reduction information losses	
Priority C	Ctrl. efficiency of machines	46	15%	20%	84	Predictive Maintenance	**Priority C**
	Secure available knowledge	33	11%	17%	70	Optimization of maintenance intervals	
	Compliance with regulations	32	11%	12%	51	Seamless collection of data	
	Optimization of maintenance intervals	25	8%	11%	47	Prevention of entry errors	
	Ctrl. costs of material	22	7%	11%	46	Secure available knowledge	
	Ctrl. costs of machines	21	7%	7%	27	Increasing availability of own machines	
	Reduction of follow-up work	20	7%	6%	26	Ctrl. costs of machines	
	Ctrl. material consumption	19	6%	6%	25	Enhanced working conditions	
	Reduction of false tasks	19	6%	6%	24	Ctrl. material consumption	
	Securing warranty claims	18	6%	6%	24	Minimised environmental impacts	
	Increased work safety	18	6%	6%	23	Securing warranty claims	
	Compliance w. environ. protection requirem.	15	5%	5%	19	Reduction of administrative Tasks	
	Minimised environmental impacts	11	4%	4%	18	Ctrl. costs of material	
	Savings on repairs	5	2%	4%	15	Increased utilization of personnel	
	Increasing availability of own machines	-6	-2%	2%	9	Ctrl. Inventory / stock	
Priority D	Increased process quality	45	28%	2%	9	Ctrl. cost of employees	
	General impr. of operat. procedures	31	19%	2%	9	Compliance w. environ. prot. requirem.	
	Red. of unnecessary work	25	16%	0%	0	Savings on material consumption	
	Red. of process interruptions	22	14%	0%	0	Increased productivity of employees	
	Red. of duplication of work	22	14%	0%	-1	Reduction of downtime of personnel	
	Ctrl. costs processes	17	11%	-3%	-14	Enabling data analysis	
	Reduction workload	5	3%	-11%	-46	Savings on repairs	
	Savings on machines	-8	-5%	-12%	-50	Savings on (maintenance)processes	
				11%	83	Ctrl. repairs of machines	**Priority D**
				11%	83	Enhanced coordination of personnel	
	Legend:			10%	80	Ctrl. efficiency of employees	
	Yellow marked cell:			10%	77	Increased predictability of tasks	
	- objectives that were identified as relevant			9%	67	Ctrl. efficiency of machines	
	by management, but not by worker (CEOs'			8%	64	Enhanced resources planning	
	column)			8%	59	Reduction of false tasks	
	- objectives that were identified as relevant			6%	46	Reduction of unnecessary work	
	by worker, but not by management (Worker's			6%	44	Reduction of duplication of work	
	column)			5%	40	Reduction of process interruptions	
				5%	35	Reduction of follow-up work	
	Priority A: Very important objective			4%	33	Compliance with regulations	
	Priority B: Important objective			3%	20	Ctrl. costs of processes	
	Priority C: Less important objective			2%	18	Increased work safety	
	Priority D: Least important objective			2%	15	Reduction of downtime of machines	
				2%	13	Reduction workload of personnel	
				0%	2	Increased utilization of machines	
				-2%	-14	Savings on machines	

Analyzing the other objectives it becomes clear, that the worker has a higher information need as his priority-A objectives focus mainly on a better data and document availability as well as on a better overview on the assignment of tasks and the state of machines. From this we can derive that the worker faces information losses and a lack of necessary information during his daily work.

The CEOs focus on very similar objectives, but from another perspective. E.g. the ‘reduction of information losses’ has received the second highest weighting for objectives of priority A, which supports the findings described in the previous paragraph (worker´s view). Five objectives focus on enhancing monitoring and controlling, mainly of processes (‘tracking of tasks’, ‘troubles within processes’, ‘efficiency of employees’), but also of machine malfunctions and repairs. The latter ones are both important factors for allowing a predictive maintenance, which was also identified as a very important objective for the CEOs. The objectives ‘unambiguousness of tasks’ and ‘enhanced coordination of personnel’ are connected to the objective ‘better task overview’ as the latter one is the prerequisite for a better coordination.

Table 8-6: Merged priority A and B objectives of CEOs and worker

	Both	CEOs	Worker
Priority A	Complete verification documentation	Ctrl. efficiency of employees	Ctrl. condition of machines
	Tracking tasks / processes	Predictive Maintenance	Overview on "who, what, when"
	Enhanced task overview	Ctrl. repairs machines	Fast access to documents
	Unambiguousness of tasks	Enhanced coordination peronnel	Ubiquitous data availability
Priority B	Enhanced task planning	Increased predictability of tasks	General impr. of operat. procedures
	Enhanced resources planning		Increased process quality
Mixed priorit	Reduction info. losses		
	Ctrl. problems / troubles machines		
	Ctrl. problems / troubles within process		
	Legend:		
	Yellow marked cell: - objectives that were identified as relevant by management, but not by worker (CEOs' column) - objectives that were identified as relevant by worker, but not by management (Worker's column)	Mixed priority: Objective received different priority	

During the feedback loop workshop the CEOs and financial advisor discussed the results. They have been asked by one of the authors to merge objectives for ‘A’ and ‘B’ prioritization. As they recognized the importance of their own but also of the worker´s high priority objectives, they agreed on the following consolidation of priorities of objectives with A or B priority:

- priority A for objectives, that are relevant for the CEOs AND the worker (column ‘Both’ in Table 8-6)
- priority A for objectives, that have priority A for the CEOs OR the worker
- priority B for all other objectives.

The resulting final target system is shown in Table 8-7. It will be used by the CEOs as starting point for the definition of requirements of an ideal resources planning system (with focus on mobile processes) and in a later stage for the support of the decision making process on which system to implement.

Table 8-7: Final target system

Priority A	Priority B
Complete verification documentation	Enhanced task planning
Tracking tasks / processes	Enhanced resources planning
Enhanced task overview	Increased predictability of tasks
Unambiguousness of tasks	General impr. of operat. procedures
Ctrl. efficiency of employees	Increased process quality
Predictive Maintenance	
Ctrl. repairs machines	
Enhanced coordination peronnel	
Ctrl. condition of machines	
Overview on "who, what, when"	
Fast access to documents	
Ubiquitous data availability	
Reduction information losses	
Ctrl. problems / troubles machines	
Ctrl. problems / troubles within process	

8.4 Conclusions, Recommendations and Implications

In this paper the authors applied the definition of the target system as part of an integrative framework for determining the economic impact of ICS using the example of mobile technologies, which was described in detail in section 8.2. This validation was carried out through the practical case in a German SME (building industry) described in this paper which was in its first stages of deciding whether to implement a mobile resource planning system. The main results of the applied procedure for defining a target system were presented in section 8.3.4. Defining the prioritized target objectives in the context of the German SME proved to be usable: We were conveniently able to a) defining a priori objectives and a resulting questionnaire through among others literature and task observation and analysis, b) holding workshops in identifying and prioritizing objectives, and c) validating and consolidating results in a separate workshop with CEOs and an external financial advisor.

In order to improve validity of the integrative framework, further implementations in practice are necessary in other branches and for different kinds of applications. Further case studies are planned within some research projects, specifically the German projects BigDieMo[59] and Mittelstand 4.0 Stuttgart and the EU-funded project PERMIDES, which are currently in the preparation phase. In addition, the proposed methodology for defining a target system can be applied to different kinds of target systems, not only in the field of mobile IT as presented in this paper as it is a generic approach based on the Analytical Hierarchy Process which is used for decision-making processes in general. The authors are aware that for validating the complete integrated framework from the very beginning of a project until the first monitoring stage (e.g. after 2 years after implementation), more case studies and longitudinal data collection is needed.

[59] For more information see: https://www.ksri.kit.edu/news_1765.php

Annex 1: Upfront case study protocol

Preamble	Confidentiality and data storage	Anonymous, full data
	Publication	For research purposes only
	Documentation	Via Laptop and Excel file
	Layout of protocol	Excel file (Annex 2)
General	Overview of research project	It is generally accepted that ICT & ICS are an integral part of most businesses. Also accepted is that many of these systems are ineffective and under-utilised, but in most cases it is less a shortcoming of the implemented technologies but the lack of business/IT alignment and appropriate evaluation methodologies. To close this gap, it is proposed that a new way of evaluation and alignment between IT and business is necessary – a so-called socio-technical approach. The proposed Integrative Approach starts from the very beginning in a user-centric way and allows to identify critical success factors (both human and technical ones) that lead to a better business/IT alignment. The research aims to address the application of the first activity of the Integrative Approach – definition of a target system – in practice at a German SME in the building sector.
	The case research method	A triangular and qualitative-quantitative research approach is followed, including a literature study, previous workshops and a questionnaire that will be used during interviews. Operational task observations: in order to learn the SME's operations several days the tasks of one or more employees are to be observed. The subsequent interviews will follow the procedure proposed by Miles and Huberman (2013): Collect data (interviews with 3 separate groups: blue collar(s), management and external financial advisor). Structure data (following steps 2-6 of the proposed procedure for defining the target system); this should also done in association with the interviewees. Reduce data (step 7).
Procedures	Initial approach to organisation	Selection of cases: As most research is done within large enterprises, SMEs are chosen as research field. Maintenance processes are chosen as the author worked for years as product manager in the field of Mobile Maintenance Management. The selected company was chosen as good contacts already existed and the company is aiming at enhancing its processes. Number of cases: 1
	Establishing contact	The contact to the company management is established via private relationship to the company.
	Scheduling of field visits	4 days of task observation, 2 visits of the management (1 visit for interviews, 1 for discussion of results (together with financial advisor) and definition of further steps to be taken) 1 interview of financial advisor 1 interview with truck driver / employee / worker
	Session length	4 separate days for task observation, per subsequent interview 1 hour in average
	Equipment	Laptop, Excel file
Research instrument	Semi-structured interviews	A questionnaire will be used during interviews, allowing also to add additional objectives that are not given by the questionnaire
Data analysis guidelines	Overview on data analysis process	Steps 2-6 of the 1st activity of the Integrative Framework (in association with the interviewees): - set up of goal hierarchy - analysis of effects (dependencies) between objectives - estimating strength of effects - assessment of the likelihood of effects - preference-neutral prioritization Step 7: - reduce objectives to final target system
	Convergence of data	Definition of an a-priori list of objectives (see annex 2): - Objectives related to "cost reductions" - Objectives related to "process quality" - Objectives related to "monitoring & control" - Objectives related to "working conditions" - Objectives related to "decision processes" - Objectives related to "environmental impact" - Objectives related to "processes" - Objectives related to "quality of work" Triangulation of data as follows: - 4 days observation of tasks of employees (truck driver) - 1 workshop with management (2 CEOs) - 1 workshop with employee (truck driver) - 1 workshop with management and external financial advisor - Suggested merging of outcomes Only one source of data (data gained during interviews) will be used as no further documentation or similar exists. Triangulation will be achieved by including all identified objectives into 1 table and taking average values of (steps 3-5)

Annex 2: Questionnaire

Key objective 1	**Profit maximization**
Basic objective 1.1	**Cost reduction**
Process objectives:	
	Savings on machines by
	Savings on personnell costs by
	Savings on (maintenance)processes by
	Savings on repairs by
	Savings on material consumption by
	Increasing availability of own machines by
	Securing warranty claims
	Other process objectives
Basic objective 1.2:	Increasing plant availability by x%
Process objectives:	
	Reduction of troubles by %
	Reduction of system failures by
	Other process objectives
Key objective 2	**Increased process quality**
Basic objective 2.1	General support of processes
Process objectives:	
	Enhanced task overview
	Reduction of information losses by
	Prevention of entry errors (validation documentation)
	Secure available knowledge
	Overview on "who, what, when"
	Predictive Maintenance
	Optimization of maintenance intervals
	Other process objectives
Basic objective 2.2	**Enhanced Controlling /Monitoring**
Process objectives:	
	Problems / troubles with machines
	Problems / troubles within processes
	Condition of machines
	Repairs of machines
	Tracking of tasks / processes
	Efficiency of employees
	Efficiency of machines
	Material consumption
	Inventory / stock
	Costs of machines
	Costs of employees
	Costs of processes
	Costs of material
	Other process objectives
Basic objective 2.3	**Enhanced working conditions**
Process objectives:	
	Reduction workload of personnel by
	Compliance with regulations
	Increased work safety
	Other process objectives
Basic objective 2.4	Enhanced data availability
Process objectives:	
	Ubiquitous data availability
	Data availability 24/7
	Realtime data collection / availability
	Seamless collection of data / information
	Other process objectives
Basic objective 2.5	**Support of decision processes**
Process objectives:	
	Enabling data analysis
	Fast access to (all) necessary documents
	Complete verification documentation
	Other process objectives
Basic objective 2.6	**Minimization of environmental effects**
Process objectives:	
	Compliance with environmental protection requirements
	Other process objectives
Key objective 3	**Reaching production targets**
Basic objective 3.1	**Optimisation of processes**
Process objectives:	
	Increasing utilization personnel by
	Increased utilization of machines by
	Reduction of downtime of personnel by
	Reduction of downtime of machines by
	Reduction of process interruptions by
	Reduction of unnecessary work by
	Reduction of follow-up work by
	Reduction of duplication of work by
	Reduction of false tasks by
	Unambiguousness of tasks
	Increased predictability of tasks by
	Enhanced task planning
	Enhanced resources planning
	Enhanced coordination of personnel
	Increased productivity of employees by
	General improvement of operational procedures
	Reduction of paperbased documentation by
	Reduction of administrative tasks by
	Other process objectives
Key objective 4	**Improved Image**
Basic objective 4.1	Increased quality of processed tasks
Process objectives	
	Increased process quality
	Enhanced working conditions
	Minimised environmental impacts
	Other process objectives

9 Identifying (Critical) Success Factors for Mobile Systems Deployment

Abstract[60]

The present work determines how to identify (critical) success factors for mobile systems and shows why they are important for deployment of these systems. In comparison to stationary systems mobile systems have a bundle of singularities calling for success factors that have to be taken into account. In order to get a clear view especially on critical success factors for a (defined) mobile system, not only the interdependencies between the single (mobile) system components and tasks but also between the success factors themselves have to be examined. The present work depicts a procedure how critical success factors can be identified and weighted. The assumptions of this work are supported by application in practice.

9.1 Mobile Systems and Productivity

Since the late 80´s, the debate about the cost-effectiveness of Information and Communication Technologies (ICT) is consistently resurrected. For example, (Solow, 1987) stated that the computer age could be seen everywhere except in the productivity statistics, and also Loveman had no doubt that *"IT capital had little, if any, marginal impact on output or labour productivity, whereas all the other inputs into production -including non-IT capital – had significant positive impact on output and labour productivity"* (Loveman, 1994). By the current state of scientific knowledge it is accepted that the assumed productivity paradox is due to the lack of appropriate methodologies for the profitability of ICT (see e.g. (Brynjolfsson, Hitt, & Yang, 1998)). Especially integrative effects of the systems are not taken into account (Pietsch, 1999).

The authors of this paper see also in depth reasons for the shortcomings between ICT investments and their monetary or qualitative outputs: ICT projects are quite often not as successful and do not support processes in the way they have been meant to do. The reason for this is that these systems are mostly quite complex systems that have to support complex processes. In contrast to robots or machines for manufacturing plants human beings are much more influencing factors. Thus success factors that originate from taking a multi-dimensional, not only technical, approach are the basis for this work. This work strictly distinguishes between ICT and ICS (Information and Communication *Systems*). The term ICS is

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defined in dependence on systems theory which is an approach that focuses on entities and that postulates that the system itself comes into existence by the relationships among the system components and the resulting interactions. The analysis of structures, reactions and functions allows certain predictions about the expected system behavior, whereas it does not focus on a separate consideration of each component (see (Bertalanffy, 1976)). Following these reflections, it becomes clear that while the term ICT is focusing only on technologies that support information exchange and communication, the term ICS comprehends besides the technological components also system-components of human nature that proceed processes as well as their relationships and their properties. These reflections can also be applied to a special type of ICS, i.e. mobile systems (with mobile technologies as a special type of ICT).

In dependence on system theory and expanding the above, the authors propose following socio-technical definition of the term mobile system:

> *A mobile system is a set of mobile technology and human (system) components which are inherently related. They form an entity due to their interactions that is earmarked or task-related and that executes appropriate business processes. The mobile system distinguishes itself in this respect from the surrounding environment. Technical components of mobile systems compass mobile hardware (e.g. PDAs and Tablet PCs), appropriate applications as well as mobile operating systems and middleware (if necessary). Additionally, they include wireless communication technologies like UMTS, GPRS and WLAN (Högler, 2012).*

Mobile systems exist in different forms and have a multiplicity of characteristics. The aim of mobile systems is to integrate mobile processes and workstations into internal, mostly stationary corporate and enterprise-wide process chains and thus to overcome their spatial separation and accompanying information losses.

Critical success factors are a limited number of properties of a system that particularly contribute to achieving the objectives (set by the company). They are defined by Rockart as follows: *"Critical success factors thus are, for any business, the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organisation"* (1979, p. 85). Relating to a mobile system, the current work defines critical success factors as technical as well as human system parameters that have a significant impact on the economics of the mobile system. System parameters are quantities, whose values characterize the behavior of the system with a given structure (cf. (DIN, 1995; Tröster, 2011)). Following the reflections given above, we define the following research question:

> *How to identify (critical) success factors for mobile systems, taking a multi-dimensional perspective?*

As mentioned before, success factors play an important role for the economic efficiency of mobile systems as they are system parameters which influence the behavior of a system. In order to predict the behavior of a system, it is necessary to identify critical success factors. As result of an explorative literature research on success factors it became clear that most of the publications that are discussing success factors in the context of mobile computing are focusing on mobile commerce and thus on the external orientation of mobile business. They mostly do not take into account the internal orientation which is the central aspect of this work. This paper proposes a methodology for the identification of success factors for the deployment of mobile systems. The following section provides further background on the singularities of mobile systems which form the basis for the identification of success factors. We build a framework for the identification of critical success factors for mobile systems in section 9.3. Through a case study we judge the validity of the framework in section 9.4. We end our paper with summarizing our results, and providing implications and anticipated further research.

9.2 Singularities of Mobile Systems

Mobile technologies promise an increased efficiency of business processes by the spatial and temporal decoupling of communication and information processes (Scheer, Feld, & Goebl, 2001). The ubiquitous access to relevant information via mobile technologies enables new ways of working, e.g. by transforming unused waiting times on airports into productive working hours. At the same time mobile systems face a bundle of challenges and hurdles like security issues (Kołodziej, Jaatun, Khan, & Koeppen, 2013) or the absence of data networks due to their singularities. Comparing mobile devices and stationary computers, the following main differences become apparent: First, mobile devices are much smaller than desktop computers and second, they are portable (in the meaning of that they can be used when being carried around which in turn implies that a screen is integrated). The singularities of mobile devices are thus a result of the size of devices and the fact that the devices are portable. At the same time, the user is not bound anymore to a stationary working place – s/he becomes mobile by using portable devices. Table 9-1 shows the relationship between the three main distinguishing features and flashlights resulting singularities of mobile systems.

Despite intensive research, mobile devices still face many restrictions (cf. (Lonthoff & Ortner, 2007; Schach, Scherer, & Menzel, 2007)) due to their size. For example, the input options of mobile devices differ substantially from those of stationary PCs. While the latter ones have a large and easy to use keyboard, the keyboards of mobile devices are – with exception of the keyboards of notebooks – mostly incomplete and in many cases unhandy. Meanwhile, most of the keyboards even do not exist – the latest generations of mobile devices have virtual keyboards that are only shown if the device is on. Although new developments promise to enhance the usability of these kinds of keyboards, they will not achieve the comfort of traditional keyboards in a long term, especially regarding writing speed.

Table 9-1: Singularities of mobile systems

Distinguishing feature	Resulting Singularity
Size	'One-piece-system' (often no keyboard, no external (big) screen, no mouse) Screen size Battery size → low capacity …
Portability	Due to environmental issues (sunlight, dust, rain, …): ruggedized, sunlight-readable display… Security problems (often stolen / forgotten, …) Connection to wireless networks Battery as only energy supply New kinds of human-device-interaction …
Mobility	Distances to be bridged (by walking, driving, …) Adaption to new environments Distraction (noise, weather, visual impressions, …) Media discontinuity …

The usage of mobile devices is hindered by the relatively small displays, which have limited facilities for the reproduction of contents (Rawolle, Kirchfeld, & Hess, 2002). For this reason, the development of mobile applications is experiencing a peak: In contrast to the earlier development trends, in which traditional applications (developed for stationary devices) are simply adopted to the restrictions of mobile devices, meanwhile special applications are designed and developed specifically for mobile devices (so called mobile apps) and take into account all peculiarities of these devices.

Due to the small battery size the battery capacity is still quite low. Taken the hitherto existing development, it can be assumed that the battery capacity will increase by only a few percent in the coming years. This fact, on the other hand, requires increased energy efficiency of mobile devices and corresponding applications; for example, by the reduction of electricity consumption (e.g. of the display and the processors). On the other hand, with decreasing size, also the computing capacity is decreased. In conjunction with inefficient main storage mobile devices have worse information processing capacities compared to the capacities of stationary ICT. This fact must be taken into account when developing mobile applications, which have to cope with the mentioned restrictions of mobile devices (Kornmeier, 2009).

Mobile devices are continuously transported, thus they have to be quickly operational. This in turn requires a small size and minimum weight of the devices with maximum robustness. A real challenge is the ambient light: Although sunlight-readable displays are available, images and texts are less visible than in closed rooms. Many devices have an automatic recognition of ambient light and adjust accordingly the backlight, reading the display in bright sunlight is very tiring for the eyes. Additionally, mobile devices are hardly usable in rain or dusty areas. Ruggedized versions of many mobile devices already exist; nevertheless it is a challenge for the users to handle them during these aggravations.

Despite a variety of security mechanisms, data security in mobile applications and devices is low compared to stationary computers. The reason therefor is not because of lacking possibilities and options, but rather in the negligence of users, who bypass security mechanisms for convenience. As mobile devices are lost or stolen much more frequently than their stationary counterparts (cf. (Day, Daly, Sheedy, & Christiansen, 2000; Gluschke, 2001; Frolick & Chen, 2004)), the security issue is not yet solved in the area of mobile technologies satisfactorily. The same applies for the security of data transfer: Many users log into unsecure wireless networks without taking into account all the risks they are facing. Especially Bluetooth is known for severe security problems, but even the security of data transfer via wide area networks is lagging behind the transfer via LANs. Thus, mobile systems deployment also has to account for security issues, e.g. by integrating the ROSI method (Return of Security Investments).

In contrast to stationary computers that are always connected to the same network, data transmission to mobile devices is carried out via many different, partially heterogeneous networks which can be based on different standards. In addition, wireless data transmission rates are still mostly much lower than cable-based transmission. Transmission problems can be caused by fluctuating bandwidth or insufficient network coverage and can hinder continuous work with mobile devices (Gerpott & Kornmeier, 2004). The quality of the 'interface' air in relation to reliability and quality of the transmission and to availability of wide area networks is subject to many fluctuations. Slow or interrupted connections represent disruptive factors and may reduce the quality of service greatly. The accessibility of required data anytime and everywhere is of key importance in order to reach the maximum possible efficiency of mobile systems.

As already mentioned, in contrast to stationary ICT mobile devices are often disconnected to electric supply networks, their only power supply is their battery which has in most cases still a low capacity. The impacts of the latter restriction have been discussed before, so no further explanation is needed.

The authors regard mobility in the context of business processes: Mobile business processes differ from stationary business processes significantly by the spatial distribution (of process steps) which is mostly unknown in advance and the mobility of people involved in the process (see also (Köhler & Gruhn, 2004a)). While an employee, who is working stationary, can focus his senses on an application or information, a mobile worker is distracted by his surroundings and has to adapt often to new environments. Additionally, in many cases he has not both hands free, which imposes additional usability requirements on the keyboards and the input methods respectively (Wallbaum & Pils, 2002).

While bridging distances employees are in motion – which again requires more attention and exposes the mobile workers to multiple distractions like ambient noise or visual impressions.

Above singularities and restrictions have to be taken into account when identifying (critical) success factors of mobile systems, because they may affect the efficiency of these systems negatively. In addition, all interdependencies between the single components of a mobile system have to be considered. Questions that have to be answered are for example: How do the single technical components like mobile devices, applications and data transfer affect each other – and what are success factors that reduce negative effects? How can the most important component of a mobile system – the human being – be affected by the technical components as well as by the surroundings when proceeding his tasks and how can these influences be minimized?

9.3 A Method for the Identification of Critical Success Factors for Mobile Systems

Back in the 80s it was recognized that the inobservance of human and social factors may contribute to the failure of technically mature and successful systems (Horváth, 1988). For this reason, the identification of critical success factors (CSFs) that are not limited on technical factors (so-called system criteria) is of particular importance for the implementation of ICS and thus also for mobile systems. The work of Ward and Peppard (2002) is considered as a profound and good starting point for the discussion of success factors, as they take a multi-dimensional approach based on Kaplan and Norton´s (1996) balanced scorecard (Ward & Peppard, 2002, p. 206). The findings of Ward and Peppard (2002) build the basis for the authors´ method to identify critical success factors for mobile systems from a multi-dimensional perspective. Nevertheless, their proposed methodology does not take into account the singularities of mobile systems which are crucial for the successful deployment of mobile systems.

Business processes are a central object of observation within organizational transformations. The terms 'process' and 'business process' are used synonymously in the present work; they are very often discussed in the literature and partially defined quite differently (see e.g. (Davenport, 1993; Becker & Vossen, 1996; Allweyer, 2005; Hammer & Champy, 2006)). The present work defines a process according to Richter-von-Hagen and Stucky: *"A business process is a sequence of activities or tasks that aim at creating a product or a service. It is started and ended by one or more incidents. An organizational structure forms the basis of all processes"* (2004, p. 23).

Defining Success Factors of Mobile Systems

Due to the fact that each single project is unique, there can be no standardized procedure for the identification of success factors that are related to this single / special system. Rather a project-specific identification of so called system-related success factors has to be proceeded that takes into account the users (user profiles) being involved in the mobile process, the tasks that have to be fulfilled and the targets that were set by e.g. the management. Additionally, a project-specific weighting of the success factors is necessary in order to take into account all specific conditions[61].

The authors propose the following procedure for identifying critical success factors (Figure 9-1):

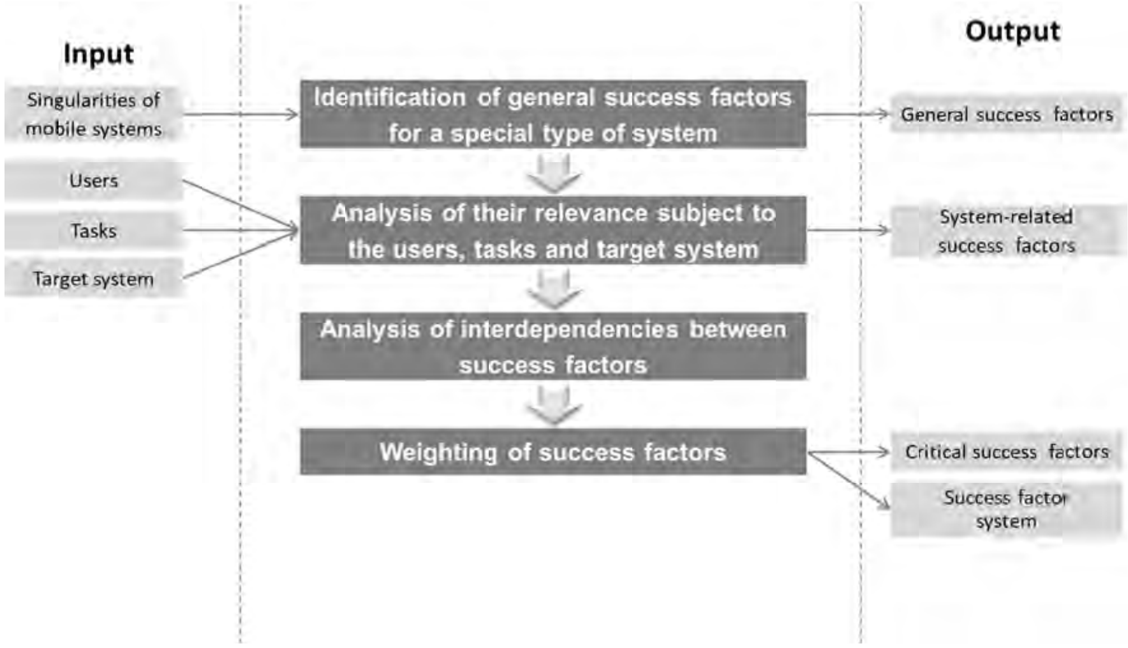

Figure 9-1: Method for the identification of success factors

In the first step, general success factors for a special kind of mobile system (e.g. a mobile maintenance or a mobile customer relationship system) are identified. This can be done by singularities of mobile systems as shown in Table 9-1. As a result a 'bunch' of general success factors for a special type of system is identified. In order to find out which of these general success factors are really relevant additional steps are necessary. The relevance of success factors is subject to user characteristics, tasks and targets/goals of the business processes which include mobile technology.

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[61] cf. Walter (1995, p. 285), who explains the topic ‚hierarchy of success factors' in detail.

For relevance determination the Task-Technology-Fit-Model by Goodhue and Thompson (1995) can be used. It allows statements about the suitability of technologies to address particular tasks that are conducted away from stationary workplaces. Meanwhile, this model has been adapted to the needs of mobile information systems by Gebauer, Shaw and Gribbins (2005). Their Task-Technology-Fit-Model is based on the general theory of Task-Technology-Fit by Goodhue and Thompson (1995) and the specific theory of Task-Technology-Fit for group collaboration support systems by Zigurs and Buckland (1998). It is defined as *"a three-way match between the profiles of managerial tasks (operationalized by difficulty, interdependence and time-criticality), mobile information systems (operationalized by functionality as notification, communication, information access, and data processing; form factors; and location-awareness), and individual use context (operationalized by distraction, movement, quality of network connection, and previous experience)"* (Gebauer, Shaw, & Gribbins, 2005, p. 2). As result of the Task-Technology-Analysis success factors most influencing the tasks can be identified.

In the next step interdependencies between success factors are analyzed. The authors suggest the Analytical Hierarchy Process (AHP) by Saaty (1980), (1996), and Ahlert (2003, p. 36ff.) as starting point for the analysis of interdependencies. As a result of this analysis it becomes apparent which success factors have positive or negative effects on other success factors, and which success factors are neutral. Success factors with a positive influence on other success factors should get a higher importance than factors with a neutral or negative effect. The reason for this is that they contribute more to the overall success of the project and thus shall get a higher weighting. On the one hand, weighting is necessary to assign the appropriate meaning to every single critical success factor; on the other hand it is needed in order to get a better valuation basis for the different alternatives. All alternatives must be examined to what extent they take into account success factors.

The following chapter will present some of the main results of practical application and by doing so it will validate the importance of success factors for deployment of mobile systems.

9.4 Validation: Application in Practice

In the previous sections we have created a method for the identification of critical success factors; this is considered important for mobile systems – at least in theory. This has motivated the authors to evaluate this proposition in several real-life projects in the chemical industry at German Global Player companies, all focusing on the support of daily tasks of maintenance engineers by mobile technologies. Describing every single objective and identified success factor even for a single project would go beyond the scope of this work. Thus the following will only depict the key findings that are important to prove the importance of defining success factors in accordance to the tasks and the components of a mobile system that was deployed in one of the companies. This company can be sketched as follows (benchmark data): It was a Global Player in the chemical industry with more than 100.000 employees. The maintenance management system was planned for a maintenance engineers group that was working under difficult conditions (explosion prevention) at a German plant.

Main objective of one of the projects on the task level was to:

- minimize errors occurring during gathering data (mainly tasks reports): Data have to be collected until the end of shift by the respective maintenance engineer and to be entered directly into the mobile devices
- minimize errors due to unclear task definitions (e.g. sometimes it is not definitely clear which machine has to be repaired, esp. if two identical machines stand by each other)
- reduction of the general information loss: Important information should not be retained in personal notepads, but it is accessible to all in a central system. Thus data and information do not get lost, esp. when employees with long-time experience leave the company
- documentation of all steps of the maintenance (proof documentation): All individual steps of the maintenance tasks that require verification should be individually signed and verified

Main objective of one of the projects on the company level was to:

- be able to interpret the data (measurements, test results, etc.): All data should be stored in a single system. The system should be able to analyze the data according to customer requirements
- improve control (with respect to activities and documentation), especially accelerate control: It has to be ensured by reading bar codes or RFID tags that the maintenance engineer was actually at the object to which the maintenance task is assigned. Incomplete documentation must be immediately identifiable

All these objectives have one target in common: to save money due to reduced processing time, less errors and due to longer life-cycle of the machines.

First, general success factors for mobile maintenance systems were determined with the support of a profound literature search (e.g. (Gebauer & Shaw, 2004; Birkhofer, Deibert, & Rothlauf, 2007; Brodt & Verburg, 2007)) and as a result of personal professional experience of the authors. Table 9-2 shows some general success factors for the chosen project as examples.

Table 9-2: General success factors for mobile maintenance management systems

Mobile Maintenance System singularity features	General success factors
Portability	Robustness (ruggedized) High security in terms of explosion control Size (subject to tasks) Weight (maintenance engineers have to carry with them a bunch of tools)
Mobility	Reach Security Stability Performance
Size and other	High usability Always on Simple reporting

The next step was to identify main tasks that have to be supported by mobile technologies and the involved user 'types', some examples are shown in the following Table 9-3.

Table 9-3: Tasks of different kinds of employees / roles

Tasks	Maintenance engineer	Decision maker
Documentation of tasks & activities	x	
Recording of detected malfunctions, problems etc.	x	
Analysis of data		x
Control		x

In order to find out the relevance of these general success factors for mobile maintenance management systems for a special kind of such a system a task-technology-fit analysis was proceeded. The task-technology-fit analysis for mobile systems by Gebauer, Shaw and Gribbins (2005) is based on the general theory of task-technology fit by Goodhue and Thompson (1995) and the specific theory of task-technology fit for systems with focus on the support of group collaboration by Zigurs and Buckland (1998). The main results of the task-technology-fit analysis including some other aspects are depicted in the following Table 9-4:

Already in the table above it becomes clear, that the tasks and requirements concerning mobile technologies differ widely between the different employees / roles. This allows the assumption that also the success factors differ in many ways. Table 9-5 shows some of the main success factors analyzed during the above mentioned project.

Table 9-4: Results of the tasks-technology-fit-analysis

Tasks	Maintenance engineer	Decision maker	Mobile device	Connectivity	Security level (confidentia-lity)
Documentation of tasks & activities	X		PDA	continuous	Low
Recording of detec-ted malfunctions, problems etc.	X		PDA	continuous	Medium
Analysis of data		x	Tablet / Notebook	temporary	High
Control		x	Tablet / Notebook	temporary	High
…..		x			

Table 9-5: Success factors subject to different tasks and roles

Tasks	Maintenance engineer	Decision maker	System-related success factors
Documentati-on of tasks & activities	x		Minimum size & weight of device Always-on connectivity Usability of device and programs Ruggedized device Explosion prevention and protection class II No ‘pen’ needed (usable only with fingers) …
Analysis of da-ta		x	High security / privacy Speed of processing data High resolution / big display Existence of a well-usable keyboard …

In order to finish the definition of system-related success factors, the influence of the general success factors on the targets set was analyzed which is shown in Table 9-6: Influence of success factors on targets.

A profound discussion of Table 9-6 would go beyond the scope of the present work. One thing that becomes obvious is that the always-on connectivity of mobile devices and the usability of devices and applications has a strong influence of most of the targets and should thus be regarded as a critical success factor (Nielsen, 1994). The same applies to the existence of a well-usable keyboard. But we also see that for some of the tasks it is of key importance that no pen shall be needed which means that the entry of data should be feasible by using only fingers. As a result only devices can be chosen that support this kind of data entry. The weighting of critical success factors is proceeded as last step. The critical success factors can be weighted according to the Analytical Hierarchy Process (cf. (Saaty, 1980; Saaty, 1996)) mentioned above.

Table 9-6: Influence of success factors on targets

	Effect on target…						
System-related success factors	Minimizing errors (gathering data)	Minimizing errors (task definitions)	Reduction of general information loss	Documentation of all steps	Data analysis / interpretation	Improve control	Critical
Minimum size & weight of device	0	0	1	1	0	0	no
Always-on connectivity	1	2	2	1	0	1	yes
Usability of device and programs	2	0--1	2	2	1	0	yes
Ruggedized device	0	0	1	0-1	0	0	no
Explosion prevention and protection class II	0	0	0	0	0	0	no
No ‘pen’ needed (usable only with fingers)	2	0	2	2	0	0	yes
High security / privacy	0	0	0-1	0	1	0	no
Speed of processing data	0	0	1	0	1	1	no
High resolution / big display	0	0	0	0	2	0-1	no
Existence of a well-usable keyboard	2	0-1	2	2	1	0-1	yes

Legend

0 = None	System-related success factor x does not influence the achievement of the target y. E.g. The minimum size and weight of a device have no influence on the achievement of the target ‘minimizing errors during gathering data’
1 = Medium	System-related success factor x does influence the achievement of the target y. E.g. The always-on connectivity does influence the achievement of the target ‘documentation of all steps’ (because if the device is not always connected, data can be lost more easily).
2 = High	System-related success factor x does strongly influence the achievement of the target y. E.g. The usability of device and programs does strongly influence the achievement of the target ‘minimizing errors during gathering data’ (because the easier an application is to be used the fewer errors are made during the insertion of data).

The described project shows the importance of identifying and taking into account success factors as well as tasks and the targets set: If a decision maker would have to proceed analysis and control tasks by using a PDA (personal digital assistant), it would not matter how excellent all other components are – he would not even rudimentary be able to be as productive if using a tablet or notebook. Thus the economic efficiency would be greatly decreased. Traditional approaches do not take success factors in this way into account.

9.5 Conclusions and Implications

This work has depicted the deficiency of existing approaches for the identification of success factors for mobile systems by identifying singularities of mobile systems. Though used meanwhile in almost all industries by all kinds of employees it still remains unclear if such a system can be deployed successfully and thus if it is profitable or not. Chapter two has shown particularities of mobile systems and thus the differences to desktop-based ICS. A method for the identification of critical success factors for mobile systems was presented in chapter three. It was shown that success factors play an important role in the deployment of such systems. Chapter five validated the findings through practical application. Here the interdependence of success factors and their relation to tasks, objectives and system components became clear.

The present work has shown the importance of not only focusing on the abilities of technologies while evaluating an ICS and mobile system respectively. Especially the 'system component' human being affects exceptionally the efficiency of a system by his behavior, his requirements on the technical components and his tasks – it becomes clear that success factors play an important role in this overall structure. Additionally, also targets set by decision makers have to be taken into account when defining success factors.

Our method can also be used to evaluate the effectiveness of mobile systems: Which success factors are already taken into account, and which can be added to provide for a strategy for more effectiveness of the mobile system. Further research is focusing on a multi-dimensional evaluation of mobile systems.

PART 4: VALIDATION

10 Validating the Integrative Framework in the Context of Digital Transformation Evaluation

Abstract[62]

Information and communication technologies (ICT) are the engine of competitiveness and innovation of the 21st century. The advances in ICT specifically enable digital transformation in (extended) enterprises. Yet, successfully leveraging ICT is a complex challenge, particularly when mobile technology with its advantages and many specific singularities is involved. Careful preparation before development and implementation, as upfront capability based planning, is needed. We present an integrative framework that prepares organizations for mobile technology enabled digital transformation. It consists of seven activities that can be categorized in three key principles of the framework, being an 'internal analysis', 'economic analysis' and 'integrative analysis'. We demonstrate the reliability, validity and applicability of the framework through a multimethod validation. In (1) a retrospective case study we analyzed and coded case documentation, (2) held qualitative semi-structured expert interviews, and 3) applied the first activity of the framework. Results support the validity of the framework and its activities. The framework (notably because of its explicit definition of the target system) is acclaimed for its novelty, accuracy and addressing the gap between project outcome and anticipated effect of a (mobile) system.

10.1 Introduction and Motivation

Mobile technologies are reshaping the global economic landscape, enhancing speed and comfort of communication and information exchange. They aim at integrating mobile processes and devices into the enterprise architecture to overcome spatial separation and accompanying information losses. If information becomes available any time at any place (cf. (Schiller, 2003; Isaac & Leclercq, 2006)) it can make digital transformation happen. We define mobile systems as *"sets of mobile technology and human (system) components which are inherently related"* (Högler, 2012). Mobile systems have a multiplicity of singularities[63], which make them specific as compared to stationary Information and Communication Systems (ICS). The challenge to take this into account in an evaluation makes mobile systems an interesting object of investigation.

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[62] This work is peer-reviewed and accepted for publication as a chapter in a Springer Publication on Digital Transformation (expected publication 2019). The title of the chapter is "Validation of the Integrative Approach for Digital Transformation Evaluation".

[63] Högler and Versendaal (2014) have provided in their work a detailed list of singularities of mobile systems.

While ICS in general and mobile systems in particular have the potential of being of great benefit for organizations, their implementation often fails in terms of scope, budget and time. Addressing and reaching business objectives before implementation appears to be difficult or is failing (Standish Group, 2014). An effective a priori evaluation of ICS implementation (e.g. to decide whether or not including mobile components) will increase understanding the potential and the effects of its implementations, and knowing the success factors. Existing approaches for this a priori evaluation of ICS and mobile systems, however, are limited because:

- They often only consider monetary effects; or, when including other qualitative effects, transform those into monetary effects as well (cf. (Horváth, 1988; Zahn, Schmid, & Dillerup, 1999; Mutschler, 2005));
- Evaluation methods lack a theoretical basis (cf. (Renkema & Berghout, 1997; Berghout, Nijland, & Powell, 2011));
- Existing evaluation approaches do not explicitly address singularities of mobile systems (Högler & Versendaal, 2014);
- Interdependencies seem insufficiently being taken care of in existing evaluation approaches: particularly interdependencies between objectives, risks and success factors, which eventually affect implementation effects (Högler, 2012);
- They fail an overall integrative framework.

According to many researchers and consulting companies, an improper requirement definition is the most-cited reason for implementation failures (cf. (Davis, Dieste, Hickey, Juristo, & Moreno, 2006; Hughes, Dwivedi, Simintiras, & Rana, 2015)). In fact, *“the lack of clear understanding of what the company wants to achieve”* (IMG, 2015) avoids that many of the requirements are not derived from the goals that should be achieved by implementing an ICS. This calls the importance of a profound ‘target system’ definition in an a priori evaluation.

Both the omission of a profound target system and a socio-technical view (Orlikowski, 2000) on mobile systems implementation, have motivated the development of an integrative framework that is presented in this paper. In the next sections we describe this framework and how it can be applied to conduct a valid and reliable a priori evaluation of mobile systems that enable digital transformation. The following sections present the framework, followed by three types of justification and validation of the framework. In the remainder of the paper we will reflect on the construction of the integrative evaluation framework and address the identified strengths and limitations.

10.2 The Integrative Evaluation Framework for Digital Transformation Evaluation

For the definition of an integrative framework we follow design science research guidelines ((Hevner, March, Park, & Ram, 2004; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007)). The proposed artifact is our integrative framework and its construction considers both the scientific body of knowledge as well as the business needs. In designing our framework we draw principles from several theoretical foundations. Principles are drawn from system theory (Bertalanffy, 1976), and from strategic alignment, business process engineering and digital strategy models. The latter have their roots in the work of Solow (1987) and Loveman (1994) who early identified that ICT implementations do not necessarily lead to increased firm productivity. Labelled as the 'productivity paradox' by Brynjolfsson (1993), notably Henderson and Venkatraman (1993) developed the Strategic Alignment Model (SAM). The key claim is that strategic fit (degree of alignment between firm strategy and firm operations) and functional integration (degree of alignment between IT and the rest of the business) should be taking into account in order to gain proposed benefit from ICT. At the same time, the famous article by Hammer (1990), set the stage for the business processes reengineering (BPR) through ICT. The literature has since been consolidated by e.g. Hammer and Champy (1993) and Peppard and Ward (2016). Looking back, one could say that BPR is part of the operationalization of Henderson & Venkatraman´s (1993) SAM. Also, one can well argue that Peppard and Ward (2016, pp. 108-110) operationalized SAM by defining their Digital Strategy Model (DSM), taking the external business environment, the internal business environment, the external IS/IT environment and the internal IS/IT environment as inputs for the identification of the future ICS-application portfolio.

Based on these different theories and models, we define a first set of six basic principles for the design of our framework for digital transformation evaluation:

1. Start from a holistic approach, taking into account economic, technical and social aspects in the a priori ICS evaluation.
2. Focus on interdependencies and mutual relationships; changes in one part effects other parts, taking into account (or not taking into account) certain success factors may limit or increase likelihood of risks, striving for certain business objectives with system implementation may strengthen or weaken other business objectives.
3. Explicitly take into account the users of ICS.
4. Align ICS systems implementation with processes, with business strategy, and with existing IT-infrastructure.
5. Consider both the internal business environment (processes, [business] objectives) and the external business environment (the economic, industry, social, regulatory and competitive climate).

6. Consider both, the internal (existing) IS/IT environment, including the existing running applications and the external IS/IT environment (trends in IT, competitor´s IT-infrastructure, etc.).

The second set of six principles is specific for the evaluation of mobile systems and based on earlier work (cf. (Högler, 2008; 2014)):

7. Deal with the specific characteristics of mobile systems (singularities), like a need for Wi-Fi-access, limited power supply, the need for hands-free working (Högler, 2014).
8. Pay attention to business objectives, benefits, costs.
9. Orientate on the life cycle of a system; e.g. a particular effect is not only taking place at a specific point of time they occur, but according to the space of time they take effect.
10. Address multi-dimensionality; not only costs and benefits that are monetary measurable, but also other beneficial aspects should be taken into account.
11. Address situationality; each project has its own context (e.g. sector, project size, implementation time), and therefore the framework provides room for extending and scaling.
12. Consider critical success factors in respect of volatility effects.

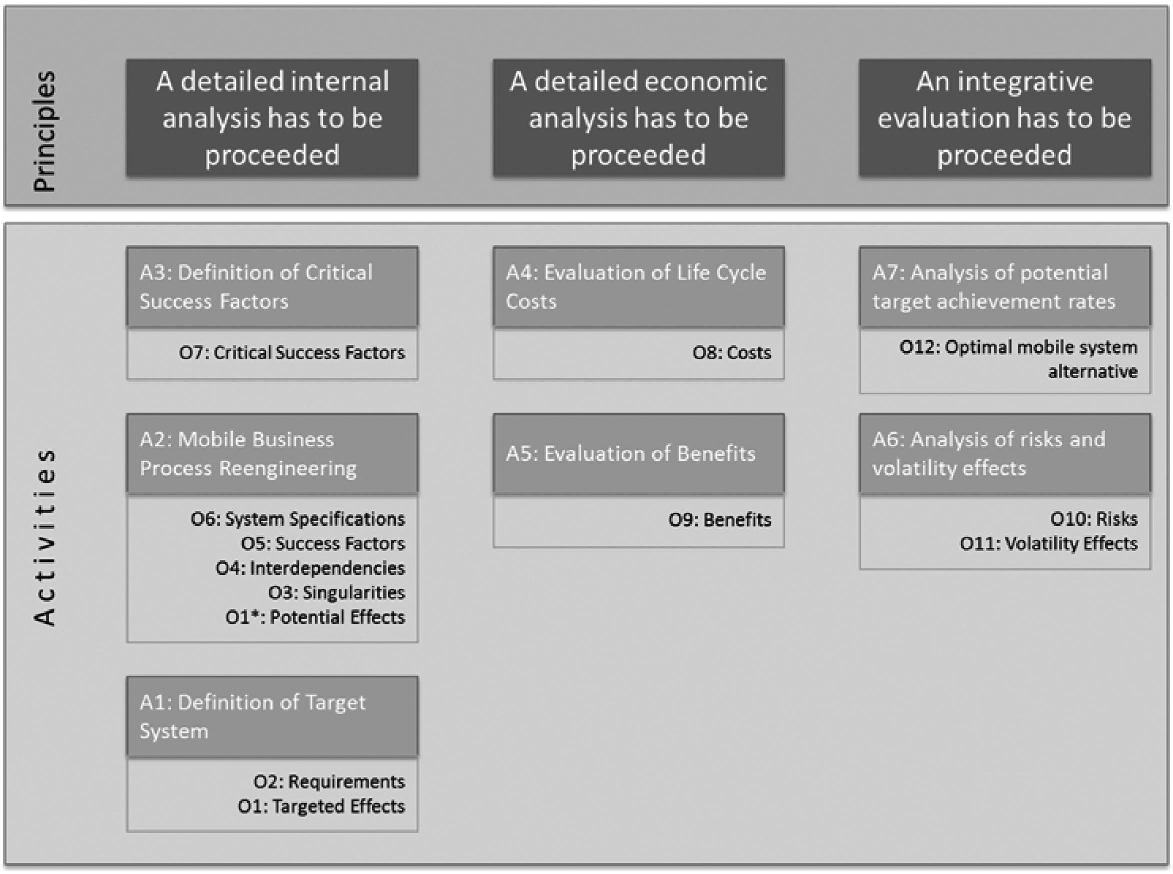

Figure 10-1: Integrative framework

The 12 principles can be categorized into to three key principles for the proposed integrative framework for digital transformation evaluation: (1) a detailed enterprise internal evaluation, (2) a detailed economic evaluation and (3) an integrative evaluation. These three key principles are broken down into sets of activities, as depicted by Figure 10-1, and elaborated in Table 10-1 to Table 10-3.

Table 10-1: First three activities of the integrative framework and their relevance for the 12 principles

	Definition of target system	Mobile business process reengineering	Definition of critical success factors
Principle 1 (holistic approach)	-	Economic, technical and social aspects are considered within the mBPR (e.g. who are the users / responsibilities, what are the current KPIs, what kind of technology is / will be used….)	This activity considers the specific environment and singularities of a project and thus takes a holistic perspective.
Principle 2 (interdependencies)	Considers interdependencies between objectives	Considers interdependencies between components of ICS (processes, users and technologies (existing infrastructure, planned infrastructure))	CSF are analyzed also regarding their interrelationships, i.e. how does CSF A affect CSF B?
Principle 3 (users)	Whenever possible, different kinds of users (white, blue collars…) should be involved in the definition of the target system	Identifies groups of users and analyses their activities, responsibilities, tasks, behavior, technical affinity, …)	Process of defining CSF considers also users and their affinity towards IT, knowledge, willingness to use IT, ….
Principle 4 (alignment)	-	ICT in alignment with (non-) mobile processes	CSF consider appropriateness of potential ICS to reach objectives
Principle 5 (business environment)	Considers objectives that have to be achieved with the project, also strategic and thus also business environment	Considers internal and external business environment (e.g. necessary changes in processes to achieve objectives; willingness of users to change kind of performing tasks / to adopt new technologies, ….)	Business environment as basis of defining CSF
Principle 6 (IS/IT environment)	Considers also external IS/IT environment	Considers internal and external IS/IT environment (analysis of existing technical infrastructure, current trends in similar / competing	IS/IT environment as basis of defining CSF

		businesses, state of the art of technology, …)	
Principle 7 (singularities)	-	During mBPR singularities of the specific project environment are identified	Singularities can be taken care of by identifying them as critical success factors
Principle 8 (objectives, benefits, costs)	Defines objectives and serves as basis for evaluation of benefits & costs connected to achieving defined objectives	During mBPR it is already analyzed if objectives can be achieved in general or if changes regarding the environment are necessary (e.g. replacement of users, additional / change of technical infrastructure, …)	CSF focus on achieving objectives (benefits) with a given budget (costs)
Principle 9 (life cycle)	-	mBPR identifies where and when a specific effect is occurring / will occur	Considers life cycle as regards to costs and timeframe in which benefits should be achieved
Principle 10 (multi-dimensionality)	All objectives, also strategic ones, are considered	mBPR as suggested considers different aspects (e.g. users, costs, benefits, singularities) and thus takes a multi-dimensional perspective.	CSF derived from different aspects (costs, benefits, environment, singularities) and follow thus multi-dimensional approach
Principle 11 (situationality)	-	mBPR considers singularities, overall environment and thus the situationality of a specific project	CSF are derived from situationality
Principle 12 (CSF)	Contributes to proper definition of CSF, based on requirements and objectives	CSFs can be derived from the findings gained during mBPR	Defines CSF

In further detail:

- Definition of the target system (activity 1: A1) follows the multi-attribute decision making (Hwang & Yoon, 1981) and leverages the Analytical Hierarchy Process (AHP) (Saaty, 1996). One of the main contributions of this work is that the AHP is extended and applied in the context of an integrative approach for ex ante evaluating the economic efficiency of mobile systems. The uniqueness of the extended AHP is that the determination of priorities is not based on subjective assessment (like the opinion of decision makers), but on a preference-neutral approach that contains the following three steps:
    1. interdependence analysis between individual goals (cf. (Kirchmer, 1999; Drews & Hillebrand, 2002; Rückle & Behn, 2007));

2. consideration of the effective strength of objectives and the probability of occurrence of interdependencies (cf. (Charette, 1991; Klabon, 2007)); and
3. preference-neutral weighting of objectives in the context of step 1 and 2.

The outputs of this activity include prioritized monetary and qualitative effects to be achieved by the implementation of a mobile system (output 1: O1) and general requirements (O2) of a mobile system. Figure 10-2 shows the individual steps that can be taken in this activity.

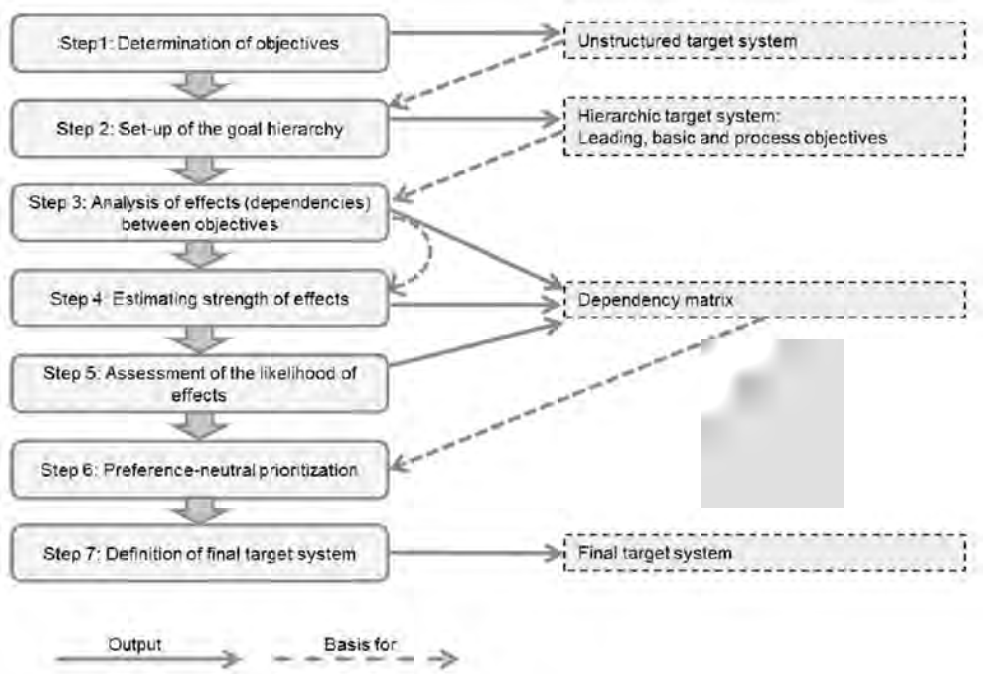

Figure 10-2: Individual steps of activity 1, taken from (Högler & Versendaal, 2016)

- Mobile Business Process Reengineering (mBPR, activity 2) is aimed at analyzing and documenting existing processes with a specific focus on their mobile parts. The resulting process models can include – besides a detailed description how and where operations are conducted – information regarding the employed data, IT resources, and other artifacts like KPIs and responsibilities (cf. (Scheer, 2000; Recker, 2009)). We leverage the systematic approach as defined by Peppard and Ward (2016), p. 158) where BPR is not aiming – as called for in the early days of BPR – on a fundamental rethinking of the company and its business processes, but rather at optimizing existing (mobile) business processes using mobile technologies. In the framework, singularities (O3) and interdependencies (O4) of the mobile system are derived from this activity. During the mBPR requirements (O2, from activity 1) are turned into system specifications (O6). Additional requirements can arise during activity 2, leading to further system specifications. Based on the requirements and specifications, general success factors (O5) for a special type of mobile system can be derived in this activity. Potential effects are also an output of this activity (potential effects: O1*); they represent targeted effects in the given mobile business process context[64].

- The outputs of A1 and A2 are used as inputs for A3, the definition of Critical Success Factors (CSF) of mobile systems. The relevance of these success factors is analyzed subject to the singularities of a specific mobile system and the targeted effects determined in activity 1 and 2. General success factors from activity 2 are prioritized following the preference-neutral approach as described for activity 1, which is a key element of the integrative framework. Success factors with the highest priority are defined as critical.

In addressing economic analysis, two activities are considered necessary: evaluation of life cycle a) costs and b) benefits.

In detail:

- Expected costs can be calculated (activity 4, O8) by applying the life cycle oriented Total Cost of Ownership approach (cf. (Grob, 1993; Gartner Group, 1997; Ferrin & Plank, 2002)) as it takes all costs into account that occur during the lifetime of a mobile system. This includes costs that occur in other departments that are directly or indirectly affected by the implementation of a mobile system (Unhelkar, 2009). Targeted effects (O1) and potential effects (O1*) can be taken as a basis for the calculation of costs of different alternatives. An alternative is defined as a particular configuration of a mobile system.
- Taking the outputs of A2 and A3 into account, a first evaluation and estimation of the potential benefits (O9) for each identified alternative is possible. To do so, the mBPR model is to be examined, potential benefits are to be identified and the best possible alternatives are to be taken as basis for further consideration. The evaluation of benefits, based on the Total Benefit of Ownership model (Gadatsch & Mayer, 2004), involves the capture of cost savings and non-monetary benefits or qualitative and strategic variables, which are not considered in the traditional approaches of economic evaluation.

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64 Example for a potential effect: During mBPR it turned out that instead of the targeted effect "20% increase in efficiency" a "35% increase in efficiency" is possible (potential effect).

Table 10-2: Activities 4 and 5 of the integrative framework and their relevance for the 12 principles

	Costs	Benefits
Principle 1 (holistic approach)	Considers costs	Considers benefits, including strategic ones
Principle 2 (interdependencies)	Considers effects of exchanging system components on expected costs	Considers effects of exchanging system components on expected benefits
Principle 3 (users)	Considers necessary trainings etc. for users	Considers how users effect benefits
Principle 4 (alignment)	Considers how alignment between technology & users affects costs	Considers how alignment between technology & users affects benefits
Principle 5 (business environment)	Considers also costs of indirectly affected units	Considers also benefits of indirectly affected units
Principle 6 (IS/IT environment)	Takes into account necessary changes of indirectly affected IS/IT environment	Takes into account how indirectly affected IS/IT environment can contribute to benefits / objectives
Principle 7 (singularities)	Effects of singularities regarding costs are taken into account (e.g. specific trainings, specific hardware…)	Effects of singularities regarding benefits are taken into account (e.g. does my current team hinder planned benefits due to their affinity towards new technologies?)
Principle 8 (objectives, benefits, costs)	Pays attention to costs	Pays attention to benefits
Principle 9 (life cycle)	Considers whole life cycle of system	Considers benefits and their development during life cycle of system
Principle 10 (multi-dimensionality)	-	Also strategic benefits are taken into account
Principle 11 (situationality)	Considers situationality and provides different granularity of detail / detail level and thus options for scaling	Considers situationality and provides different granularity of detail / detail level and thus options for scaling
Principle 12 (CSF)	Allows consideration of cost changes if CSF are / are not taken into account	Allows consideration of changes in benefits if CSF are / are not taken into account

The last principle evaluates the mobile system in an integrative way, combining the results of the previous activities.

Table 10-3: Activity 6 of the integrative framework and its relevance for the 12 principles

	Risks
Principle 1 (holistic approach)	Economic, technical and social aspects are considered; also how they are affected by risks
Principle 2 (interdependencies)	It can be analyzed how risks influence each other (see procedure of analyzing interdependencies between objectives; same procedure can be applied here so that critical risks can be identified)
Principle 3 (users)	Risks caused by users are considered
Principle 4 (alignment)	Risks that go along with – particularly not happening – business/IT alignment are considered
Principle 5 (business environment)	Risks that are linked to the business environment are considered (e.g. what kind of risks is caused by different processes?)
Principle 6 (IS/IT environment)	Risks that are linked to the IS/IT environment are considered (e.g. what happens if network coverage is not good enough?)
Principle 7 (singularities)	Singularities of a specific system are analyzed in terms of risks that go along with them
Principle 8 (objectives, benefits, costs)	Risks influence benefits & costs
Principle 9 (life cycle)	-
Principle 10 (multi-dimensionality)	-
Principle 11 (situationality)	Risks analysis takes into account the situationality of a specific project
Principle 12 (CSF)	CSFs and risks are inherently related. If CSFs are not taken into account, risks are higher.

In further detail, including activity 7:

- This key principle starts with the identification and analysis of risks (Kronsteiner & Thurnher, 2009) for the different alternatives. Based on the results we perform a sensitivity analysis by taking CSFs into account for each risk for the alternatives. Subsequently, volatility effects are identified.
- The final assembly of hitherto existing outputs leads to the assessment of potential target achievement rates (activity 7). Different problem-solving techniques and mathematical methodologies for improved decision making, as regards to the identified alternatives, are existing. Which of these methodologies should be applied for the analysis of potential target achievement rates, and thus for the final choice of an alternative, depends on many factors like complexity of the project. The alternative with the highest achievement rate is the alternative with maximized benefits against minimized costs, taking into ac-

count how critical success factors influence risks. This will also result in a feasible target system.

Thus in fact, activity 7 is the holistic approach as in previous activities (1-6) we take specific perspectives (e.g. only defining objectives; only defining CSF, only analyzing potential costs). In this activity 7, we check if e.g. costs will probably be 10,000 EUR or if costs will be 50,000 EUR as most of the CSFs are not considered or that singularities show that specific equipment and training is needed. As particular example: During mBPR we identify the singularities (e.g. team of 3 IT-hating blue collars). For the mobile technologies we need 25.000 EUR, for trainings 5,000 EUR - in total 30,000 EUR (here we consider only the best case / average costs). We e.g. have identified CFS 'technology acceptance'. If we cannot reach technology acceptance with trainings of employees we will probably need two additional trainings with additional 10,000 EUR. So in contrast to earlier planned 30,000 EUR, we will have to spend in this case 40,000 EUR.

10.3 Research Methodology

Next to the development of the integrative framework, a design science research execution implies that it is validated as an artifact (Hevner, March, Park, & Ram, 2004, pp. 85-87). Hevner et al. define three generic criteria for such validation: 1) utility of the artifact, 2) quality of the artifact, and 3) efficacy of the artifact. They explicit these criteria by (appropriate) functionality, completeness, consistency, accuracy, performance, reliability, usability, and fit with the enterprise (Hevner, March, Park, & Ram, 2004, p. 85). As these criteria leave room for more specifications, (Carvalho, 2012) additionally mentions among others: generalizability, novelty and explanation capability (i.e. being able to explain the success of the framework, in comparison with alternative models).

How to validate our framework, taking into account the large set of the validation criteria, can be considered a complex and wicked problem. In any case a single validation approach would be insufficient. Therefore we consider a *multimethod* approach – as presented and discussed by Mingers (2001) and Venkatesh, Morris, Davis and Davis (2003) – as the most appropriate way to evaluate our framework. We adopt the 4-step guidelines presented by (Venkatesh, Morris, Davis, & Davis, 2003, p. 41) to define the *process and structure* of the validation:

Step 1: Define the goals to clarify the appropriateness of a multimethod approach.

We define as overall objective of our study to reliably show the validity and applicability of the framework that is designed for the preparation of mobile technology enabled digital transformation. Following Mingers multimethod research is necessary *"to deal effectively with the full richness of the real world. [Also advantages like] (i) triangulation - seeking to validate data and results by combing a range of data sources, methods, or observers, (ii) cre-*

ativity – discovering fresh or paradoxical factors, (iii) expansion - widening the scope of the study to take in wider aspects of the situation [advocate multimethod work]" (2001, pp. 243-244) for reaching our goal.

Step 2: Define a strategy for multimethod validation.

The strategy that drives the evaluation of our framework´s applicability is based on multiple methods. A primary method applied is an in-depth case study of a mobile technology enabled digital transformation. As case studies only show applicability in a certain specific context, for generalizability we conducted experts´ opinions as well. As elaborated below, we execute a general retrospective case study in the healthcare sector to evaluate the full integrative framework. In addition we conduct a specific case study focusing on the first activity of the framework dealing with definition of the target system (at the Dutch fire brigade). Finally, semi-structured interviews with experts are held (project managers and scientists in the field of digital transformation).

Step 3: Define a strategy for analyzing data.

The multimethod strategy as defined in step 2 naturally results into different types of data and results. Therefore we set-up, process and analyze the results of the validation methods via separate techniques and protocols. In the next section, each validation method and its resulting data will be introduced and described, including the description of the protocols and analysis techniques. Also, we described how we can then draw inferences from the combination of the data analyses.

Step 4: Draw meta-inferences from the separate validation studies.

The framework evaluation is finalized by synthesizing to provide overall inferences. As we will show in the evaluation and conclusion sections, we extract the common validation criteria, and reflect on them.

The integrative framework we developed to evaluate mobile system implementations ex-ante, will be validated by these four steps. This research methodology will structure the remainder of this paper leading to conclusion and reflection in the last section.

10.4 Qualitative Evaluation of the Integrative Framework

In this section we describe a qualitative evaluation of the integrative framework based on (1) a retrospective case study, (2) a case action study of the first activity (A1), and (3) an assessment by domain experts. The results of this evaluation, demonstrating the applicability of our framework, are presented in the following subsections.

10.4.1 Nursemapp – A Retrospective Case Study

The case study of Nursemapp, a mobile app for nurses that allows entering vital body functions of patients into mobile devices, provides documentation by which the framework can be validated from an integrative holistic view[65]. For a detailed case description and execution, see its details (Versendaal, Högler, & Batenburg, 2016).

The thesis of Heerink (2014) is used as the main case study source to investigate which of the activities of the integrative framework can be recognized in this document of the Nursemapp prototype implementation. We focused on the main text, not on the appendices, and examined if the activities of the integrative framework be identified in the Nursemapp implementation case. We reflected on the activities not explicitly mentioned in the thesis and what this implies.

The analysis of the thesis was executed iteratively: First, one researcher studied and coded the thesis, with a priori codes for each of the activities of the framework. Subsequently, this coding was checked and – if necessary – completed by a second researcher. All occurring discrepancies were discussed and a joint decision was made if a change was needed. The second researcher confirmed in almost every situation the coding of the first researcher. Discrepancies occurred only in few situations and were solved, by, in general, following the second researcher´s opinion, who is also the author of the integrative framework (Högler, Versendaal, & Batenburg, 2015). The coding of the original work of Heerink (2014) is detailed in Versendaal, Högler and Batenburg (2016), from which the following Table 10-4 was literally taken. It describes the agreed upon results of the coding of Heerink´s (2014) observation of the Nursemapp implementation.

[65] See the title of a master thesis: "Should health records go mobile: exploring a mobile health record application in its support to process and quality improvement within hospitals".

Table 10-4: Coding overview (Heerink, 2014)

A priori code	# times a code is identified through a text fragment	Text fragments referring to the particular code in (Heerink, Should health records go mobile? Exploring a mobile health record application in its support to process and quality improvement within hospitals, 2014), examples
Targets	25	"To make work processes predictable and manageable [...]" (p. 27) "[...] and provide information access at the point of care [...]" (p. 27)
BPR	47	"During a patient assessment, nurses inspect at least one patient. Vital values like blood pressure, temperature and saturation are being measured. During the traditional way of working nurses generally use an A4 printed patient list, sometimes accommodated with a pad, to write down their measurements. After every patient in a round was checked upon, nurses walk to a workstation, log on to the electronic health record and enter all scores per patient. With the use of Nursemapp, a nurse will log on in the beginning of a clinical round of assessments. While assessing a patient, the nurse will select the respective patient and enters every vital value. The input will automatically be imported in the electronic health record." (p. 18) "Users saw potential for mobile [Nursemapp] documentation during rounds, where paper-based methods are currently in use." (p. 38)
Success factors	212	"[...] obstacles concern the Wi-Fi connection and choice of device [...]" (p. 91) "[...] projects fail due to the lack of a high-esteem physician buy-in." (p. 28)
Costs	0	-
Benefits	90	"Almost one and a half minute per patient was won by using Nursemapp and health records are more complete since its release." (p. 91) "Using Nursemapp, compared to using pen and paper, significantly differs in the amount of vitals entered in ward A (0.734, $p < .0005$, $d = 0.29$) and in ward B (0.184, $p = .042$, $d = 0.10$)." (p. 83)
Risk analysis	57	"[...] technical inabilities as crashing or freezing is seen as obstacle and unusable and will cause frustration." (p. 94) "[...] inaccurately or omitted vital sign data can result in inappropriate, delayed or missed patient treatment." (p. 19)
Target achievements	7	"To what extent [...] can a mobile health record application support process and quality improvement within hospitals?" (p. 9) "The more obstinate obstacles are, the less strong the effects experienced." (p. 89)

The retrospective case demonstrates the following:

1. We found all activities of the integrative framework – except for 'Costs' – in text fragments of the thesis, confirming *completeness* and *appropriate functionality*. Costs were indirectly addressed as Heerink mentioned 'funding' as of key importance for the success of her case study.

2. The distribution of code occurrences is not even. Particularly 'target achievements' were mentioned only few times whereas 'success factors' were represented very often in the thesis. We explain the limited number of references to 'target achievements' by the fact that Heerink´s thesis uses the terms 'targets' and 'benefits' synonymously. In contrast to Heerink´s thesis, we distinguish between different levels of abstraction and thus between benefits and targets.
3. We particularly checked *whether* activities could be recognized in the text, not *how* they were specifically executed. Yet in some activities similar techniques are used; for instance, the Technology Acceptance Model is described in the thesis and suggested in the detailed description of our framework in connection with the definition of success factors. In this case the validation criterion *consistency* is supported.

10.4.2 Electronic Learning Environment – A Case Study at the Dutch Fire Brigade

The second case study, evaluating the first activity (target system definition) of the integrative framework, concerns the introduction of an Electronic Learning Environment (ELE), leveraging mobile components, at the Dutch fire brigade (see for detailed description and execution of the case study (Versendaal, Högler, & Batenburg, 2016)).

1. It should address the validation of the first activity (target system definition),
2. it should relate to a major (mobile) system implementation, in a large enterprise, currently being prepared,
3. iIt should be easily made clear to the enterprise that carefully thinking about targets, upfront system implementation, is utmost important, and
4. there should be willingness from the enterprise to participate in the validation activity.

The Dutch fire brigade had acquired Three Ships N@tschool!, as a system for supporting lifelong (place and time independent) learning for firemen. Now it is to be decided, which goals have to be achieved with the system, within the fire brigade organization. Having the goals and their prioritization clear, requirements can be derived and the system can be configured accordingly. Therefore, the case study focused on the definition of the target system. Six of the 25 fire brigade regions (representing almost 6000 firemen), with the support of the educational department, decided to take a leading role in developing a showcase how to implement the ELE.

We followed a structured case study protocol that guides in conducting the case study (Yin, 2013). We took the standard research design template of Maimbo and Pervan (2005) for describing our validation protocol. It contains information about chosen procedures, research instruments and data analysis guidelines. While the case study was conducted, the proposed protocol was followed. The procedure and outcomes are described in the in-depth report by Versendaal et al. (2016).

In performing the first activity of the integrative framework, we closely followed the steps identified in figure 2 above and started with the brainstorming of the goals of the ELE implementation with the six region heads, including some bystanders (step 1). One of the researchers managed the process during the brainstorming, while a secretary of the fire brigade observed and took notes, and created afterwards the dependency matrix (step 3, 4 and 5; see figure 3 for a snapshot of interdependencies between objectives). Based on these results, the researchers constructed a goals´ hierarchy (step 2), which was checked and approved by the secretary. The researchers together performed step 6 (defining high, medium and low priority goals from the values in the dependency matrix, only considering lowest level – so called process – goals). In addition to the prioritization using the dependency matrix, one of the team managers (involved as a bystander in step 1) created an ad-hoc prioritization; this helped in the discussions while executing step 7 (describing the final target system, with final prioritized goals).

To validate the framework with this pilot implementation as case study, we elaborate on the following validation criteria:

1. Can all steps of the first activity of the integrative framework be performed successfully? The fire brigade case shows that indeed all steps of activity 1 can indeed be applied successfully.
2. Is the execution of the first activity of the integrative framework considered to be accurate? In a reflection the fire brigade´s secretary states that he considers the model highly accurate, if applied following a robust procedure: He suggests to undertake step 3-5 with multiple employees, so that consensus on the resulting goal priorities can be made. This confirms the procedure as applied by Högler and Versendaal (2016), in which multiple user groups created multiple dependency matrices, which were consolidated in step 7 of the framework´s first activity. In addition, as demonstrated at the fire brigade´s validation, an extra ad-hoc prioritization helps in providing a reference for discussion on the prioritization through the dependency matrix.
3. Is the execution of the first activity of the integrative framework considered to be useful? In relation to especially step 3-5 the remark of the secretary was that it was an *"[...] extremely time-consuming execution; [...] it lets you focus on what is really of importance, but it costs a lot of effort. Yet at the same time I admit it is very useful: it will help during the actual execution of the implementation project for the ELE to concentrate on the really important things!"*. What might help in saving time with steps 3-5 is the determination of the object hierarchy before (instead of 'in parallel') step 3, so that the dependency matrix only consists of process goals (the lowest level goals, that are drilled down from key goals and basic goals, see figure 3). Also presenting the dependency matrix in another format (e.g. as a list) may contribute to the speed

with which values can be entered in the matrix. We end with the statement of the secretary saying that, although creating the goals´ prioritization through the dependency matrix was time-consuming, the investment at the start of the project (in defining thoroughly the target system) would definitely pay itself back during the execution of the actual ELE-implementation.

	Uniformiteit in verblende producten tussen r	Eenduidige context van opleiden	Content meer delen met regio's; inhoud/cont	Verhoging kennisniveau door gebruik kennis	Ontwikkelen content door en voor meerdere	Landelijk ontwikkelen van leertraject ipv regi	Zelfde niveau opgeleid over regio's	Samenwerking intensiever mbt vakbekwaam	Leuk en uitdagende leeromgeving	State-of-the-art leeromgeving	Hoge kwaliteit leerproducten	Inspirerende leeromgeving
Uniformiteit in verblende producten tussen regio's		2	3	2	3	3	2	2	2	1	2	1
Eenduidige context van opleiden	2		3	3	3	3	3	2	2	1	2	1
Content meer delen met regio's; inhoud/content gelijk over regio's	3	2		3	3	2	2	2	2	1	2	2
Verhoging kennisniveau door gebruik kennis verschillende regio's	2	1	3		3	2	1	2	2	2	2	2
Ontwikkelen content door en voor meerdere regio's	3	2	3	3		1	2	2	2	2	2	1
Landelijk ontwikkelen van leertraject ipv regionaal	3	2	3	1	-1		2	0	1	0	0	1
Zelfde niveau opgeleid over regio's	2	3	3	2	3	1		1	0	0	0	0
Samenwerking intensiever mbt vakbekwaamheid	2	2	3	2	3	-1	1		1	1	1	1
Leuk en uitdagende leeromgeving	1	0	1	2	2	1	1	1		3	2	2
State-of-the-art leeromgeving	0	0	0	0	0	0	0	0	2		1	3
Hoge kwaliteit leerproducten	1	1	1	1	0	0	1	1	1	1		1
Inspirerende leeromgeving	0	0	1	1	1	0	0	0	2	2	1	

Figure 10-3: Snapshot of dependency matrix (in Dutch)

<u>Legend</u>:

-1 horizontally depicted objective A has a moderate negative impact on obtaining vertically depicted objective B
0 horizontally depicted objective A has no impact whatsoever on vertically depicted objective B
1 horizontally depicted objective A has moderate impact on vertically depicted objective B
2 horizontally depicted objective A has quite some impact on vertically depicted objective B
3 horizontally depicted objective A has major impact on vertically depicted objective B

10.4.3 Validation of the Framework by Experts

In the timeframe of February and March 2017 6 experts from research and practice were recruited to validate the framework as in a consultation round. The selection criteria for choosing experts were:

1. A high familiarity with the topics IT project management and
2. A high familiarity with the evaluation of economic efficiency of IT systems and
3. A long-time experience in practice.

To identify the experts efficiently, personal business contacts were used in order to identify potential candidates. To select them on experience related to the integrative framework, CV of each candidate was checked including their company web page.

In a second step, a first group of 7 evaluators was contacted. These experts were addressed personally via email, explaining the purposes of the study and asking them if they were interested in participating in the survey and an interview. Eventually six evaluators were found to participate. Upfront they have been provided a description of the framework and the related survey. With the first three experts the survey was discussed during the interview. The other experts were asked to send the completed questionnaires back before the actual interview, so that in the interview the authors could focus on particular parts of the questionnaire (i.e. the parts in which the expert did not (fully) agree). For details on this procedure we refer to the report (Högler & Versendaal, 2017)

10.4.3.1 Structure of the Questionnaire

The questionnaire contained 11 sections (figure 4): one introductory section that contained general information like scope of the interview and questions as regards to the general understanding of the procedure (questions 1-4 (Q1-4)). Section 2 gathered general information about the interviewee like personal data, experience in the topic of the integrative framework and confidentiality / usage of the gathered data. The third section of the questionnaire provided specific assumptions, that we call axioms, of the integrative framework and validated them (Q5-7). Section 4 concentrated on the validation of the integrative framework as a whole (Q8-13) whereas sections 5-11 validated every single of the seven activities of the framework (Q14-32).

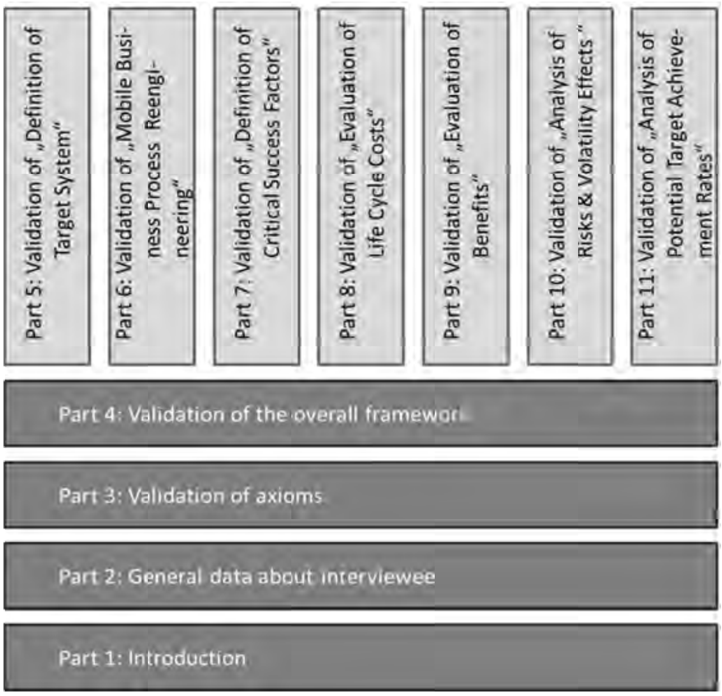

Figure 10-4: Structure of the questionnaire

The questionnaire consisted of survey questions that could be answered by dropdown menus with pre-defined answers (yes / no / partly) and the possibility to enter free text for the case, if ‘no’ or ‘partly’ was chosen in the previous question as answer. With the questionnaire as an interview guiding instrument, the validity and applicability of the integrative framework was assessed, specifically by asking the experts about the (appropriate) functionality, completeness, correctness, usability, generalizability and novelty of the integrative framework.

10.4.3.2 Analysis of Results and Suggestions for Improvement of the Integrative Framework

In terms of their business position, the six evaluators came from SMEs and research institutions. They all had positions like CEO or professor and many years of experience in the topic ‘IT project management’ (Table 10-5).

Table 10-5: Participants of the study

Name	Affiliation	Position	Familiarity	Practical experience since
Prof. Dr. Hans Mulder	Venture Informatisering Adviesgroep NV Antwerp Management School	Managing director Academic Director & Executive Professor	Very familiar	1995
Prof. Dr. Rainer Neumann	University for Applied Sciences, Karlsruhe	Professor	Very familiar	1998
Prof. Dr. Dieter Hertweck	HHZ Research Centre, Reutlingen University	Professor, Head of Research Group	Very familiar	1996
Dr. Asarnush Rashid	Zentrum für Telemedizin Bad Kissingen	Managing director	Familiar	2004
Daniel Stucky	Keller Informatik AG	Owner	Very familiar	1988
Rüdiger Bäcker	@TOLL GmbH	CEO	Very familiar	2004

The detailed interview results are described in the report by Högler and Versendaal (2017). See a snapshot of the report in Figure 10-5, including part of the questionnaire:

	Yes	No	Partly	*Total no. of answers*
Q5:In our approach we derive requirements from objectives as defined in the target system. Do you agree that in this manner objectives and requirements are inherently related?	5	0	1	6
Q6: In our approach we derive the (technical) system specification from requirements (as defined in activity 1) during activity 2 (mobile Business Process Reengineering / mBPR). Do you agree that in this manner a system specification can be derived from (general) requirements during the mBPR??	4	0	2	6
Q7: In our approach we define risks as (critical) success factors that are not taken into account. Do you agree that in this manner risks and success factors are inherently related?	5	1	0	6

Table [illegible]: Part 3 of the questionnaire: Validation of Axioms

We received following input for Q5:
Prof. Hertweck (partly agreeing) said that "[...] requirements (e.g. security, feasibility, personnel skills of workforce,...) are more or less a derived target system from business strategy that constitute itself a target system (bundle of requirements) for the Information System strategy, whereas mobile systems are only one possible solution for the predefined requirements".

As regards to Q6, Prof. Mulder stated that "[...] not all specifications can be derived from requirements during activity 2[2]", whereas Prof. Neumann said that the "[...] derivation is correct on a coarse level – but having only the descriptive paper [in Annex 2] it is not clear if the technical specifications will be complete by applying this approach". So for both experts, an in-depth analysis of requirements is needed in the mBPR.

All experts – except for R. Bäcker – confirmed, that risks can be defined as (critical) success factors that are not taken into account and that thus risks and success factors are inherently related. R. Bäcker stated that "risk could be a critical success factor by itself", implying that vice-versa consideration is also needed.

Figure 10-5: Snapshot of the expert interview results described by Högler and Versendaal (2017)

From the comments and suggestions queried to validate the integrative framework by the experts, the following becomes clear:

1. The *axioms* of the framework were confirmed by the experts. Discussion came up as regards to activity 2 (mBPR) which needs to be described more precisely for a better understanding. For example, it could be useful for readers to know if Business (IT) Strategy is taken into account during mBPR. Otherwise it is difficult to judge, if all requirements (based on activity 1) and system specifications can be derived from mBPR[66]. In addition, it needs to be pointed out clearly, that also stationary information and communication systems can be a result of activity 2 and not necessarily

[66] Remember: System specifications are derived from requirements (which are outputs of activity 1), and based on outcomes of activity 2.

only mobile systems. 'Singularity' as a term needs to be defined more precisely, particularly it needs to be better elaborated that it contains also aspects of 'stories', 'context' and 'personas'.

2. The *framework* as a whole is confirmed by all experts as regards to the *correctness* and *usefulness* of its set of three principles and its seven activities. Discussion came up as regards to the term 'completeness': Two experts stated that without being provided a more detailed description on *how* the activities are implemented, it is difficult to judge if they are complete as for different kinds of projects different sub-activities and methodologies can become necessary. Due to the fact that the integrative framework delivers a guideline for evaluating (mobile) ICS which can take place in different contexts and within different sizes of projects, it does not provide a standard procedure that can be applied with the same quality of results for all kinds of projects. Following general statement can be made: The bigger and more complex a project is, the more detailed and extensive the evaluation has to be. This in turn means, that additional methods within an activity can become necessary, which are currently not made explicit in the integrative framework (e.g. a culture analysis as proposed by H. Mulder, which can be part of mBPR). Main recurring feedback is related to the iteration of the 7 activities. The framework can be significantly improved by explicitly stating that iterations between activities are possible. An iterative approach within the framework was in general possible, but the iteration mainly focused on activity 7 (analysis of the potential target achievement rates) and activity 1 (definition of the target system) – by figuring out which targets can finally be achieved with the given project framework (e.g. budget, timeframe) the target system (i.e. result of activity 1) can be adapted.
3. An enhancement of the framework would be reached by following a comment by R. Neumann: He suggested to define critical success factors in the description of the framework in a clearer way (keyword: 'intersection', which success factors are general ones, when do they become critical etc.), e.g. by applying a Venn diagram for visualizing of results of the matrices. This additional – descriptive – sub-step would make it easier to understand how success factors turn into critical success factors. In addition, he also suggested conducting the analysis of risks and volatility effects at an earlier stage; generally speaking, this analysis could take place at an earlier stage but then the integrative approach would be lost as the analysis of risks and volatility effects considers results of the previous activities.

10.4.4 Concluding Remarks for Improvement

As regards to their completeness of the seven activities, two experts pointed out that a more detailed description about *how* the activities are implemented and *which methods* are applied are necessary to be able to provide a profound validation as regards to completeness.

The analysis of all potentially applied methodologies and sub-activities could be part of a future study.

To enhance the framework, it was suggested to allow iteration between single activities and to implement the analysis of risks and volatility effects at an earlier stage. Though, by analyzing risks and volatility effects at an earlier stage, the integrative character of the approach would be lost as outputs of previous steps could not been taken into account anymore. Another suggestion for improvement was to provide a more detailed description on evaluation criteria ("when does a success factor become a critical success factor") which would enhance the framework / this activity.

10.5 Reflection on the Validation Criteria

The main objective of the chosen multimethod approach for validation was to reliably show the validity and applicability of the framework that is designed for the preparation of mobile technology enabled digital transformation. To do so, we have used different validation criteria. In Table 10-6 we summarize the validation results as for support for these criteria:

Table 10-6: Results from the case studies and experts interviews with regard to the validation criteria of the integrative framework

	Retrospective case study	Fire brigade case study	Experts
Consistency	Usage of same type of approaches in activities		
Accuracy		Following a robust procedure, the first activity (building the target system through a dependency matrix) is considered highly accurate	
Appropriate functionality	All activities, except for an explicit cost evaluation, were also identified in case	All steps of the first activity can be performed successfully	Appropriateness of activities is confirmed by all experts. One even mentioning to start applying it for his own anticipated projects (Högler & Versendaal, 2017)
Completeness	All activities, except for an explicit cost evaluation, were also identified in case		Only verifiable when the execution procedure for each activity is known. The more complex a project, the more detailed and extensive each activity needs to be executed.
Correctness	All activities, except for an explicit cost evaluation, were also identified in case	All steps of the first activity can be performed successfully	Underwritten by experts for principles and activities. Suggestion for leveraging specific techniques in third activity (Critical Success Factors identification). Suggestion for more interaction between activities and re-addressing certain activity based on outcome of other activity.
Usability		The execution of the first activity is, especially in the case of many identified goals, cumbersome	Underwritten by experts for all activities
Novelty			No similar integrative approaches known
Generalizability		Applicability for ICS that has limited mobile technology	Applicability of the framework even beyond mobile systems confirmed by experts

10.6 Conclusion

In this paper, an integrative framework to evaluate mobile system is presented (Högler, Versendaal, & Batenburg, 2015) `that delivers insight into its tangible and intangible effects before it is being implemented; and thus represents an ex-ante evaluation approach.

The integrative framework was evaluated by applying a multimethod approach, i.e. a retrospective case study, a case action study and a validation by experts in the area of project management. The results of these validations are shown in this paper and can be explored in further detail in the respective separately available validation reports.

Summarizing these findings, we can state that the framework has potential applicability in supporting decision making processes for mobile system evaluation in a comprehensible way. Its appropriate functionality was confirmed in both case studies and by all interviewed experts who assessed the framework based on their long-time practical experience in this field. For the Nursemapp case study the general approach of the framework could be addressed explicitly for six out of seven activities. The fire brigade case action study confirms particularly the accurateness, utility and effectiveness of the first activity of the framework, the preference-neutral definition of the target system. The set of the three principles (internal analysis, economic analysis and integrative evaluation) as well as the seven activities were confirmed by all of the consulted experts.

The *novelty* of the integrative framework as a whole, but particularly the proposed approach for defining the target system and critical success factors, was approved by all experts, stating that they did not know any similar approaches. Suggestions for improvement (from the expert validation) focus on the re-addressing of activities and more insight into the method of particular activity execution.

Further research on the validity of the integrative framework can be done for the single methodologies and approaches applied in the seven activities. The lack of a detailed description was mentioned by several of the involved experts, meaning that there is room to improve the completeness of the framework.

PART 5: REFLECTION

11 Conclusion and Outlook

11.1 Recapitulation

Since many years *mobile computing* has strategic value for organizations (cf. (Scornavacca & Herrera, 2007; Schönberger, 2014)), as mobile technologies are applied in many business processes, providing ubiquitous access to information (Basole, 2008) and enabling new business processes and opportunities (cf. (Picoto, Palma-dos-Reis, & Bélanger, 2010; Euler, Hacke, Hartherz, Steiner, & Verclas, 2012)). The evolving mobile systems, sets of mobile technology and human (system) components, which are inherently related, are becoming increasingly complex as they offer a broad variety of fields of application and as their components can appear in many combinations. They evolved *"from small projects focused on productivity improvements and cost savings to large-scale enterprise-wide strategic implementations that enable companies to gain and sustain competitive advantages"* (Kornak, Teutloff, & Welin-Berger, 2004) in (Basole, 2005, p. 364).

Up to now, only 29-39% of IT projects are successfully implemented (cf. (Standish Group, 2013; 2014)). Considering the complexity of mobile systems, there are plenty of explanations why projects aiming at implementing such systems still fail or at least do not reach the objectives set by the management. To address this challenge, we proposed to evaluate these systems in an integrative way, taking into account their specific characteristics (i.e. singularities) which are amongst others (for details see chapter 1):

- *technical hardware-related aspects* like usability (cf. (Dinh, Lee, Niyato, & Wang, 2013; Pryss, Reichert, Bachmeier, & Albach, 2015))
- *security aspects* like privacy (cf. (Modares, Lloret, Moravejosharieh, & Salleh, 2014; Sadkhan & Abbas, 2014; Hasan & Gómez, 2017))
- *data-related aspects* like context sensitivity (Basole, 2005, p. 367)
- *environment-related aspects* like heterogeneity of devices (cf. (Punithavathi & Duraiswamy, 2008; Dinh, Lee, Niyato, & Wang, 2013; Schönberger, 2014; Pryss, Reichert, Bachmeier, & Albach, 2015))
- *organizational aspects* like the mobilization of business processes and workflows (cf. (Forman & Zahorjan, 1994; Euler, Hacke, Hartherz, Steiner, & Verclas, 2012; Pryss, Reichert, Bachmeier, & Albach, 2015; Bernsteiner, Kilian, & Ebersberger, 2016)).

This lead to the main research question (MRQ):

MRQ: *How can mobile systems be evaluated in an integrative way?*

To answer this MRQ, we define three main objectives that guide our research work:

- Objective 1: to have shown the necessity of an integrative evaluation model for mobile systems by surveying why existing approaches are not appropriate for evaluating the business value of this type of systems
- Objective 2: to have defined an integrative framework for evaluating mobile systems, in particular for evaluating their business value
- Objective 3: to have evaluated this integrative framework by validating it in terms of its completeness, correctness and its usefulness using different validation methods.

The necessity of an integrative evaluation framework for ICS in a mobile world is shown in the first part of this thesis which provides an introduction into the research topic (chapter 1) and a motivation to integrate (critical) success factors into the approach (chapter 2). As also the outcomes of literature analysis show (chapter 3), existing evaluation approaches for mobile systems lack focus on business value and insufficiently take an integrative view; this encouraged the further development of the integrative framework. Chapter 4 concludes the preceding chapters and provides a research agenda for the succeeding parts of the thesis (parts 2-4). It suggests addressing of:

- generic identification and further validation of components of mobile systems and their relations;
- further confirmation, detailing and identification of singularities;
- determination of success factors from singularities, system components behavior and interdependencies between components;
- construction of a model for mobile systems evaluation taking into account success factors, components and interdependencies of components;
- validation, case studies and more related to constructed mobile systems evaluation models;

which is elaborated in the following parts of the thesis.

The second part focuses on the development of an integrative framework and on the description of its characteristics (chapters 5-6) while the third part of this thesis further details and applies the integrative framework in practice (chapters 7-9). In the fourth and last part of the thesis the integrative framework is validated in terms of its completeness, correctness and its usefulness by two further case studies and experts´ interviews (chapter 10).

In the following sections, the results, conclusions, contributions and limitations of this research are described and recommendations for further research are given.

11.2 Results and Conclusions

The above mentioned MRQ covers a broad and complex field in the context of the main topics ‘economic evaluation’ and ‘mobile computing’. In order to handle this complexity, we break the MRQ down into four research questions (RQs) that are addressed in the thesis´ chapters and that address the above mentioned objectives.

- RQ1: Why is an integrative approach for mobile systems necessary? (Objective 1)
- RQ2: What are the components that build an integrative approach? (Objective 2)
- RQ3: How to apply the integrative approach for mobile systems in practice? (Objective 2 and 3)
- RQ4: Is the integrative approach for mobile systems a valid approach? (Objective 3)

Concepts of design science research (DSR) (cf. (March & Smith, 1995; Hevner, March, Park, & Ram, 2004; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007)) were chosen as research design and strategy of this thesis. DSR improves understanding of IS *“through the construction and evaluation of these systems and their components”* (Vaishnavi & Kuechler, 2007) and *“creates and evaluates IT artifacts intended to solve identified organizational problems”* (Hevner, March, Park, & Ram, 2004, p. 77), which is the key objective of this thesis. The integrative framework is our proposed artifact that is constructed considering business needs and the scientific body of knowledge. The two main design processes we use are to build the artifact and to validate the artifact in case studies and by experts´ interviews. The applied validation criteria are leveraged from Hevner, March, Park and Ram (2004) and Carvalho (2012), relating to the framework´s completeness, correctness and usefulness.

An additional reason why the DSR approach was chosen is its usefulness for addressing so-called ‘wicked’ problems. A wicked problem is a *“class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing”* (cf. (Churchman, 1967; Rittel, 1972)). As mobile systems have different complex components, including people, that are continuously influencing each other and that have manifold singularities that need to be considered, the evaluation of such systems can be considered a wicked problem.

11.2.1 Necessity for an Integrative Approach

To answer the first RQ

RQ1: Why is an integrative approach for mobile systems necessary?

we observe some current developments in part I of this thesis which contains chapters 1 to 4, but also in part 3 (chapter 10). Considering the results and outcomes of these chapters, existing approaches for an a priori evaluation of mobile systems seem to be limited because (see also chapter 10):

- They often only take into account monetary effects or transform qualitative effects into monetary effects (cf. (Horváth, 1988; Zahn, Schmid, & Dillerup, 1999; Mutschler, 2005)).
- They lack a theoretical basis (cf. (Renkema & Berghout, 1997; Berghout, Nijland, & Powell, 2011)).
- They do not explicitly address singularities of mobile systems (Högler & Versendaal, 2014).
- They insufficiently consider interdependencies, particularly between system components, between objectives, risks and success factors, which eventually affect implementation effects (Högler, 2012).

Based on these findings and the results of this research work, the main reasons for the necessity of an integrative approach for evaluating the business value of mobile systems are the following ones:

Reason 1: Scope of evaluation needs to be amplified (I): From economic efficiency to business value

As we have seen in chapter 1 of this thesis, mobile computing is an important field of research in ICS research and practice[67] (cf. (Bernsteiner, Kilian, & Ebersberger, 2016; Imran, Quimno, & Hussain, 2016)) as it is right now strongly contributing to digital transformation of enterprises and consequently has a high strategic and business value for organizations ((Scornavacca & Herrera, 2007; Schönberger, 2014)). Business value is the measure that describes how much a specific (mobile) ICS contributes to the objectives of an organization that should be achieved by implementing this specific ICS, independently of the kind of effect. Therefore, it is more than the economic or qualitative impact of any technological change as it encompasses a broad variety of intangible, strategic or long-term effects on the whole organization and its environment. Having a closer look at this interpretation it becomes clear, that the definition of objectives is highly important for the success of an ICS project in general (King, 2015) and mobile system implementation specifically, and should thus be incorporated into the integrative approach:

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[67] According to Kevin Kimberlin, Chairman of Spencer Trask & Co., *"No other technology has impacted us like the mobile phone. It's the fastest growing manmade phenomenon ever -- from zero to 7.2 billion in three decades"* (Boren, 2014)

- An improper requirement definition is the most-cited reason for implementation failures (cf. (Davis, Dieste, Hickey, Juristo, & Moreno, 2006; Hughes, Dwivedi, Simintiras, & Rana, 2015)) while technical and non-technical requirements are derived from objectives and
- The *"lack of clear understanding of what the company wants to achieve"* (IMG, 2015) and thus improperly defined objectives can lead to project failure or at least to a reduced overall business value.

Consequently, the success of a mobile system implementation is tightly connected to a proper definition of objectives.

Taking the above said into account, we conclude that the scope of evaluation of mobile systems needs to be amplified towards business value. It should incorporate the definition of objectives as a first step of evaluation. Both is not the case yet in most of the existing approaches known to the author.

Reason 2: Scope of evaluation needs to be amplified (II): Taking a socio-technical systems theory perspective

In chapter 1 we have seen that in order to evaluate mobile systems in an integrative way, it is essential to understand them as socio-technical systems (cf. (Orlikowski, 1992; Orlikowski & Iacono, 2001)) whose implementation *"affects the organization as a whole, the related business process and those people inside and outside of the organization that have to use these information systems"* (Bernsteiner, Kilian, & Ebersberger, 2016, p. 72). Considering this statement, it becomes clear that it is necessary to evaluate mobile systems beyond the mere technologies implemented: A socio-technical systems theory perspective is needed as technologies on their own have no value – they *can* generate value only when being used or applied by humans. Consequently, the interactions between the single system components, including users, have to be considered.

This cognition illustrates – as shown in chapter 3 – that a proper alignment between the single system components, (i.e. technologies, users and business processes), is necessary when discussing the economic efficiency and business value of any ICS. Hence, principles of business/IT alignment (Henderson & Venkatraman, 1993) seem appropriate for the evaluation for mobile systems. This statement is valid in particular for mobile systems by cause of their singularities that distinguish them from stationary systems, making such systems even more complex (cf. (Camponovo & Pigneur, 2003; Prinz & Schwarz, 2003; Krupp, 2015; Bernsteiner, Kilian, & Ebersberger, 2016; Xiu, Fulgenico, Asino, & Baker, 2017)). As a consequence, singularities need to be considered not only during implementation of such systems, but particularly during their ex-ante evaluation: If the single components of mobile systems are not functional similar to a 'clockwork', their overall business value cannot be achieved.

Taking the above said into account, we propose that the scope of evaluation of mobile systems needs to leverage socio-technical *systems theory principles* and needs to be amplified towards including the alignment of IT with the business (*business/IT alignment*) and considering *singularities* of mobile systems, which is not the case yet in most of existing approaches known to the author.

Reason 3: Scope of evaluation needs to be amplified (III): Considering success factors

Another reason for the necessity of an integrative framework was provided in chapter 2 of this thesis while analyzing success factors for effectively implementing mobile commerce in businesses. We define a success factor as a factor which has a sustainable and positive effect on the success and consequently on the business value of a company. As mobile commerce can be seen as part of mobile business and thus of mobile computing in general, the same findings can be considered for mobile systems in general.

The main outcomes of this research show that – in contrast to earlier research with main focus on technology – more emphasis on the user´s perspective is needed when discussing success factors. Effectively implementing mobile systems calls not only for a more in-depth understanding of mobile technologies, but particularly for a better understanding of user behavior and his needs with regard to the applied technologies. As a result also CSF are explicitly to be derived from singularities (see e.g. chapter 4).

Taking the above said into account, we propose that the scope of evaluation of mobile systems needs to be amplified towards considering (critical) **success factors**, which is not the case yet in most existing approaches known to the author.

Recapitulating the reasons for the necessity of an integrative approach, we draw principles from several theoretical foundations to design our framework and define following three pillars of an integrative approach for evaluating mobile systems (cf. chapter 3):

- Systems theory (Bertalanffy, 1976),
- Business/IT-alignment and
- Taking into account the specific mobile context, by properly dealing with singularities of mobile systems.

Our literature review and analysis of existing evaluation approaches for evaluating ICS and mobile systems respectively show, that the above described considerations are not yet fully covered (see also chapter 8). Hitherto, there is – to the knowledge of the author – no approach known, that takes systems theory perspective, integrates business/IT alignment principles and that explicitly considers singularities of mobile systems for evaluation. Existing approaches mainly focus on the economic efficiency of such systems as they have been developed during the industrial era or during the early stages of computers. They are not able to determine the effects of technology as used in the current digital age and hence disregard many of mobile systems´ benefits. This finding may well explain the low success rates of IT/IS projects which levelled off between 29 and 39% (cf. (Standish Group, 2013; 2014)).

With the increasing complexity of systems – as for their scope and functionality – the appropriateness of the identified approaches decreases since still limited attention is put on the business value. To capture the benefits of ICS and particularly mobile systems a change in the perspective – from an economic efficiency ('efficiency view') to an integrative perspective ('effectiveness view') that focuses on business value – is needed as shown in chapter 1 (cf. (Stratopoulos & Dehning, 2000; Basole, 2005)).

11.2.2 Building the Integrative Approach

Based on the results of this discussion and insights gained, we formulate hence RQ2 which is addressed by chapters 5 and 1:

RQ2: What are the components that build an integrative approach?

In chapter 5 we start building the integrative approach. Doing so, we identify a number of activities for an integrative framework that can be listed as follows, with added literature references.

- Activity 1: Definition of a target system. This activity follows the Multi-Attribute Decision Making (Hwang & Yoon, 1981) and delineates a procedure for defining a target system. During this process, the mutual effects of single objectives are analyzed following the Analytical Hierarchy Process (AHP) (Saaty, 1996), which is extended by this research work.
- Activity 2: Mobile Business Process (Re-)Engineering (mBPR). This activity includes the analysis, modelling and re-designing of business processes. It is built upon Mobile Process Landscaping as drafted by Gruhn et al. (Gruhn & Wellen, 2001; Köhler & Gruhn, 2004). In this activity, singularities of a mobile system at hand, interdependencies between system components and KPIs are identified.
- Activity 3: Definition of critical success factors (CFS). This activity is based on singularities of a mobile systems (incl. analysis of their interrelationships and weighting), which are derived from singularities that are identified in activity 2. Also in this activity we analyze the interdependencies between success factors in order to identify the ones with the largest effects (CFS) (cf. (Gebauer & Shaw, 2004; Gichoya, 2005)).
- Activity 4: Evaluation of life-cycle costs. For this activity different existing approaches and analyses can be applied. For the integrative framework, we suggest to apply the Total Cost of Ownership (Gartner Group, 1997), whereupon considering the whole life cycle of a mobile system.
- Activity 5: Evaluation of benefits. Also for this activity different existing approaches can be employed. We suggest for gathering and analyzing benefits utilizing the Total Benefit of Ownership Model (TBO) (Gadatsch & Mayer, 2004) that captures besides monetary and non-monetary also qualitative and strategic benefits.

- Activity 6: Analysis of risks. In this activity, particularly the variables 'success factors' (cf. (Rockart, 1979; Corsten, 2000)) and 'risks' (Kronsteiner & Thurnher, 2009) are analyzed.

Systems theory perspective (Bertalanffy, 1976) is taken in this chapter by the definition of mobile systems as socio-technical systems that perform business processes. Business/IT alignment is addressed by the inclusion of activity 2, the analysis, modelling and re-designing of business processes where also singularities of a mobile system at hand are identified.

Already presented for the analysis of existing approaches from literature (chapter 3), in chapter 6 we consolidate the criteria for the integrative framework as follows:

- Multi-dimensionality (as regards to costs/benefits, life cycle, process orientation, interdependencies)
- Scalability (as regards to the requirements of a specific project like financial resources or time restrictions) (Kern, 1974)
- Consideration of critical success factors
- Systematics (as regards to the reproducibility and comparability of results, even if approach was adapted to the specific needs or framework of a project)

In chapter 6 we extend the mentioned six activities of the integrative approach as follows, leading to an update of activity 6 and additional activity 7:

- Activity 6: Analysis of risks *and volatility effects* – as we propose to consider how risks affect the potential success of a project and what happens, if specific (critical) success factors are or are not considered.
- Activity 7: Evaluation of the potential target achievement rates – as we propose to take an integrative view and combine all the knowledge gained during the previous activities of the evaluation.

We further structure the activities into three phases[68]:

- a detailed internal analysis, which comprises activities 1-3
- a detailed economic analysis, which comprises activities 4-5
- an integrative evaluation, which was evolving from a profitability analysis (chapter 6) to a sensitivity analysis (chapter 8) to the integrative evaluation (comprises activities 6-7)

[68] In the further evolution of the work labeled as *'principles'*.

The developed integrative framework is further detailed and tested in practice within several case studies that are described in part 3 (chapters 7-9) of the thesis. Further evaluation and validation takes place in chapter 10.

11.2.3 Detailing and Application of the Integrative Framework in Practice

After having defined the characteristics and concepts of the integrative framework, we address with RQ3 particularly the question

RQ3: How to apply the integrative approach for mobile systems in practice?

In part three of this thesis (chapters 7-9), we detail and apply the integrative framework in practice; further testing with two additional case studies takes place in part 4, but with focus on validating the integrative framework. To do so, following sub research questions were defined[69]:

Sub RQ3.1: How can a framework be developed for the evaluation of mobile systems, their productivity and process improvements, taking into account special characteristics of mobile systems, and applying an integrative perspective using systems theory, business/IT alignment, behavioral and design science?

The integrative framework in its entity is detailed as regards to its activities, but also as regards to inputs and outputs of the activities and the related information and data flows in chapter 7. Chapter 8 further details activity 1 – definition of the target system – and describes in detail steps that need to be taken to implement this first activity.

To approve the applicability of the integrative framework it was tested in several case studies that covered SMEs and Global Players, both from different fields.

In the first case study (chapter 7), the integrative framework was applied in the field of mobile maintenance management at a German manufacturer for synthetic resin, involving more than 500 employees. The case study concerned the stage of decision making including the first steps of implementation. In the second case study (chapter 8), we validate the first activity of the integrative framework, i.e. the definition of the target system, by operationalizing it at a German SME in the building industry in the field of resource planning processes for workers who spend most of their working time outside of the company´s industrial premises.

[69] We use the terms *'special characteristics'* and *'singularities'* synonymously.

In further detailing of activity 3 we posed the following sub RQ:

Sub RQ3.2: How to identify (critical) success factors for mobile systems, taking a multi-dimensional perspective?

After identifying general success factors for a special type of system, we propose to analyze their relevance subject to users, tasks and the defined target system, taking into account singularities. Similar to activity 1, defining the target system, we propose to analyze interdependencies between success factors (see also chapter 5) and to weight them, so that – based on the results of these steps – the critical success factors can be identified.

This activity was implemented as case study at a German Global Player of the chemical industry in chapter 9. The results of the case study show, that it is important to understand the interdependence of success factors and their relation to tasks, objectives and system components, particularly the human ones, while the objectives set by decision makers have to be considered when defining success factors. Thus, a project-specific identification of so called system-related success factors is proposed that takes into account the users (user profiles) being involved in the mobile process, the tasks that have to be fulfilled and the targets that were set by e.g. the management.

11.2.4 Further Validation

In the chapter 10 we deal with last research question of the present work which addresses the validity of the integrative approach:

RQ4: Is the integrative approach for mobile systems a valid approach?

To address this research question, a multimethod approach as presented and discussed by Mingers (2001) and Venkatesh, Morris, Davis and Davis (2003) was chosen. Validation criteria were the framework´s completeness, correctness and usefulness.

A case study (i.e. Nursemapp), representing a mobile app for nurses that allows entering vital body functions of patients into mobile devices, provides documentation by which the framework can be validated from a retrospective view. It is used as the main case study source to investigate which of the activities of the integrative framework can be recognized and coded in the document of the Nursemapp prototype implementation.

The retrospective case demonstrates the following: All activities of the integrative framework – except for 'costs', which were only indirectly mentioned as 'funding' – were found in text of the thesis, confirming its completeness and appropriate functionality.

In the second case study we evaluate the first activity (definition of the target system) of the integrative framework in a project aiming at introducing Three Ships N@tschool! at the Dutch fire brigade. Three Ships N@tschool! is an Electronic Learning Environment (ELE), leveraging mobile components, for supporting lifelong (place and time independent) learning for firemen. The aim of the case study was to define goals that have to be achieved with the system.

The fire brigade case shows that all steps of activity 1 of the integrative framework can be applied successfully in practice. However, due to the large number of targets identified, their prioritization was found extremely time-consuming – yet forced at the same time to focus on what is really of importance.

The last validation of the integrative framework was done by six experts´ interviews and focused on the framework´s completeness, correctness and usefulness from theoretical and practical view.

The framework as a whole and its three principles were confirmed by all experts as regards to the correctness and usefulness of its set of three principles and its seven activities. Detailed feedback was provided and suggestions for enhancements were made. The framework (notably because of its explicit definition of the target system) is acclaimed by the experts for its novelty, accuracy and addressing the gap between project outcome and anticipated effect of a (mobile) system.

11.3 Contributions and Implications

Design science research in IS provides two design processes which are applied in this thesis: Build artifacts to address formerly unsolved problems and evaluate them with respect to the utility provided in solving those problems (March & Smith, 1995, p. 78). Having this in mind, we first illustrate the scientific contributions followed by contributions and implications for practice.

11.3.1 Contribution to Science

The targets pursuit by implementing ICS have changed during the last decades (cf. (Peppard & Ward, 2016; Rahimi, Møller, & Hvam, 2016)). Nowadays, the focus is increasingly turning towards business value and strengthening the competitiveness of companies on a global scale. Consequently, traditional economic analyses are not capable to evaluate such systems as they are applied in the digital age. The reason for this is that they still apply conventional KPIs like monetary values while strategic or qualitative benefits are disregarded. At the same time, ICS and particularly mobile systems are complex constructs with different fundamental kinds of components – processes, people and technology – that are continuously influencing each other and that thus have an impact on the overall business value (Irani & Love, 2001). Therefore, a socio-technical systems theory perspective is suitable to integratively considering them – the trigger for the present work. Although the importance of ICS and mobile systems is reflected by scientific and industry publications, there is room for more socio-technical approaches. Publications related to the effectiveness of mobile systems are rare and there is still a lack of relevant evaluation approaches (see e.g. (Ashurst, Doherty, & Peppard, 2008)). We were not able to identify publications that take our operationalization of socio-technical systems theory and thus for our integrative view for evaluating the business value of mobile systems. The existing body of knowledge seems to lack approaches to consider and act on the specific challenges of mobile systems.

Consequently, a new approach is useful, that takes and operationalizes an integrative perspective to capture all effects of such systems. These findings, discussed in chapter 1 and by answering the first RQ, illustrate the scientific relevance of this thesis: the need for a new approach for evaluating ICS, particularly mobile ICS. We address this demand by applying design science research which seeks to *“construct and evaluate artifacts designed to meet the identified business need”* ((Krouwen, Land, & Offerman, 2016, p. 6), cf. (March & Smith, 1995; Hevner, March, Park, & Ram, 2004)).

We took notice of Sawyer´s and Jarrahi´s encouragement to address conceptualization, empirical activity, and methodological effort in specifically the mobile context (Sawyer & Jarrahi, 2014). The scientific contribution of this research work is the integrative framework which is an innovative solution to an identified problem – the evaluation of mobile systems, based on the following three pillars:

- Systems theory,
- Business/IT alignment and
- Singularities of mobile systems.

The integrative approach as a whole is an innovative, unprecedented approach for ex ante evaluation of mobile systems. We evaluate and validate it in practice, and by doing so we develop a new artifact.

We have formulated RQ2 that intends to answer the question “What are the components that build an integrative approach?”. Novelty is given and scientific contribution is provided by the development of following artifact components:

- Preference-neutral definition of a target system, based on an extended Analytical Hierarchy Process, taking structurally into account interdependencies of the single objectives, and by applying risk analysis in a unique way (activity 1);
- Definition of success factors by deriving them from singularities of mobile systems and by applying risk analysis in a unique way to identify the critical success factors (activity 3);
- Extending a traditional risk analysis by integrating critical success factors (activity 6);
- Taking an integrative perspective, by combining results of all activities of the integrative framework.

The generality of the artifact and the artifact components was supported in several case studies where they have been applied in different contexts.

11.3.2 Contribution to Practice

The main research question of this thesis "How can mobile systems be evaluated in an integrative way?" presumes that there is a lack of appropriate evaluation approaches and thus a need for a new, integrative one. To understand the practical contribution of this thesis, we need to consider the latest developments of IT/IS.

The main organizational problem which motivated an integrative approach is the fact, that still a huge percentage of I(C)S projects fails or at least does not achieve the objectives set by the management to a great extent: *"Organizations spend billions of dollars annually on IT, only too often to conclude that those dollars were wasted* (Keil, 1995; Keil, Cule, Lyytinen, & and Schmidt, 1998; Keil & Robey, 1999). *This community would welcome effective artifacts that enable such problems to be addressed"* (Hevner, March, Park, & Ram, 2004, p. 85). Same should be valid for mobile systems, as they are even more complex forms of ICS, showing many specific singularities that need to be considered in an integrative way. Particularly as IT and mobile technologies are reshaping the global economic landscape and as they are driving forces of the digital era, their successful implementation into systems seems to be an important, yet complex challenge in practice as it often fails in terms of scope, budget and time. As a result, it is not constructive to focus only on economic and productivity effects while evaluating a priori mobile systems, but to take an integrative perspective, enabling addressing business objectives before implementation as well as success factors that influence the overall project (implementation) success. These considerations lead to the realization that an integrative perspective is necessary to cope with the specifics of mobile systems.

This work contributes to addressing one of the mayor organizational problems that are related to ICS: increasing the success-rate of IS projects. To do so, in contrast to the definition by Hevner, March, Park and Ram (2004) not a technology-based, but a technology-*oriented* solution to this important and relevant wicked business problem is developed – the integrative framework (part 2 of this thesis). We deal with complex human-technology-systems (i.e. mobile systems) that have specific singularities that need to be considered during evaluation as they highly influence the overall efficiency and effectiveness of the mobile system.

In this thesis we produce and evaluate an applicable artifact[70] in the form of a model inheriting a method – the integrative framework for evaluating the business value of ICS with mo-

[70] which includes components of the organization and people involved in the use of technologies, in our case mobile technologies

bile components (i.e. mobile systems). We have identified following contributions to practice:

1. The framework as a whole with its seven activities supports decision makers step by step in evaluating a potential investment in a mobile system. It provides a 'hands-on' guideline for the evaluation of mobile systems that can be applied in practice. This approach cannot only be used for ex post evaluation, but also for an ex ante appraisement of the potential benefits – as a consequence, it offers decision support for organizations intending to implement such systems.

2. The second contribution are following artifact components (i.e. activities that can be applied in practice) that are innovative and that support evaluation and decision making:

   - Definition of the target system: As a novelty, the proposed definition of the target system is taking structurally into account interdependencies of objectives. The result of this analysis is a matrix that contains all mutual effects of objectives, their strengths as well as the likelihood of their appearance. This matrix allows a preference-neutral prioritization of objectives. This activity of the integrative framework was tested in two case studies, namely at an SME of the Building Industry in Rhineland-Palatinate, Germany, with focus on implementing a mobile maintenance system (chapter 8), and at the Dutch fire brigade, that focused on a life-long learning system for firemen (chapter 10).
   - Definition of success factors (see chapters 4 and 9): As each single project is unique, there can be no fully standardized procedure for the identification of success factors that are related to this single / special system. Rather a project-specific identification of so called system-related success factors has to be proceeded that takes into account the users (user profiles) being involved in the mobile process, the tasks that have to be fulfilled and the targets that were set by e.g. the management. The proposed method can also be applied to evaluate the effectiveness of mobile systems: Which success factors are already considered and which can be added to provide a strategy for more effectiveness of the mobile system. The activity 'definition of success factors' was validated in a case study in the chemical industry at a German Global Player.

3. The integrative framework can be leveraged to other settings where decision making is necessary like stationary systems or even e.g. for the purchase of a car. Particularly the first activity, definition of a preference-neutral target system, can be applied for totally different purposes, like for the development of a business model, where a focus on 'most efficient tagets' is essential.

11.4 Limitations

The design science research execution implies that the integrative framework is validated as an artifact (Hevner, March, Park, & Ram, 2004, pp. 85-87). In the fourth part of this thesis, we apply three generic validation criteria *'utility'*, *'quality'* and *'efficacy'* (Hevner, March, Park, & Ram, 2004) and complete them with additional criteria suggested by Carvalho (2012): *'generalizability'*, *'novelty'* and *'explanation capability'.*

The first limitation of this research work is that the integrative framework was not fully implemented in all details. Only the novel parts of the integrative framework were analyzed and tested in practice. The reason for this is that several of the framework´s activities represent standard approaches that are widely applied in practice and recognized by science, accordingly their implementation and validation would not contribute to the validity of the integrative framework, specifically activity 2 (business process re-engineering), activity 4 (evaluation of life cycle costs) and activity 5 (evaluation of benefits). Activity 6 (analysis of risks and volatility effects) is based on standard risk analysis procedures as proposed by (Kronsteiner & Thurnher, 2009), but integrates (critical) success factors into its considerations. Activity 7 of the integrative framework, the analysis of potential target achievement rates, was not further implemented; its implementation would have required the development of e.g. an IT program based on operations research principles that calculates results, which was not the intention of the present work. Rather, our research aimed at providing a guideline on how to successfully implement mobile systems projects, which factors to consider and how to define objectives properly (in a preference-neutral way) in order to achieve business value. It would require a more quantitative, standardized approach to properly identify typical values[71], based on a multitude of case studies, to be able to deliver such a program – a potential future research direction. At the same time, based on the project size the application of the framework can differ (cf. criteria framework: extensibility / scalability are required), so that even if not fully applied (as this would be probably the case in smaller projects), the framework provides a valid and useful guideline on what to consider when implementing ICS in a mobile environment. Regardless this limitation, the integrative framework in its entirety and its general approach were validated and confirmed by experts and with an ex-post evaluation (Nursemapp mobile healthcare system).

Another limitation of the present work is that it was applied in a limited number of application fields: a) mobile maintenance management in different sectors and b) mobile learning system at a Dutch fire-brigade. A retrospective case study – focusing on the implementation of a mobile healthcare system (Nursemapp, see (Versendaal, Högler, & Batenburg, 2016)) – was employed to investigate which of the activities of the integrative framework can be rec-

[71] quantitative approach for e.g. defining success factors, KPIs, risks

ognized to prove its applicability in a context that is independent from the first ones. Although the integrative framework was implemented in a few application fields and sectors only, they differ fundamentally so that we can conclude the applicability of this approach in different contexts. Nevertheless, more case studies and the application in a stationary context would certainly contribute to the research rigor and validity of the integrative framework.

11.5 Outlook

In the past sections we have seen the contributions, but also the limitations of the present thesis. As we focused on providing a practice-oriented guideline for implementing successful ICS projects within a mobile context, we applied solely qualitative research methods (case studies), while quantitative analyses were not applied. This approach is justified as the framework aimed at providing *"provisional explanations of phenomena, often introducing a new construct and proposing relationships between it and established constructs"* (Edmondson & McManus, 2007, p. 1158). The objective of the implemented qualitative surveys and case studies of limited sample size was to validate the construct of the framework, i.e. its axioms and the proposed activities and procedures. The goal of the thesis, to construct as well as validate an artifact, was addressed, while the generalizability of the framework was confirmed by experts.

According to Peppard and Ward, *"information technology (IT) is one of the greatest disruptive forces confronting organizations today"* while the *"effects of IS/IT on every enterprise […] are continuing, steadily and inexorably, to become more profound and complex year on year"* (2016, p. xv). The reason for this are developments of the last decade, particularly the prevalence and ubiquity of mobile devices[72] in a multitude of business areas (Pryss, Reichert, Bachmeier, & Albach, 2015) which requires their sustainable, thus business value oriented, and effective integration in business processes. The latter ones have been and continue to be digitized and mobilized across all industries, and people get increasingly used to deal with mobile devices and to access and proceed data and information – network coverage presupposed – anywhere, anytime. But even though mobile devices have evolved very fast towards 'smart mobile devices', equipped with sensors and large processing capacity, and have often more functionality then consumer desktop computers of the previous decade, they still have restraints and therefore specific characteristics that need to be taken into account.

The complexity of mobile systems is reinforced by the increasing intelligence of single system components (keyword: Artificial Intelligence (AI)) and rising connectivity (keyword: In-

[72] Since 2014, there are more mobile devices than people in the world, and they are multiplying five times faster than the humanity is (Boren, 2014)

ternet of Things (IoT)). Particularly by the IoT-related connection of different kinds of sensors, delivering huge amounts of data (keyword: Big Data), allows the integration of context information and parameters into business processes, so that an integrative perspective becomes more and more important. An epiphenomenon is, that the evaluation of effects that mobile systems have has become a wicked problem that needs an integrative approach.

In line with the business/IT-alignment insights, the integrative framework does not only consider the singularities of mobile systems, but especially the interdependencies, relations and interactions of the single system components. Hence it is not only meant to 'predict' the potential target achievement of mobile ICS and thus business value, but can also help to conduct and to monitor the implementation of such a project by providing guidance – a handbook on how to start and conduct such a project and which factors to consider.

From a theoretical perspective, a more structured literature review is suggested as *"conducting effective literature reviews is essential to advance the knowledge and understand the breadth of the research on a topic of interest, synthesize the empirical evidence, develop theories or provide a conceptual background for subsequent research, and identify the topics or research domains that require more investigation*" (Paré, Trudel, Jaana, & Kitsiou, 2015, p. 183). As a result, structured literature research should be a project on its own.

Based on the fact that the programming of activity 7 – evaluation of the potential target achievement rates – was not implemented, it offers a broad field of further research. It is a complex endeavor as this activity considers and merges all results and insights gained in activities 1-6. To implement a computer program that can be used for decision making, would need probably a more quantitative approach that delivers valuable, generic data. Operations Research principles could be leveraged as they seem to be a promising way to provide a mathematical result. Operations Research is here just a promising technique, but also other mathematical techniques could lead to useful results.

As a number of the case studies focused on the field of mobile maintenance, further research could be to validate the correctness and effectiveness of the integrative framework in other contexts (similarly to the medical / hospital context as of the ex-post validation Nursemapp).

The consideration of (mobile) ICS as entities that are encompassing all system components of technical and human nature, that have properties and relationships and that are thus influencing each other is a rising research field. The importance and necessity to take this socio-technical view has been recognized by acknowledged authors like (Peppard & Ward, 2016).

12 References

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Appendix A: On the Validation of an Evaluation Framework: Assessment by Experts[73]

1 Introduction

Högler et al. (2015) describe a framework that delivers insight into the tangible and intangible effects of a mobile (IT) system, before it is being implemented. The framework has been developed because of a lack of such insight (other frameworks merely focusing on monetary effects, neither taking into account singularities of mobile technologies). The framework consists of 3 pillars with 7 included activities. Figure 1 shows the framework, also identifying interdependencies between the activities and their inputs and outputs.

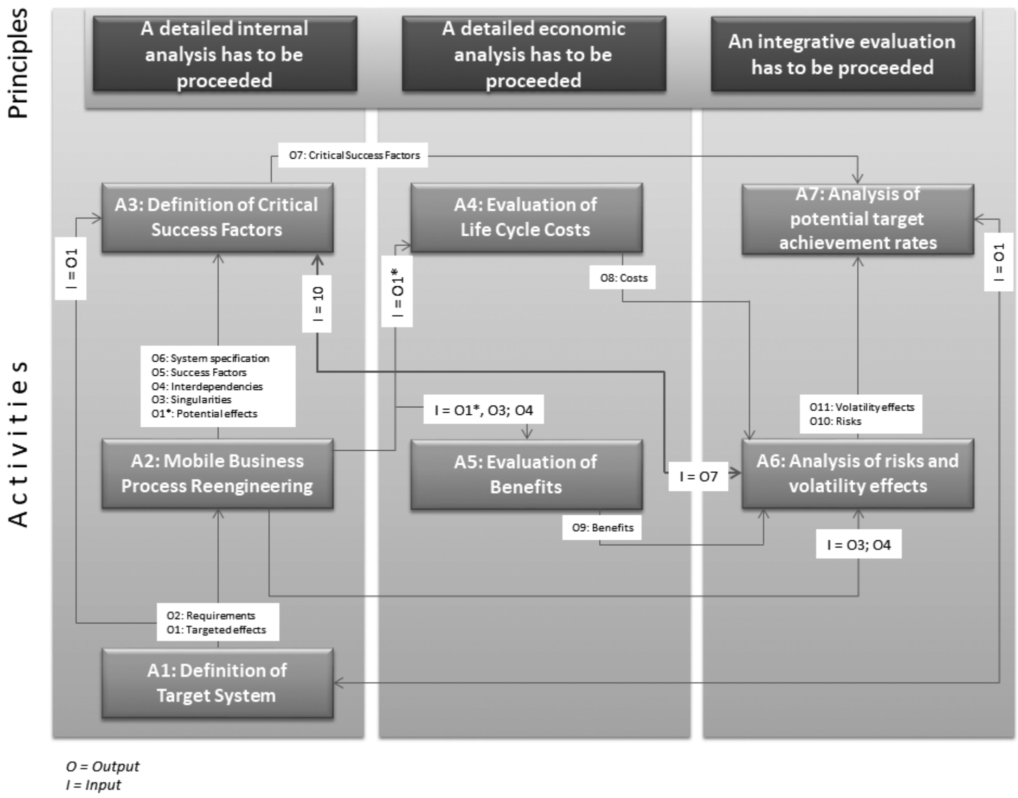

Figure 1: Integrative Framework for Mobile Systems (Högler, Versendaal, & Batenburg, 2015)

[73] This paper by Tamara Högler and Johan Versendaal was originally published as: Högler, T., & Versendaal, J. (2017). *On the Validation of an Evaluation Framework: Assessment by Experts.* Technical Report Open University of the Netherlands. TR-OU-INF-2017-02.

A description of each of the activities from figure 1 is taken from Högler & Versendaal (2016, pp. 3-4):

1. "Activity 1: Definition of the target system by following the multi-attribute decision making (Hwang & Yoon, 1981); this activity outlines a procedure for defining the target system leveraging the Analytical Hierarchy Process (AHP) (Saaty, 1996) which is extended by following activities (see Figure 2), differing fundamentally from previous approaches:
   - interdependence analysis between individual objectives (cf. (Kirchmer, 1999; Rückle & Behn, 2007; Drews & Hillebrand, 2002));
   - consideration of the effective strength of the objectives and the probability of occurrence of interdependencies (cf. (Charette, 1991; Klabon, 2007)) and thus their respective value; and
   - weighting of objectives in the context of these latter two aspects.
   - [...]
2. Activity 2: Mobile Business Process Reengineering as proposed by the authors builds upon Mobile Process Landscaping (cf. (Gruhn & Wellen, 2001; Köhler & Gruhn, 2004)).
3. Activity 3: Definition of critical success factors, their interdependencies, correlation analysis and weighting (cf. (Hway-Boon & Yu, 2003; Iqbal, Nadeem, & Zahee, 2015; Nysveen, Pedersen, & Skard, 2015)).
4. Activity 4: Evaluation of life cycle costs (cf. (Wild & Herges, 2000; Berghout, Nijland, & Powell, 2011)), performed by identifying costs during the whole lifecycle of mobile systems including the preliminary phase, utilization phase and disposal phase.
5. Activity 5: The evaluation of benefits, based on the total benefit of ownership model (Gadatsch & Mayer, 2004), involves the capture of cost savings and non-monetary benefits or qualitative and strategic variables which are not considered in the traditional approaches of economic evaluation.
6. Activity 6: Sensitivity analysis: As an uncertainty of the results achieved in the previous steps remains, a sensitivity analysis is conducted to check the stability of results. Particularly the variables success factors (cf. (Rockart, 1979; Corsten, 2000)), risks (Kronsteiner & Thurnher, 2009) and the accompanying volatility effects (Kulk & Verhoef, 2008; Singh & Vyas, 2012) are analysed.
7. Activity 7: Analysis of potential target achievement rates: Based on the results of the sensitivity analysis, the potential achievement rates can be determined. To do so, results of activity 1 (target system), activity 2 (current and target processes incl. key (performance) indicators) and activity 6 (volatility effects) are merged."

Although both papers (Högler, Versendaal, & Batenburg, 2015; Högler & Versendaal, 2016) provide an evaluation of this integrative framework for mobile systems to some extent, in both papers it is suggested that effort is needed in validating it more extensively. In this report we test the validity of the framework through an assessment by experts in terms of its completeness, correctness and its usefulness.

The study took place in the timeframe of February and April 2017 and involved 6 experts from research and practice. The selection criteria for choosing experts were:

1. a high familiarity with the topic IT project management and
2. a high familiarity with the evaluation of economic efficiency of IT systems and
3. a long-time experience in practice.

To identify the experts efficiently, we have chosen the following procedure: One of the authors checked her business contacts (LinkedIn, Xing and her own contact list) in order to identify potential candidates. To get a better understanding of their experience related to the integrative framework, we manually checked the Curriculum Vitae of each potential respondent and their company web page to gain as much understanding as possible on their experience.

In a second step, the authors agreed on a first group of seven evaluators from Europe to be contacted within one week. These experts were addressed personally via email, explaining the purposes of the survey and asking them if they were interested in participating in the survey. If successfully acquired as evaluator, they have been provided a description of the framework and the related questionnaire.

The questionnaire was developed by one of the researchers following the general rules for a questionnaire (Kirchhoff, Kuhnt, Lipp, & Schlawin, 2008): a first part with focus on a general introduction into the topic and the scope of the interview; a second part that gathered general data about the interviewee, followed by a contextual third or – in our case – more main parts that focused on the validation of the research topic (see Figure 1). In our case, the contextual parts that were focusing on the validation of the framework contained following main parts: Validation of the axioms of the framework, validation of the framework (overall approach of the framework) and separate validation of all seven activities of the framework.

The second researcher reviewed the questionnaire and provided improvement suggestions, that were bilaterally discussed between the researchers and agreed upon. Annex 1 contains the full questionnaire.

In the first stage of the survey, interviews with three experts (two from research, yet with profound knowledge of practice, and one from business) were conducted. The questionnaire (see Annex 1) as well as a description of the integrative framework were sent out to the experts prior to the interview. Two out of three interviews have been recorded with the mobile phone[74], notes were taken by one of the authors directly into the questionnaire. The duration of the interviews was approximately 1.5 hours. The comments and suggestions for improvement of the integrative framework were elaborated more in detail following the interview and sent to the interviewees for approval. No revisions of the elaborated questionnaires were needed.

Based on the feedback of these three interviewees the authors decided not to proceed on this particular interview strategy due to following reasons:

- It was very time consuming to get an appointment for an interview scheduled as the interviewees had high positions (mainly professors, CEOs and similar) and where thus extremely busy. In addition, re-scheduling of the interviews was necessary in 2 cases which caused additional delays.
- Most of the questions had discrete (yes/no) answers that did not provoke much discussions.
- Merely in the case that the answer was ‚no‘ or ‚partly‘, an explanation was asked from the expert (interviewee).

Thus, we encouraged subsequent respondents to fill out the (unchanged) questionnaire and to return it to the authors using e-mail. This procedure was much easier to handle as the experts were able to fill in the questionnaire whenever they had time to do so and no scheduling and re-scheduling of appointments was necessary.

In case of any ambiguities in the provided feedback, or not agreeing (fully) with the parts of the framework, the experts were providing feedback through a call and/or personal meeting.

2 Detailed Structure of the Questionnaire

The questionnaire contained 11 sections: One introductory section that contained general information like scope of the interview and questions as regards to the general understanding of the procedure (questions 1-4 (Q1-4)). Section 2 gathered general information about the interviewee's personal data, experience in the topic of the integrative framework and confidentiality / usage of the gathered data. The third section of the questionnaire provided the most important axioms of the integrative framework for validation (Q5-7). Section 4 concentrated on the validation of the integrative framework as a whole (Q8-13) whereas sections 5-11 validated every single of the seven activities of the framework (Q14-32).

[74] One interview was not recorded due to technical problems with the mobile phone.

The questionnaire had mainly dropdown menus with pre-defined answers (yes / no / partly) and the possibility to enter free text for the case, if “no” or “partly” was chosen in the previous question as answer.

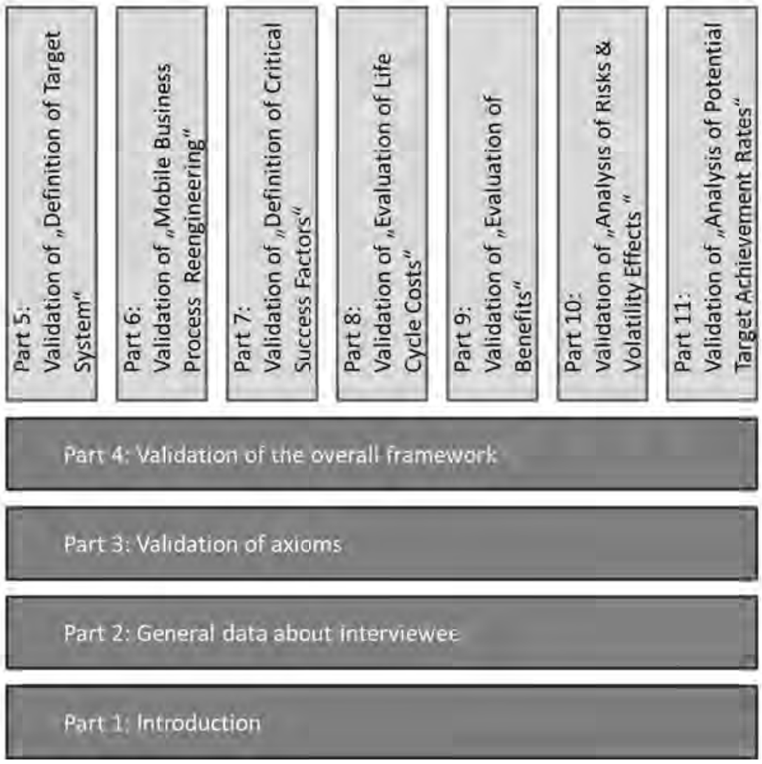

Figure 2: Structure of the questionnaire

3 Survey Results

In terms of organization characteristics, the six interviewees came from SMEs and research institutions. They all had high positions like CEO or professor and several years of experience in the topic “IT project management”.

All evaluators confirmed all questions in the first section of the questionnaire, i.e. that they received (Q1) and read (Q2) the questionnaire and that they understood the general description of the framework (Q3), as provided in Annex 2. They also confirmed that it was clear that the approach was meant for the decision making process / ex-ante evaluation of mobile systems (Q4).

Table 1: Participants of the study

Name	Affiliation	Position	Familiarity	Practical experience since
Prof. Dr. Hans Mulder	Venture Informatisering Adviesgroep NV Antwerp Management School	Managing director Academic Director & Executive Professor	Very familiar	1995
Prof. Dr. Rainer Neumann	University for Applied Sciences, Karlsruhe	Professor	Very familiar	1998
Prof. Dr. Dieter Hertweck	HHZ Research Centre, Reutlingen University	Professor, Head of Research Group	Very familiar	1996
Dr. Asarnush Rashid	Zentrum für Telemedizin Bad Kissingen	Managing director	Familiar	2004
Daniel Stucky	Keller Informatik AG	Owner	Very familiar	1988
Rüdiger Bäcker	@TOLL GmbH	CEO	Very familiar	2004

Table 2: Results of part 1 of the questionnaire

	Yes	No	Partly	Total no. of answers
Q1: Did you receive the document describing the integrative framework?	6	0	0	6
Q2: Did you have time to read the document?	6	0	0	6
Q3: Did you understand the general procedure of the framework?	6	0	0	6
Q4: Was it clear for you that the approach is meant for supporting the decision process (i.e. ex ante evaluation)?	6	0	0	6

In the second section of the questionnaire, all evaluators provided their personal data and information about familiarity / experience with the topic and confirmed that data provided by them can be used by fully stating their names and affiliations. All experts were familiar or very familiar with the topic and have been working in the field of IT project management for at least 13 years. Table 3 shows the structure of the second part of the questionnaire:

Table 3: Structure of part 2 of the questionnaire

Name:		Company:	
Surname:		Position:	
Familiarity with topic	*Very familiar / familiar / somehow familiar / not familiar at all*	City:	
Working in the topic since	*Insert year*	Country:	

The third section of the questionnaire focused on validating the axioms of the integrative framework. Table 4 shows the general results:

Table 4: Part 3 of the questionnaire: validation of axioms

	Yes	No	Partly	Total no. of answers
Q5:In our approach we derive requirements from objectives as defined in the target system. Do you agree that in this manner objectives and requirements are inherently related?	5	0	1	6
Q6: In our approach we derive the (technical) system specification from requirements (as defined in activity 1) during activity 2 (mobile Business Process Reengineering / mBPR). Do you agree that in this manner a system specification can be derived from (general) requirements during the mBPR??	4	0	2	6
Q7: In our approach we define risks as (critical) success factors that are not taken into account. Do you agree that in this manner risks and success factors are inherently related?	5	1	0	6

We received following input for Q5:

Prof. Hertweck (partly agreeing) said that *"[…] requirements (e.g. security, feasibility, personnel skills of workforce,…) are more or less a derived target system from business strategy that constitute itself a target system (bundle of requirements) for the Information System strategy, whereas mobile systems are only one possible solution for the predefined requirements"*.

As regards to Q6, Prof. Mulder stated that *"[…] not all specifications can be derived from requirements during activity 2*[75]*"*, whereas Prof. Neumann said that the *"[…] derivation is correct on a coarse level – but having only the descriptive paper [in Annex 2] it is not clear if the*

[75] Mobile Business Process Reengineering

technical specifications will be complete by applying this approach". So for both experts, an in-depth analysis of requirements is needed in the mBPR.

All experts – except for R. Bäcker – confirmed, that risks can be defined as (critical) success factors that are not taken into account and that thus risks and success factors are inherently related. R. Bäcker stated that *"risk could be a critical success factor by itself"*, implying that vice-versa consideration is also needed.

The 4th section of the questionnaire focused on validating the overall approach of the framework with following six questions (Q8-Q13):

Table 5: Part 4 of the questionnaire - validation of the overall framework

	Yes	No	Partly	*Total no. of answers*
Q8: Do you agree with the set of 3 Principles, in terms of completeness and correctness?	4	0	2	*6*
Q9: Do you agree with the set of 7 activities of the framework, in terms of completeness and correctness, and their order?	4	0	2	*6*
Q10: Do you think that the framework is applicable for non-mobile environments as well?	5	0	1	*6*
Q11: Do you think that the framework is complete (as for the seven described activities)?	4	0	2	*6*
Q12: Do you think that the framework is correct (as for the seven described activities)?	6	0	0	*6*
Q13: Do you think that the framework is usable (as for the seven described activities)?	6	0	0	*6*

Prof. Mulder confirmed that the 3 principles are correct (Q8), but that he is not sure if they are complete in terms of all aspects as, e.g., an analysis of culture could be needed in some cases. He also stated that the completeness of the approach can be achieved by amplifying the approach with additional methods. At the same time he pointed out that the completeness depends on the project scope. Also Prof. Neumann confirmed that the principles are correct. Nevertheless he emphasized that it is important to depict when the principles are "complete" or "good enough" for a reasonable result as the questionnaire did not provide any definition of "complete". As regards to the questionnaire, he suggested that it would be better to use the term "sufficient"[76] instead of the term "complete".

[76] Additional note from Prof. Neumann: From a mathematical and engineering view the framework would not be valid if we are talking about "completeness". "Completeness" as it is meant in the questionnaire is more like the "time-boxing model" in Software Engineering ("what is feasible in a given timeframe" / "what is feasible with a given budget"), which confirms that it is better to apply the term "sufficient".

Question 9 tried to figure out if the set of 7 activities of the framework were acceptable for the experts, in terms of completeness and correctness, and their order. All experts confirmed their correctness and order, but similar to Q8, Prof. Mulder stated that the completeness depended on the level of details of the analysis, so that it could be necessary to extend the activities with more detailed specification if a very high level of details is needed. Prof. Neumann suggested to mention that this is an iterative approach which did not become clear in the provided description of the framework. Nevertheless, he stated that also without a change the set of 7 activities would keep its validity, but that in practice a waterfall model, even in an a priori evaluation context, would not lead to useful results. Dr. Rashid provided a quite similar input as he stated that he missed the possibility to reflect the definition of the target system in case that the former target system is not applicable or not defined well enough. Thus, he also suggested an iterative approach. Also R. Bäcker suggested an iterative approach by taking a redesign loop into account (see also Q11), as he did not see the seven activities as a straight forward process.

In Q10 the experts were asked to evaluate the applicability of the integrative framework for non-mobile environments. Stucki stated that Business Process Reengineering is even more important when dealing with mobile environments than with non-mobile environments. In fact, his remark confirms the importance of mBPR particularly for mobile environments and systems.

Section 5 of the questionnaire focused on validating the first activity of the integrative framework – the definition of the target system.

Table 6: Part 5 of the questionnaire: Validation of activity 1 - Definition of the target system

	Yes	No	Partly	*Total no. of answers*
Q14: Do you agree with the approach for defining a preference-neutral target system?	6	0	0	*6*
Q15: Do you know similar approaches?	3	3	0	*6*
Q16: Which alternatives do you propose for getting a valid target system that is based on effects / influences between targets?				*see text below*
Q17: Do you agree that the main outputs of this first activity are the Targeted Effects (i.e. benefits that should be achieved by the system) and the requirements?	6	0	0	*6*

All experts confirmed the validity of the approach of the preference-neutral target system (Q14). None of the experts knew another preference-neutral approach, although three experts knew similar approaches (Q15). Prof. Neumann and Dr. Rashid commented, that also in agile development approaches a pairwise comparison is applied which is deemed as useful as it makes comparison easier than other approaches. Prof. Neumann proposed these approaches as an alternative for identifying targets (Q16). In the suggested case, the pairwise comparison is not applied for defining objectives, but for comparing two tasks as regards to the effort needed for their implementation and their expected business value. Similar to the preference-neutral approach, the result of agile methodologies is a matrix. All experts agreed that the main outputs of this first activity are the Targeted Effects (i.e. benefits that should be achieved by the system) and the requirements (see Q17).

The sixth section of the questionnaire was dedicated to the validation of activity 2 – Mobile Business Process Reengineering (mBPR). It contained following questions:

Table 7: Part 6 of the questionnaire: Validation of activity 2 - Mobile Business Process Reengineering

	Yes	No	Partly	*Total no. of answers*
Q18: Do you agree that analyzing the current processes is important in order to figure out how they could be supported by mobile systems?	6	0	0	*6*
Q19: Do you agree that the main outputs of the mBPR are the identification of Singularities of mobile systems, of Interdependencies (between the single system components, i.e. people, technologies, processes) and of Success Factors?	4	0	2	*6*

All experts confirmed that analyzing the processes is important in order to figure out how they could be supported or improved by mobile systems (Q18), though Prof. Mulder added to this the importance to also include a culture analysis. In Q19 the experts were asked if they agree that the main outputs of the mBPR are the identification of Singularities of mobile systems, of Interdependencies (between the single system components, i.e. people, technologies, processes) and of Success Factors. Four out of six experts confirmed this. Prof. Neumann explicitly acknowledged that it is highly important that interdependencies between the single system components are taken into account, as risks can only be identified if singularities and their interdependencies are considered. The approach of Agile Methodologies, where Personas, Stories and Context and thus interdependencies play an important role, confirm the chosen approach. D. Stucki said, that Mobile Business Process Reengineering should also show the (economical) potential resulting from such process optimization[77]. For R. Bäcker, a singularity is not an outcome, but a condition[78].

Section 7 focused on the validation of activity 3 – Definition of Critical Success Factors.

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77 This is in fact done in activity 4, “Analysis of life-cycle costs”

78 The reason for this answer is probably the formulation of the question Q19. Singularities are not “created”, but identified. Thus we assume that the term “outcome” is here slightly misunderstood.

Table 8: Part 7 of the questionnaire: Validation of activity 3 - Definition of Critical Success Factors

	Yes	No	Partly	*Total no. of answers*
Q20: Do you agree with the proposed procedure for defining Critical Success Factors?	6	0	0	*6*

All experts confirmed the proposed procedure for defining Critical Success Factors (Q20). Prof. Neumann suggested to define CFS in the description of the framework in a clearer way, so that it becomes clearer at which point success factors become critical. To do so, he recommended to apply e.g. a Venn diagram for visualization.

In the eighth section, the validity of activity 4 – Evaluation of Life Cycle Costs was examined:

Table 9: Part 8 of the Questionnaire: Validation of Activity 4: Analysis of Life Cycle Costs

	Yes	No	Partly	*Total no. of answers*
Q21: Do you agree that it is important to take into account all life cycle costs IF this is appropriate for the project?	6	0	0	*6*

All experts confirmed that it is important to take into account all life cycle costs for the case that this is appropriate for the project (Q21). Prof. Neumann pointed out that particularly for software and the development of software it is very difficult to evaluate life-cycle costs as the innovation cycles are very short.

Section nine validated activity 5 – Evaluation of Benefits. Table10 shows the related questions. Again, all experts confirmed that it is important evaluate the POTENTIAL benefits of the implementation of a mobile system (Q22), and that also objectives (as defined in activity 1) (Q23) and the singularities of a mobile system (as identified in activity 2) (Q24) as well as interdependencies between the single system components (Q25) have to be taken into account when evaluating potential benefits. Prof. Neumann underlined that without taking singularities into account the framework would not keep its validity and that also in this case Agile Methodologies with their Personas, Stories and Context (i.e. singularities) confirm the chosen approach. In addition, he emphasized the importance of change management after implementation of a mobile system.

Table 10: Part 8 of the Questionnaire: Validation of Activity 5 - Analysis of Benefits

	Yes	No	Partly	*Total no. of answers*
Q22: Do you agree that it is important evaluate the POTENTIAL benefits of the implementation of a mobile system?	6	0	0	*6*
Q23: Do you agree that when evaluating potential benefits also the objectives (as defined in activity 1) have to be taken into account?	6	0	0	*6*
Q24: Do you agree that when evaluating potential benefits also the singularities of a mobile system (as identified in activity 2) have to be taken into account?	6	0	0	*6*
Q25: Do you agree that when evaluating potential benefits also the interdependencies between the single system components (as defined in activity 2) have to be taken into account?	6	0	0	*6*

The validation of activity 6 – analysis of risks and volatility effects took place in part 10:

The experts were asked if they agreed that it is important to analyze the risks and (related) volatility effects when evaluating the implementation of a mobile system (Q26). All experts confirmed the importance; nevertheless, prof. Neumann stated that he would have expected the analysis of risks and volatility effects in an earlier activity as this step if highly important. He added that also criteria for the evaluation of risks should be defined.

Table 11: Part 10 of the Questionnaire: Validation of Activity 6 - Analysis of risks and volatility effects

	Yes	No	Partly	*Total no. of answers*
Q26: Do you agree that it is important to analyze the risks and (related) volatility effects when evaluating the implementation of a mobile system?	5	0	1	*6*
Q27: Do you agree that when analyzing risks and volatility effects also the singularities of a mobile system (as defined in activity 2) have to be taken into account?	6	0	0	*6*
Q28: Do you agree that when analyzing risks and volatility effects also the critical success factors (as defined in activity 3) have to be taken into account?	6	0	0	*6*
Q29: Do you agree that when analyzing risks and volatility effects also the costs (as evaluated in activity 4) have to be taken into account?	6	0	0	*6*

As regards to the analysis of risks and volatility effects, all experts confirmed that singularities of a mobile system (as defined in activity 2) (Q27), critical success factors (as defined in activity 3) (28) and costs (as evaluated in activity 4) (Q29) have to be taken into account.

The last section of the questionnaire was dedicated to the validation of the last activity – analysis of the potential target achievement rates (see Table 12). All experts confirmed that it is important to analyze the potential target achievement rates (Q30) and that these can be estimated by taking into account critical success factors, risks and volatility effects (Q31). They also confirmed that potential target achievement rates should take the formerly defined target system into account (Q32).

Table 12: Part 11 of the Questionnaire: Validation of Activity 7 - Analysis of the Potential Target Achievement Rates

	Yes	No	Partly	*Total no. of answers*
Q30: Do you agree that it is important to analyze the potential target achievement rates?	6	0	0	*6*
Q31: Do you agree that potential target achievement rates can be estimated by taking into account critical success factors, risks and volatility effects?	6	0	0	*6*
Q32: Do you agree that potential target achievement rates should take the formerly defined target system into account?	6	0	0	*6*

4 Analysis of Results and Suggestions for Improvement of the Integrative Framework

Analyzing the above shown comments and suggestions by the experts following becomes clear:

1. The set of three principles and the set of the proposed seven activities and thus the framework as a whole were confirmed as correct by all experts. Also the usability and usefulness of the framework were confirmed.

   As regards to the completeness of the three principles, the seven activities and thus of the framework as a whole, the experts commented that the completeness depends on the scope and probably specific techniques are useful. Due to the fact that the integrative framework delivers a guideline for evaluating (mobile) ICS which can be applied in different contexts and within different sizes of projects, it does not provide a standardized procedure that can be applied with the same quality of results for all kinds of projects. The framework can definitely be 'situationally' applied, and the following statement makes sense: the bigger and more complex a project is, the more detailed and extensive the evaluation has to be. This in turn means, that additional techniques within an activity can become necessary, which are currently not made explicit in the integrative framework (e.g. a culture analysis as proposed by Prof. Mulder, which can be part of a.o. mBPR).

2. Several times the interviewees mentioned an iteration of the seven activities. The framework can indeed be improved by explicitly stating that iterations between activities are possible. Note that readdressing activities within the framework is already possible, but it mainly focuses on activity 7 (analysis of the potential target achievement rates) including activity 1 (definition of the target system) – by figuring out which targets can finally be achieved with the given project framework (e.g. budget, timeframe).
3. As regards to the axioms, the level of detail for activity 2 (mBPR) needs to be described more precisely for a better understanding. Otherwise it is difficult to judge, if all requirements (based on activity 1) and system specifications can be derived from mBPR[79].
4. The framework, especially activity 2 – mBPR, seems also useful for specifying non-mobile IT components. It is confirmed that stationary IT can and also probably will, at least partly, be part of the solution that fulfills the target system. As one of the interviewees stated that *"mobile systems are only one possible solution for the predefined requirements"*.
5. Earlier consideration (and collection) of risks and volatility effects is suggested and can e.g. be part of the activity related to the definition of critical success factors.
6. The definition of the target system and its proposed preference-neutral prioritization contributes to the uniqueness of the framework.
7. Interesting in general, but expected, is the approach of the experts towards the integrative framework: Each expert bases its comments on his current research and / or business topic, so that we gained a good insight into potential improvements from different perspectives.

5 Conclusions

In this report, the integrative framework as presented by (Högler, Versendaal, & Batenburg, 2015) is shortly presented. This framework delivers insight into the tangible and intangible effects of a mobile (IT) system, before it is being implemented and thus represents an ex-ante evaluation approach. It consists of three pillars with seven included activities which are

[79] System specifications are derived from requirements (which are outputs of activity 1), and based on outcomes of activity 2.

evaluated in this case by experts that are familiar or very familiar with the topic of the framework. The results of this validation are shown in detail in this report.

The experts confirmed the validity of the framework to large extend and gave several suggestions for improvements, notably in the consideration of specific techniques to ensure quality of results of the activities of the framework.

Summarizing we conclude that the framework's applicability can be improved by

- Providing some additional definitions and explanations as regards to the used terms
- Allowing iterations explicitly
- Providing more details on how the single activities shall be implemented (description of related techniques)

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Annex 1: Questionnaire

Part 1 Introduction: Scope of the interview and general understanding

The scope of this interview is to validate the integrative framework as regards to its usefulness, correctness and applicability in practice.

Question 1. Did you receive the document describing the integrative framework?

yes / no / partly

Question 2. Did you have time to read the document?

yes / no / partly

Question 3. Did you understand the general procedure of the framework?

yes / no / partly

If "partly" or "no" in answer 3: Could you please explain? _______________________

Question 4. Was it clear for you that the approach is meant for supporting the decision process (i.e. ex ante evaluation)?

(Remark: Decision making process regarding whether to implement a mobile system at all and / or to be able to choose the most appropriate alternative / system)

yes / no / partly

If "no" or "partly" in answer 4: How can I make it clearer / more comprehensible?

____

Part 2General data about interviewee

Name:		Company:	
Surname:		Position:	
Familiarity with topic	Wählen Sie ein Element aus.	City:	
Working in the topic since	INSERT YEAR	Country:	

Herewith I agree that the content of my interview can be used for a publication related to this thesis.

yes / no / partly

___ Anonymously

___ By mentioning my full name and affiliation

____

Part 3 Validation of Axioms

Question 5. In our approach we derive requirements from objectives as defined in the target system. Do you agree that in this manner objectives and requirements are inherently related?

yes / no / partly

If "no" or "partly": Could you please explain? ____

Question 6. In our approach we derive the (technical) system specification from requirements (as defined in activity 1) during activity 2 (mobile Business Process Reengineering / mBPR). Do you agree that in this manner a system specification can be derived from (general) requirements during the mBPR?

yes / no / partly

____

If "no" or "partly": Could you please explain? ____

Question 7. In our approach we define risks as (critical) success factors that are not taken into account. Do you agree that in this manner risks and success factors are inherently related?

yes / no / partly

____

If "no" or "partly": Could you please explain? ____

Part 4 Validation of the framework (overall approach of the framework)

Question 8. Do you agree with the set of 3 Principles, in terms of completeness and correctness:

Principle 1: A detailed internal analysis has to be proceeded

Principle 2: A detailed economic analysis has to be proceeded

Principle 3: An integrative evaluation has to be proceeded

yes / no / partly

If "no" or "partly": Could you please explain? ____

Why is this change necessary?

____

Would the framework keep its validity also if the proposed changes would be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Would the framework keep its validity also if the proposed changes would NOT be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Question 9. Do you agree with the set of 7 activities of the framework, in terms of completeness and correctness, and their order?

1. Definition of target system
2. Mobile Business Process Reengineering
3. Definition of Critical Success Factors
4. Evaluation of Life cycle costs
5. Evaluation of benefits
6. Analysis of risks and volatility effects
7. Analysis of potential target achievement rates

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Why is this change necessary?

____

Would the framework keep its validity also if the proposed changes would be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Would the framework keep its validity also if the proposed changes would NOT be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Question 10. Do you think that the framework is applicable for non-mobile environments as well?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Which changes would be necessary in order to make it applicable for non-mobile environments?

____

Would the framework keep its validity also if the proposed changes would be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Would the framework keep its validity also if the proposed changes would NOT be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Question 11. Do you think that the framework is complete (as for the seven described activities)?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Which changes would be necessary in order to make it complete?

____

Would the framework keep its validity also if the proposed changes would be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Would the framework keep its validity also if the proposed changes would NOT be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Question 12. Do you think that the framework is correct (as for the seven described activities)?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Which changes would be necessary in order to make it correct?

____

Would the framework keep its validity also if the proposed changes would be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Would the framework keep its validity also if the proposed changes would NOT be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ____

Question 13. Do you think that the framework is usable (as for the seven described activities)?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ____

Which changes would be necessary in order to make it usable?

____

Would the framework keep its validity also if the proposed changes would be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ____

Would the framework keep its validity also if the proposed changes would NOT be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ____

Part 5 Validation of activity 1: Preference-neutral target definition

Question 14. Do you agree with the approach for defining a preference-neutral target system?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ____

Why is this change necessary?

____

Would the framework keep its validity also if the proposed changes would be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain?

____

Would the framework keep its validity also if the proposed changes would NOT be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ____

Question 15. Do you know similar approaches?

yes / no / partly

If yes, which ones?

____

Question 16. Which alternatives do you propose for getting a valid target system that is based on effects / influences between targets?

____

Question 17. Do you agree that the main outputs of this first activity are the Targeted Effects (i.e. benefits that should be achieved by the system) and the requirements?

yes / no / partly

If "no" or "partly": Could you please explain? _____________________________________

From your point of view: What are the main outputs of activity 1?

____

Part 6 Validation of activity 2: Mobile Business Process Reengineering" (mBPR)

Question 18. Do you agree that analyzing the current processes is important in order to figure out how they could be supported by mobile systems?

yes / no / partly

If "no" or "partly": Could you please explain? _____________________________________

Question 19. Do you agree that the main outputs of the mBPR are the identification of Singularities of mobile systems, of Interdependencies (between the single system components, i.e. people, technologies, processes) and of Success Factors?

yes / no / partly

If "no" or "partly": Could you please explain? _____________________________________

What are the main outputs in your opinion?

____

Part 7 Validation of the activity 3: Definition of Critical Success Factors

Question 20. Do you agree with the proposed procedure for defining Critical Success Factors?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Why is this change necessary?

____

Would the framework keep its validity also if the proposed changes would be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Would the framework keep its validity also if the proposed changes would NOT be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Part 8 Validation of activity 4: Evaluation of Life Cycle Costs

Question 21. Do you agree that it is important to take into account all life cycle costs IF this is appropriate for the project?

(Remark: Appropriate = cost-benefit-ratio of investment in this in-depth-analysis is reasonable)

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Which alternative do you propose?

____

Would the framework keep its validity also if the proposed changes would be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Would the framework keep its validity also if the proposed changes would NOT be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Part 9 Validation of the activity 5: Evaluation of Benefits

Question 22. Do you agree that it is important evaluate the POTENTIAL benefits of the implementation of a mobile system?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _______________________________________

Which alternative do you propose?

____

Would the framework keep its validity also if the proposed changes would be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ____

Would the framework keep its validity also if the proposed changes would NOT be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ____

Question 23. Do you agree that when evaluating potential benefits also the objectives (as defined in activity 1) have to be taken into account?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ____

If objectives would NOT be taken into account, would the framework still keep its validity?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ____

Question 24. Do you agree that when evaluating potential benefits also the singularities of a mobile system (as identified in activity 2) have to be taken into account?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ____

If singularities would NOT be taken into account, would the framework still keep its validity?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ____

Question 25. Do you agree that when evaluating potential benefits also the interdependencies between the single system components (as defined in activity 2) have to be taken into account?

yes / no / partly

If “no“ or ”partly“: Could you please explain?

____

If interdependencies would NOT be taken into account, would the framework still keep its validity?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ______________________________________

Part 10 Validation of activity 6: Analysis of risks and volatility effects

Question 26. Do you agree that it is important to analyze the risks and (related) volatility effects when evaluating the implementation of a mobile system?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ______________________________________

Which alternative do you propose?

____

Would the framework keep its validity also if the proposed changes would be made?

yes / no / partly

____

Would the framework keep its validity also if the proposed changes would NOT be made?

yes / no / partly

____

Question 27. Do you agree that when analyzing risks and volatility effects also the singularities of a mobile system (as defined in activity 2) have to be taken into account?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ______________________________________

If interdependencies would NOT be taken into account, would the framework still keep its validity?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ______________________________________

Question 28. Do you agree that when analyzing risks and volatility effects also the critical success factors (as defined in activity 3) have to be taken into account?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ______________________________________

If critical success factors would NOT be taken into account, would the framework still keep its validity?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ______________________________________

Question 29. Do you agree that when analyzing risks and volatility effects also the costs (as evaluated in activity 4) have to be taken into account?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ______________________________________

If costs would NOT be taken into account, would the framework still keep its validity?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ______________________________________

Part 11 Validation of the activity 7: Analysis of the potential target achievement rates

Question 30. Do you agree that it is important to analyze the potential target achievement rates?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ______________________________________

Which alternative do you propose?

____

Would the framework keep its validity also if the proposed changes would be made?

yes / no / partly

____

Would the framework keep its validity also if the proposed changes would NOT be made?

yes / no / partly

____

Question 31. Do you agree that potential target achievement rates can be estimated by taking into account critical success factors, risks and volatility effects?

yes / no / partly

If “no“ or ”partly“: Could you please explain? ______________________________________

Which alternative do you propose?

____

Would the framework keep its validity also if the proposed changes would be made?

yes / no / partly

____

Would the framework keep its validity also if the proposed changes would NOT be made?

yes / no / partly

____

Question 32. Do you agree that potential target achievement rates should take the formerly defined target system into account?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _____________________________________

Which alternative do you propose?

____

Would the framework keep its validity also if the proposed changes would be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _____________________________________

Would the framework keep its validity also if the proposed changes would NOT be made?

yes / no / partly

If “no“ or ”partly“: Could you please explain? _____________________________________

Appendix B: On the Validation of the Initial Step of an Upfront System Implementation Evaluation Framework: The Fire Brigade Case[80]

1 Introduction

In Högler et al. (2015) a framework is described that, when applied, should deliver insight into the value of a (mobile) IT system, before it is being implemented. The framework has been developed because of a lack of such insight (other frameworks merely focusing on monetary effects, neither taking into account singularities of mobile technologies). The framework consists of 3 pillars with 7 included activities. Figure 1 shows the framework, also identifying interdependencies between the activities and their inputs and outputs.

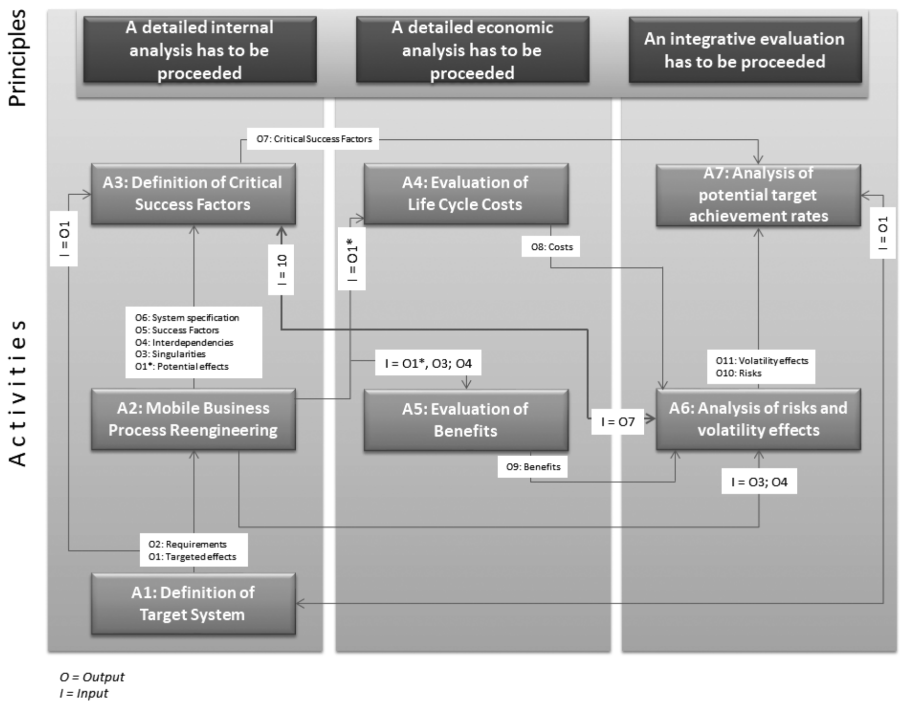

Figure 1: Integrative Framework for Mobile Systems (Högler et al., 2015)

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80 This paper by was originally published as: Versendaal, J., & Högler, T. (2017). *On the validation of the initial step of an upfront system implementation evaluation framework: The Fire Brigade Case.* Technical Report Open University of the Netherlands. TR-OU-INF-2017-01.

A description of each of the activities from figure 1 is taken from Högler & Versendaal (2016):

1. "Activity 1: Definition of the target system by following the multi-attribute decision making (Hwang & Yoon 1981); this activity outlines a procedure for defining the target system leveraging the Analytical Hierarchy Process (AHP) (Saaty 1996) which is extended by following activities (see figure 2), differing fundamentally from previous approaches:
   - interdependence analysis between individual objectives (Kirchmer 1999; Drews & Hillebrand 2010; Rückle & Behn 2007);
   - consideration of the effective strength of the objectives and the probability of occurrence of interdependencies (Klabon 2007; Charette 1991) and thus their respective value; and
   - weighting of objectives in the context of these latter two aspects.
   - [...]
2. Activity 2: Mobile Business Process Reengineering as proposed by the authors builds upon Mobile Process Landscaping (Gruhn & Wellen 2001; Köhler & Gruhn 2004).
3. Activity 3: Definition of critical success factors, their interdependencies, correlation analysis and weighting (Iqbal et al. 2015; Nysveen et al. 2015; Hway-Boon & Yu 2006).
4. Activity 4: Evaluation of life cycle costs (Wild & Herges 2000; Berghout et al. 2011), performed by identifying costs during the whole lifecycle of mobile systems including the preliminary phase, utilization phase and disposal phase.
5. Activity 5: The evaluation of benefits, based on the total benefit of ownership model (Gadatsch & Mayer 2004), involves the capture of cost savings and non-monetary benefits or qualitative and strategic variables which are not considered in the traditional approaches of economic evaluation.
6. Activity 6: Sensitivity analysis: As an uncertainty of the results achieved in the previous steps remains, a sensitivity analysis is conducted to check the stability of results. Particularly the variables success factors (Corsten 2000; Rockart 1979), risks (Kronsteiner & Thurnher 2009) and the accompanying volatility effects (Kulk & Verhoef 2008; Singh & Vyas 2012) are analyzed.
7. Activity 7: Analysis of potential target achievement rates: Based on the results of the sensitivity analysis, the potential achievement rates can be determined. To do so, results of activity 1 (target system), activity 2 (current and target processes incl. key (performance) indicators) and activity 6 (volatility effects) are merged." (pp 3-4).

Although both papers (Högler et al., 2015; Högler & Versendaal (2016)) provide an evaluation of this integrative framework for mobile systems to some extent, in both papers it is suggested that effort is needed in validating it more extensively. In a separate validation by an e-health mobile app (Nursemapp, 2017) it is furthermore suggested that especially the first activity of the integrative framework needs additional validation. It is therefore that we focus on the validation of the 'Target system definition' by a separate case study. The separate steps of the first activity of the integrative framework are illustrated in Figure 2.

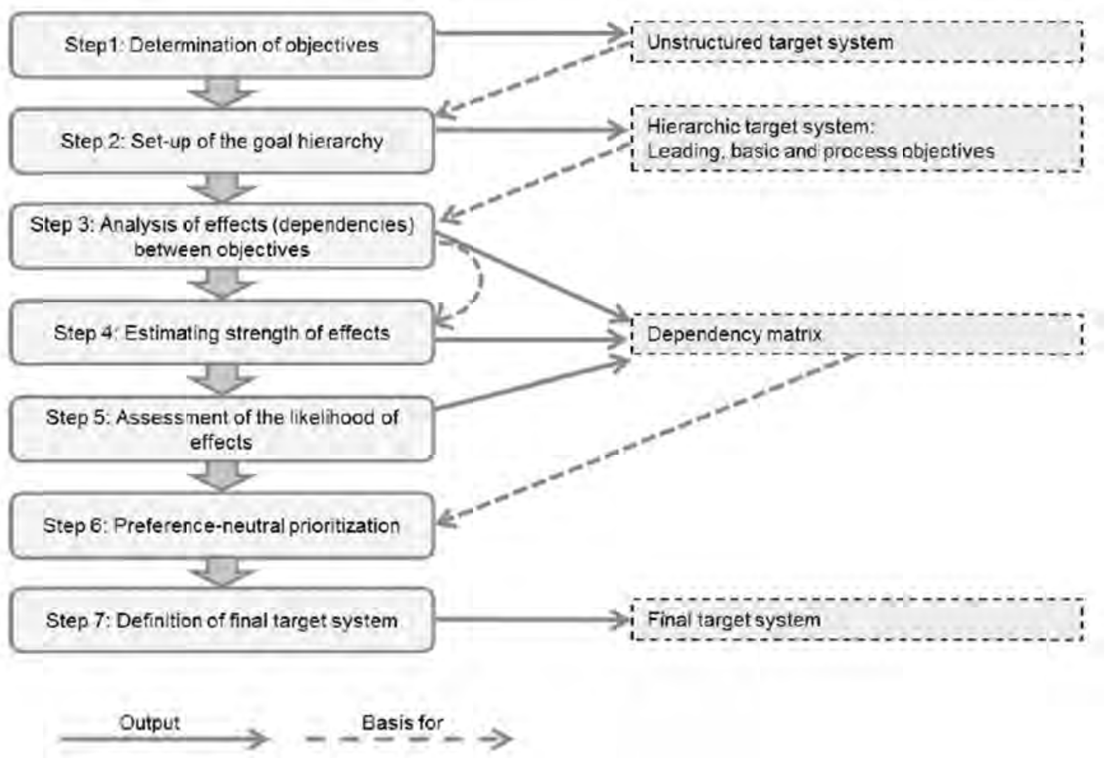

Figure 2: Steps of the first activity of the integrative framework, from Högler & Versendaal (2016)

The steps from Figure 2 are described in detail by Högler & Versendaal (2016):

1. "First, objectives are determined e.g. by task observation, in a workshop or from interviews with the help of a questionnaire. An unstructured target system contains all gathered objectives.
2. In step 2, the identified objectives are brought in a hierarchical relationship (what we define in levels 'key objectives', 'basic objectives' and 'process objectives'). A goal hierarchy is only complete if "each element of a hierarchy level has a direct relationship to the next higher element [...]" (Ahlert 2003, p. 37). [...]
3. In the 3rd step, the identified process objectives are evaluated in a paired comparison concerning their mutual, direct interdependencies. The aim of this comparison is to identify particularly competing objectives, as setting priorities among them reduces inconsistencies in the target system.
4. The strength of interdependencies is estimated in step 4, which is largely subjective and based on experience of the involved interviewees. The scale for the estimation can be chosen freely, but it should not be too fine-grained, since this would cause

pseudo-accuracies (Meixner & Haas 2012, p. 202). Thus, the authors propose a three-level scale (low, medium, strong effects).

5. Next the estimation of their likelihood (probability) is needed (step 5). It is methodologically based on risk management (e.g. NIST 2012, p. 23) and in practice on the experience of the involved individuals. Again a three-level scale is proposed to estimate the likelihood of effects: effect is possible, but improbable; effect is probable; effect will occur with the utmost probability. It is necessary that the interviewees agree internally on the nature of the effects – but not necessarily on their effective strength and likelihood, since without such an agreement, the target-relation-matrix cannot be installed. The individual effects between objectives should not be regarded as absolute and as in all circumstances occurring, but rather they indicate general trends which may be reinforced, mitigated or neutralized under certain circumstances, or by the use of respective (appropriate or inappropriate) systems.
6. To ensure that mainly high priority objectives are pursued, which have the greatest benefit, competing relations between objectives must be detected. This is done in the 6th step, where the objective priorities are determined. Based on the prospect theory by Kahneman & Tversky (1979), a preference-neutral weighting assumes that the weight of an objective can be determined by its active and passive value. To receive these values, for each objective its strength of effects is multiplied with the likelihood of its occurrence. The resulting (mathematical) products are subsequently summed up for each objective in both the horizontal (so-called "active value") as well as in the vertical ("passive value") axis of the table. This procedure is legitimate insofar as the value of an effect can be defined as the product of strength of effects and their likelihood of occurrence (see also Kahneman & Tversky, 1979). A threshold should be defined by a decision maker which allows the classification of objectives in different priorities. As there is no standardized procedure for defining a threshold, the authors propose to choose a threshold that divides the objectives 'on sight'.
7. In the last step (7) the final target system is defined by consolidating the earlier steps and assigning final priorities to objectives."

2 Case Context

As criteria for choosing our case for validation, we can now define:

- it should address the first activity (target system definition) validation;
- it should relate to a major system implementation, in a large organization, currently being prepared;

- it should be easily made clear to the organization that carefully thinking about targets and goals, upfront system implementation, is of utmost important;
- moreover, there should be willingness from the organization to participate in the validation activity.

The Dutch fire brigade consists of nearly 28.000 firemen. The personnel (of which about 2/3rd are volunteers) should be kept long life professionally skilled.

For the NL, country-wide, the fire brigade has acquired Three Ships N@tschool! Electronic Learning Environment (ELE) as a system for supporting the training for staying life-long professionally skilled ('vakbekwaam blijven'). After developing a number of trial courses and digitizing another number of existing training courses, the management of 6 of the 25 fire brigade regions (i.e. region 4, 5, 6, 7, 8 and 25, see Figure 3, representing almost 6.000 firemen), together with the so called 'BOGO' educational institute for the fire brigade, decided to take a leading role in developing a showcase how to implement the ELE.

Figure 3: Fire brigade regions in the NL (source: veiligheid.org)

With the existing good relations with the heads of the mentioned regions, the researchers feel comfortable in meeting the above mentioned criteria for case selection. Note that the implementation of the ELE has *mobile* components (facilitating time and place independent learning), but it does not specifically focus on mobile learning or mobile processes. For executing the first activity of the framework the researchers do not consider this as a necessary prerequisite nor essential in the context of the framework's first activity validation, as the integrative framework was developed as a generic approach that is meant for evaluating IT systems in general.

In taking the pilot implementation at the 6 Dutch fire brigade regions as our case study, we check the following (see also Hevner et al. (2004; p 85) for the mentioned standard validation criteria):

1. Can all steps of the first activity of the integrative framework be performed successfully?
2. Is the execution of the first activity of the integrative framework considered to be accurate?
3. Is the execution of the first activity of the integrative framework considered to be useful?

3 Validation protocol

We take the standard research design template of Maimbo & Pervan (2005) for describing our validation protocol, see Table 1.

Table 1: Validation protocol, using the template of Maimbo & Pervan (2005)

Section	Protocol details regarding the Dutchfire brigade case
Preamble	The head and management of region 7 has, on behalf of the other 5 regions, approved execution of the validation of the first activity of the integrative framework in conjunction with the preparation of the implementation of the ELO. This is confirmed in e-mails between the fire brigade and the researchers.
General	Högler et al. (2015) describe an integrative framework for a priori evaluation of the effects of (mobile) IT system implementation. For further validating the integrative framework we choose to focus on validating the first activity of the framework.
Procedures	In determining the utility and efficacy of the first activity of the integrative framework, we execute a brainstorm with the 6 region heads for determining the goals/targets/objectives of the ELE implementation (step 1); one of the researchers is managing the process during brainstorming, while a secretary of the fire brigade observes and takes notes. Once we have determined agreed upon objectives among the region heads, the secretary involved in the brainstorm is asked to create the dependency matrix (step 3, 4 and 5). In parallel the researchers will construct an objectives hierarchy. The secretary checks the constructed objectives hierarchy. Once approved the secretary and the researchers together perform step 6 (defining high, medium and low priority process objectives from the values in the dependency matrix, only considering process objectives), and step 7 (describing the final target system, with prioritized objectives).
Research instrument(s)	We will use a template in Excel that supports all steps (see appendix A) and guides the researchers in data analysis
Data analysis guidelines	Once data is collected through brainstorming (step 1) and in creating the dependency matrix (step 3, 4 and 5), an important data analysis concept is the interpretation of the calculated *active and passive values* from the dependency matrix. The *active* value of an objective is the degree to which this objective influences other objectives; the *passive* value of an objective is the degree indicating how much this objective is influenced by other objectives. Not explicitly taking into account an objective with high active values, has also consequences for attaining other objectives; not taking into account an objective with high passive value is possibly not too bad as other objectives add to the attainability of that particular objective. Active and passive values of objectives help in assigning priorities to the objectives.
Appendix	In e-mails between the fire brigade and the researchers confirmation of participation in the validation is indicated. Appendix A shows the used template for creating the dependency matrix and showing the prioritization

4 Validation Results and Analysis

4.1 Step 1: Determination of Objectives

On 13th of October 2016, the 6 heads of the regions came together, to dedicate the afternoon for defining the target system under guidance of the researchers. In the morning of the same day the heads had conversations with some training experts, ELO-experts and the researchers to discuss the pitfalls, success factors and best practices of the ELO-prototype implementations so far. Because of this the 6 heads were in the afternoon considered to be fully up to speed to make good contributions to defining the target system in the afternoon.

The afternoon session of October 13th, 2016 proceeded as follows:

a) The heads of the regions, for themselves, took 30 minutes time to describe individual targets on separate sticky notes.

b) Each of the heads explained shortly each of the identified individual targets. Making a plenary round, guided (process managed) by one of the researchers.

c) Subsequently, each of the heads put the sticky notes on the brown/white-paper on the wall, trying to combine / stick together similar targets from their colleagues

d) One of the researchers (as process manager of the brainstorm session) took 15 minutes time to try to make up a proper clustering of each of the sticky notes.

e) Under guidance of one of the researchers, plenary with the 6 heads, the categorization and targets were discussed. Resulting in reducing the number of individual targets, yet also adding one or two.

The results are depicted in the following figures:

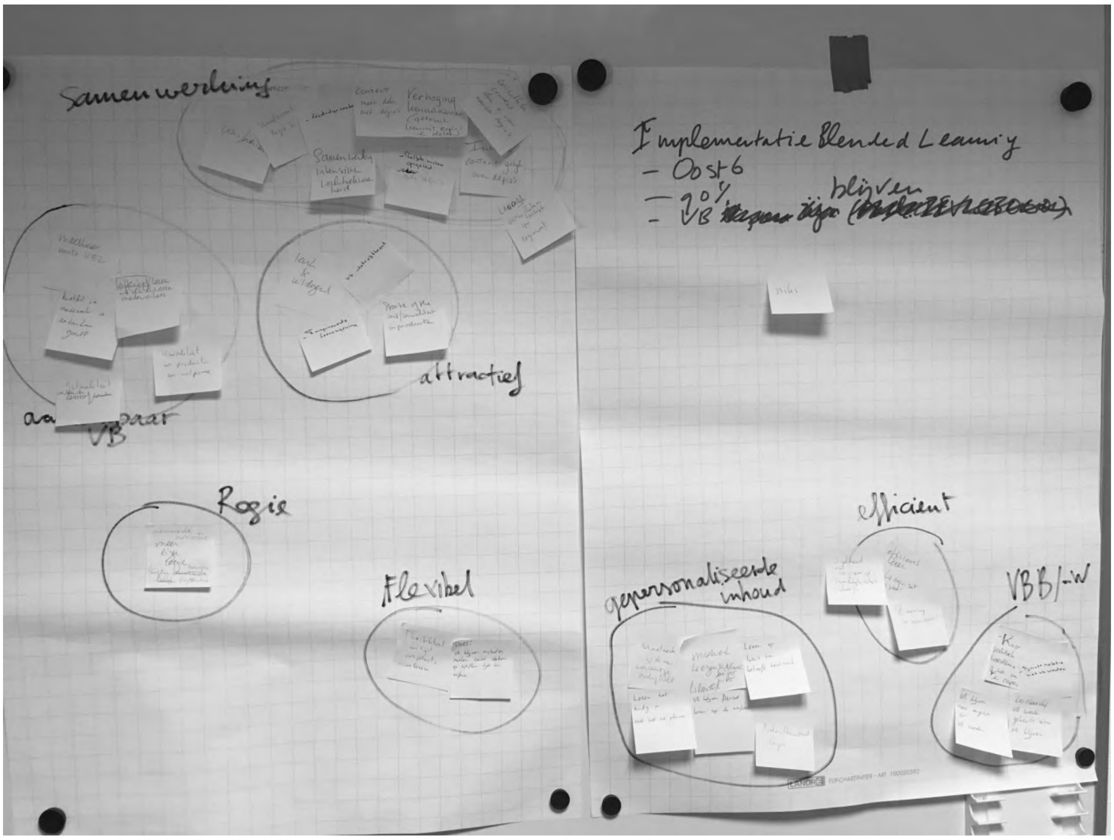

Figure 4: Overall view of perceived correct individual targets

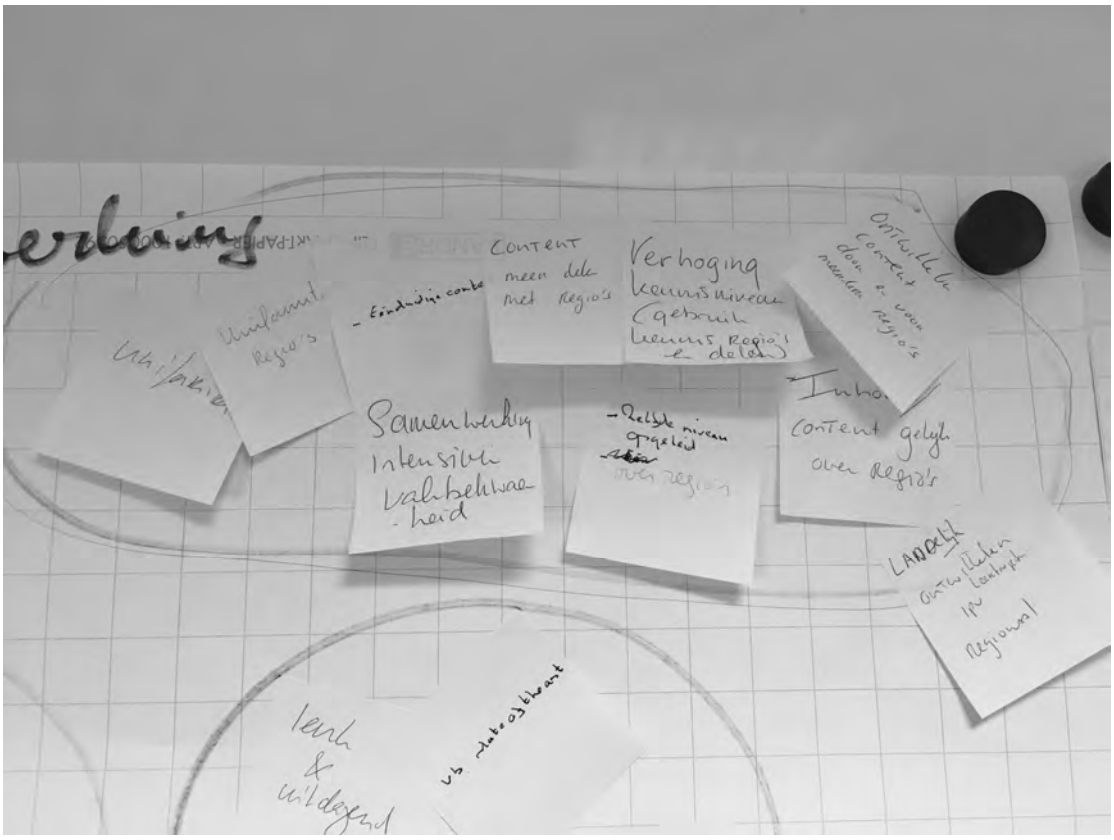

Figure 5: Clustering of objectives dealing with 'cooperation between regions'

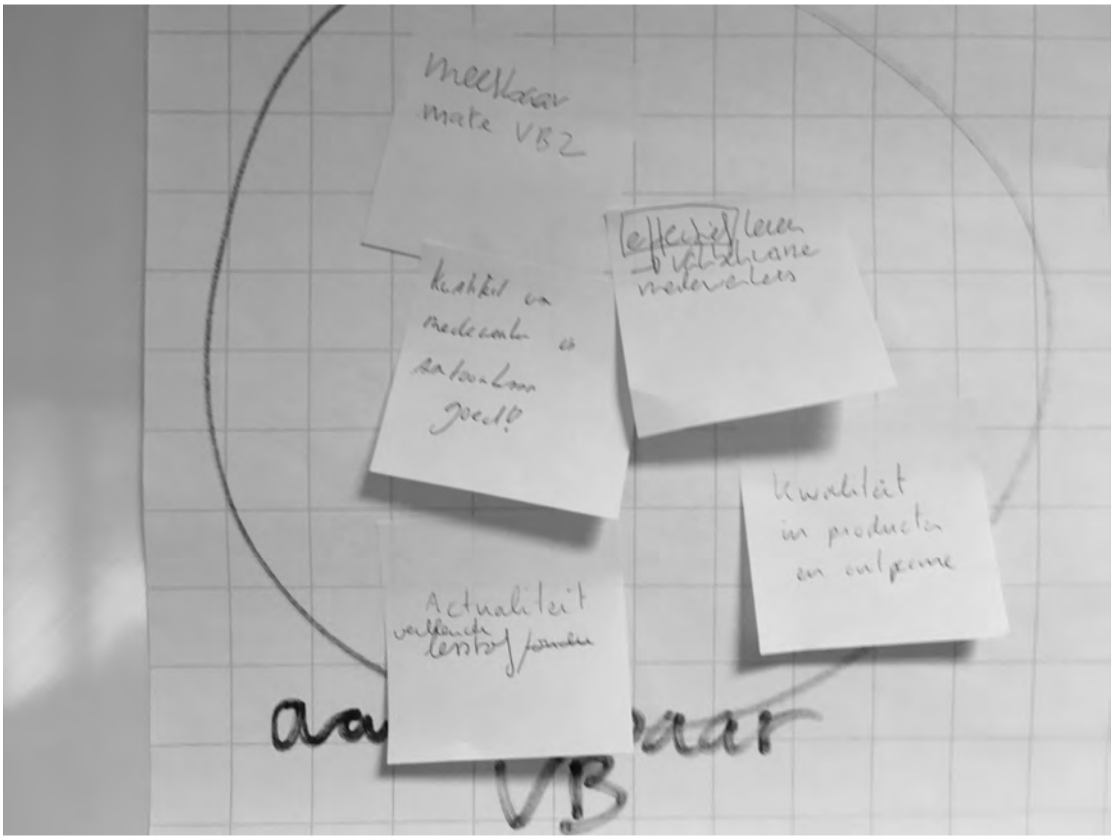

Figure 6: Clustering of objectives dealing with being 'identifiably professionally skilled'

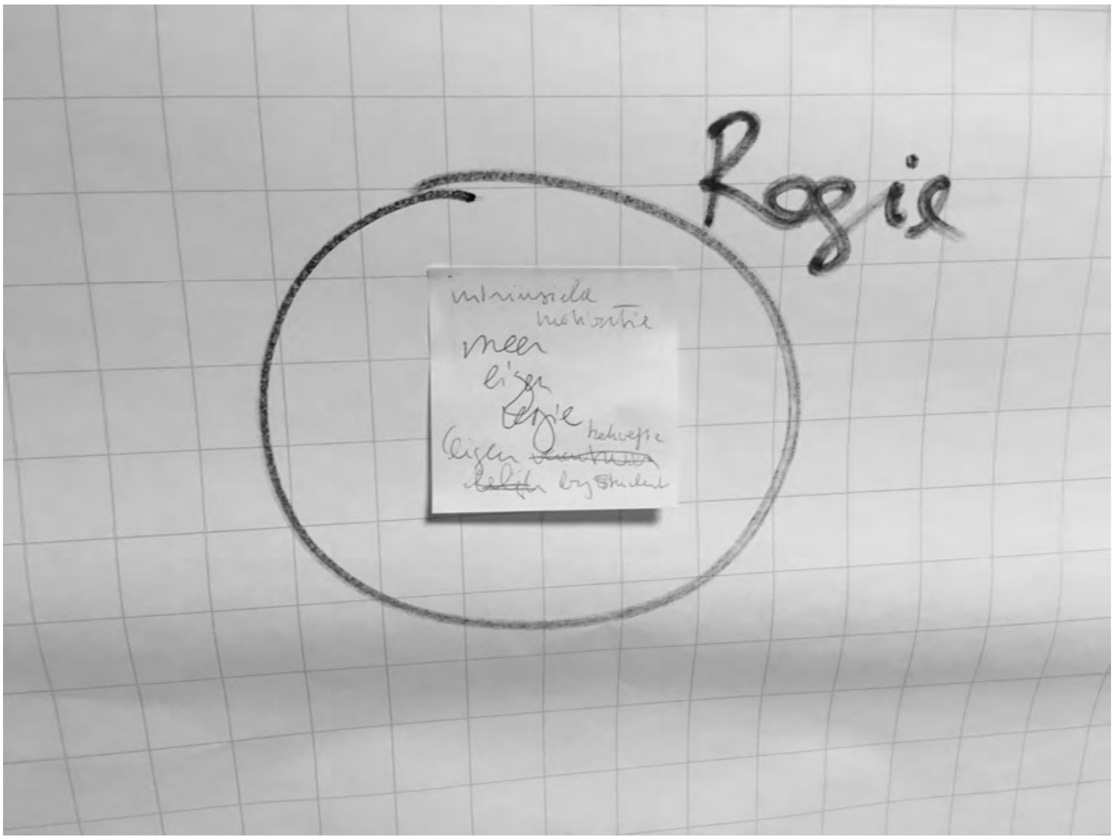

Figure 7: Objective relating to 'self-control'

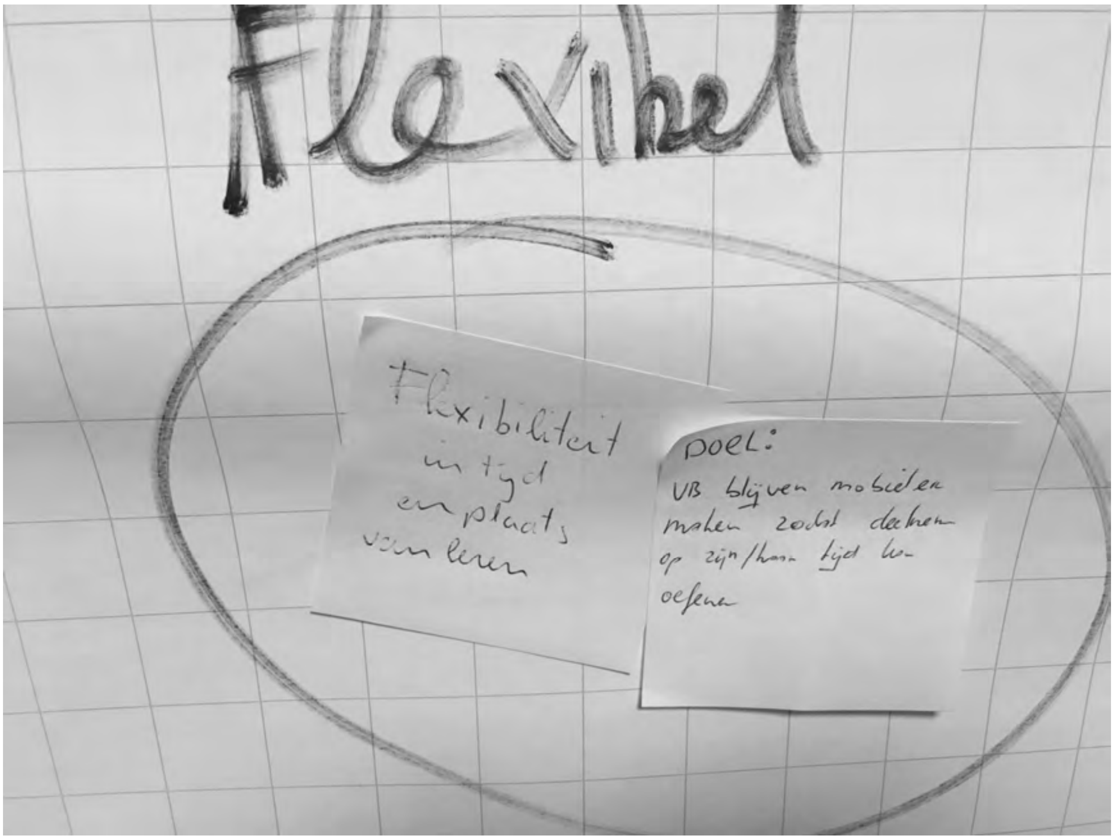

Figure 8: Objectives relating to 'flexibility in learning'

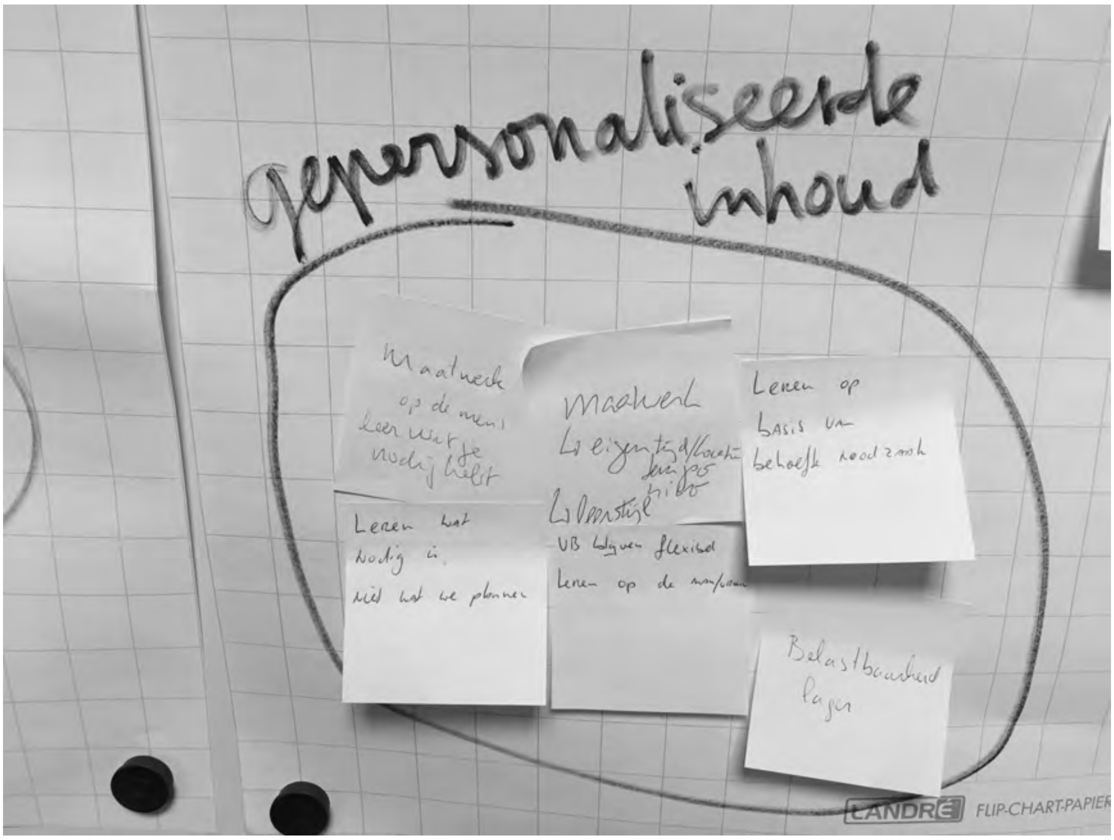

Figure 9: Cluster of objectives relating to 'personalized learning'

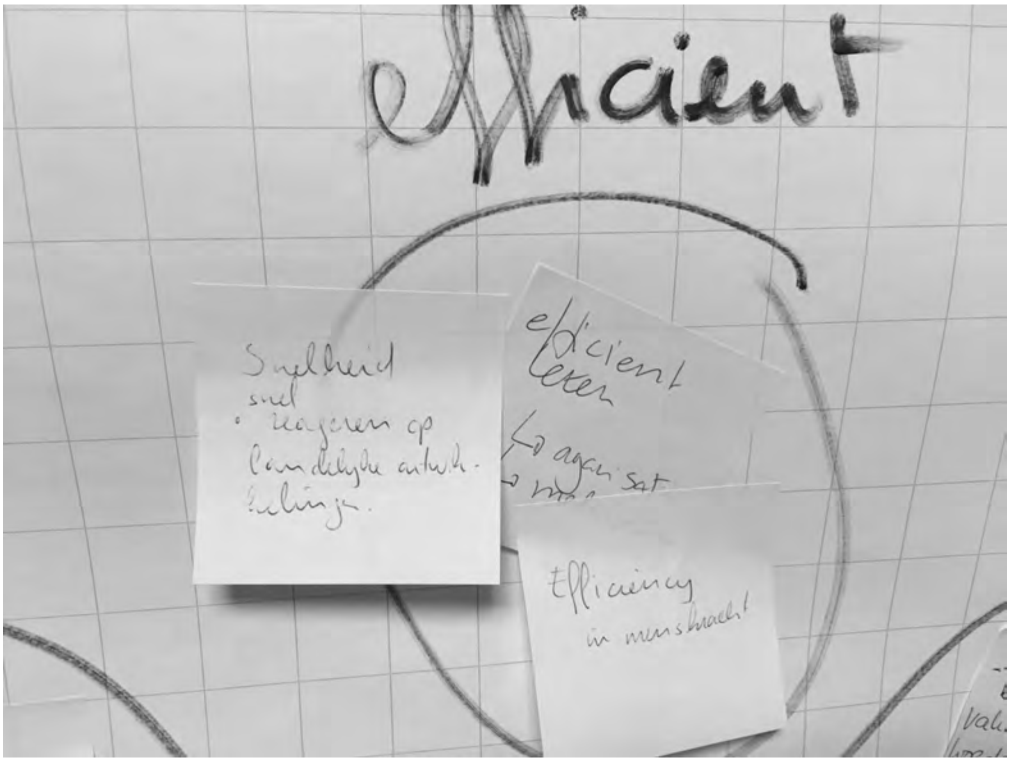

Figure 10: Cluster of objectives relating to 'efficient learning'

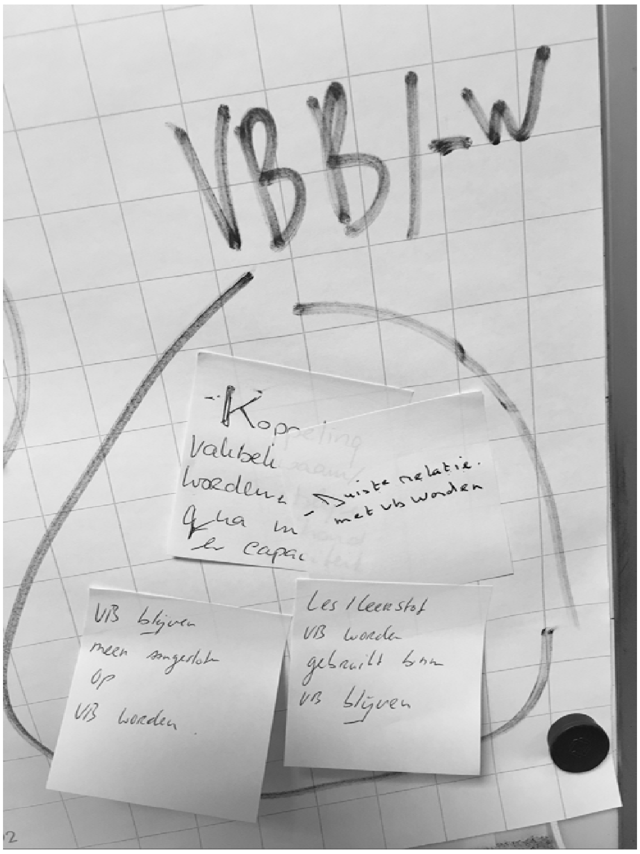

Figure 11: Cluster of objectives regarding 'relation <u>staying</u> professionally skilled with <u>becoming</u> professionally skilled'

The researchers made a proposal from this first objectives identification, and translated them to English. The secretary present during the brainstorm checked the translations and agreed after some discussion to the list and its translation. The resulting list is depicted in Table 2.

Table 2: List of objectives from the brainstorm, with their English translation

Original objective (in Dutch)	English translation
Uniformiteit in verblende producten tussen regio's	Uniformity of learning material between different regions
Eenduidige context van opleiden	Uniform context for learning
Content meer delen met regio's; in-houd/content gelijk over regio's	Shared similar content between regions
Verhoging kennisniveau door gebruik kennis verschillende regio's	Improved knowledge level by sharing knowledge between regions
Ontwikkelen content door en voor meerdere regio's	Develop content by and for different regions
Landelijk ontwikkelen van leertraject ipv re-gionaal	Country level learning process (instead of regional)
Zelfde niveau opgeleid over regio's	Firemen equally educated in different regions
Samenwerking intensiever mbt vakbek-waamheid	More intensive cooperation with regard to life-long professional skills
Leuk en uitdagende leeromgeving	Nice & challenging learning environment
State-of-the-art leeromgeving	State of the Art learning environment
Hoge kwaliteit leerproducten	High quality learning material
Inspirerende leeromgeving	Inspiring learning environment
Meetbare mate van vakbekwaam zijn	Measurable level of professional skills
Effectief leren leidend tot vakbekwame me-dewerkers	Effective learning leading to life-long professional skills
Kwaliteit van medewerkers is aantoonbaar goed	Quality of firemen´s skills demonstrably good
Kwaliteit in outcome	Quality in outcome
Actualiteit van verblende lesstof	Currentness of learning material
Meer eigen regie (intrinsieke motivatie) van de medewerker op eigen leeractiviteiten	More own responsibility (intrinsic motivation) for firemen for their own learning activities / Learning process
Flexibiliteit in tijd en plaats van leren	Flexibility in time and place of learning
Mobieler maken vakbekwaam blijven zodat medewerker op zijn/haar tijd kan oefenen	Place independent (Mobile!) learning so that fire-men can learn time independent
Maatwerk op de mens (leer wat je nodig hebt)	Taylor-made training for firemen - learn what you need
Maatwerk leerstijl	Taylor-made learning style
Leren op basis van behoefte en noodzaak	Learning on basis of need & necessity
Flexibel leren voor de man/vrouw	Flexible learning for firemen

Original objective (in Dutch)	English translation
Belastbaarheid voor medewerker lager	Reduce stress & strain for firemen
Leren wat nodig is, niet wat we plannen	Learning what is needed not what is planned
Snelheid (snel nieuwe lesstof op basis van landelijke ontwikkelingen)	Speed (learn quickly new learning material because of country wide developments in fire brigade)
Efficëntie voor organisatie vwb training	Efficiency for organization regarding training
Efficiënt leren voor de medewerker	Efficient learning for firemen
Efficiëncy in mensen en middelen	Efficiency in firemen and means
Koppeling vakbekwaam worden/blijven qua inhoud en capaciteit	Connection of initial learning to life-long learning (becoming professional / staying professional as for content and trainers involved
Les- en leerstof vakbekwaam worden gebruikt binnen vakbekwaam blijven	Initial learning materials will be used for life-long learning
Vakbekwaam blijven meer aangesloten op vakbekwaam worden	Staying professional / life-long learning more connected to initial learning

4.2 Step 2: Set-up of the Objectives Hierarchy

In this step, the researchers derived leading (key), basic and process objectives from Table 2. A key objective (first column) is the highest abstraction level of objectives, representing benefits, then comes the basic objectives (which are still high level), and finally process objectives (concrete lowest level objectives, representing how to achieve the benefits). The process objectives of a particular color will contribute to the basic objectives of that same color, which in turn will contribute to the key objective of that color. Figure 12 illustrates an early version of the objectives hierarchy. Table 3 shows the result of creating the initial hierarchy.

Note that the row with key objective 'Measurable quality level of skills' has been newly created from two existing identified objectives 'Measurable level of professional skills' and 'Quality of firemen's skills demonstrably good'. This suggested change was agreed by the fire brigade's secretary.

Furthermore, in this step it was suggested to combine the following objectives:

- Connection of initial learning to life-long learning (becoming professional / staying professional as for content and trainers involved)
- Initial learning materials will be used for life-long learning
- Staying professional / life-long learning more connected to initial learning into 1 objective:
- Connection of initial with life-long learning (staying professional / life-long learning more connected to initial learning)

It was also suggested by the researchers to combine the following objectives (basically, letting the first objective be included in the second)

- Learning on basis of need & necessity
- Learning what is needed not what is planned into the latter objective:
- Learning what is needed not what is planned

Both suggestions were again approved by the secretary of the fire brigade. Now the resulting hierarchy of objectives is shown in Table 3. Note that the list contains 17 Process objectives that need to be prioritized.

Figure 12: In the process of defining the initial objectives hierarchy

Table 3: Initial hierarchy of objectives (in Dutch)

Key objective	Basic objective	Process objective
Eenduidige context van opleiden (Uniform context for learning)	Zelfde niveau opgeleid over regio's (Firemen equally educated in different regions)	Uniformiteit in verblende producten tussen regio's (Uniformity in learning material between different regions)
		Content meer delen met regio's; inhoud/content gelijk over regio's (Shared similar content between regions)
		Verhoging kennisniveau door gebruik kennis verschillende regio's (Improved knowledge level by sharing knowledge between regions)
		Ontwikkelen content door en voor meerdere regio's (Develop content by and for different regions)
Measurable quality level of skills	Kwaliteit in outcome (Quality in outcome)	Landelijk ontwikkelen van leertraject ipv regionaal (Define a (standardised) country level learning process (instead of regional))
Eenduidige context van opleiden (Uniform context for learning)	Zelfde niveau opgeleid over regio's (Firemen equally educated in different regions)	Samenwerking intensiever mbt vakbekwaamheid (More intensive cooperation with regard to life-long professional skills)
Belastbaarheid voor medewerker lager (Reduce stress & strain for firemen)	Meer eigen regie (intrinsieke motivatie) van de medewerker op eigen leeractiviteiten (More own responsibility (intrinsic motivation) for employees for their own learning activities / Learning process)	Effectief leren leidend tot vakbekwame medewerkers (Effective learning leading to life-long professional skills)
Efficëntie voor organisatie vwb training (Efficiency for organisation regarding training)	Efficiëncy in mensen en middelen (Efficiency in firemen and means)	Actualiteit van verblende lesstof (Currentness of learning material)
Belastbaarheid voor medewerker lager (Reduce stress & strain for firemen)	Meer eigen regie (intrinsieke motivatie) van de medewerker op eigen leeractiviteiten (More own responsibility (intrinsic motivation) for employees for their own learning activi-	Flexibiliteit in tijd en plaats van leren (Flexibility in time and place of learning)
		Mobieler maken vakbekwaam blijven zodat medewerker op zijn/haar tijd kan oefenen (Place independent (Mobile!) learning so that employee can learn time independent)
		Maatwerk op de mens (leer wat je nodig hebt) (Taylormade training for employee - learn what you need)
		Maatwerk leerstijl (Taylormade learning style)
		Leren op basis van behoefte en noodzaak (Learning on ba-

Key objective	Basic objective	Process objective
	ties / Learning process)	sis of need & necessity)
		Flexibel leren voor de man/vrouw (Flexible learning for firemen)
		Leren wat nodig is, niet wat we plannen (Learning what is needed not what is planned)
Efficëntie voor organisatie vwb training (Efficiency for organisation regarding training)	Efficiëncy in mensen en middelen (Efficiency in firemen and means)	Snelheid (snel nieuwe lesstof op basis van landelijke ontwikkelingen) (Speed (learn quickly new learning material because of country wide developments in firebrigade)
		Efficiënt leren voor de medewerker (Efficient learning for firemen)
		Connection of initial with life-long learning (Koppeling vakbekwaam worden/blijven qua inhoud en capaciteit (Connection of initial learning to life-long learning (becoming professional / staying professional as for content and trainers involved)
		Connection of initial with life-long learning (Les- en leerstof vakbekwaam worden gebruikt binnen vakbekwaam blijven (Initial learning materials will be used for life-long learning)
		Connection of initial with life-long learning (Vakbekwaam blijven meer aangesloten op vakbekwaam worden (staying professional / life-long learning more conntected to initial learning)

Table 4: Final hierarchy of objectives (translated)

Key objective	Basic objective	Process objective
Uniform context for learning	Firemen equally educated in different regions	Uniformity in learning material between different regions
		Shared similar content between regions
		Improved knowledge level by sharing knowledge between regions
		Develop content by and for different regions
		More intensive cooperation with regard to life-long professional skills
Measurable quality level of skills	Quality in outcome	Define a (standardised) country level learning process (instead of regional)
Reduce stress & strain for firemen	More own responsibility (intrinsic motivation) for employees for their own learning activities / Learning process	Effective learning leading to life-long professional skills
		Flexibility in time and place of learning
		Place independent (Mobile!) learning so that employee can learn time independent
		Taylormade training for employee - learn what you need
		Taylormade learning style
		Flexible learning for firemen
		Learning what is needed not what is planned

Key objective	Basic objective	Process objective
Efficiency for organisation regarding training	Efficiency in fi- remen and means	Currentness of learning material
		Speed (learn quickly new learning material because of country wide developments in firebrigade
		Efficient learning for firemen
		Connection of initial with life-long learning (staying professional / life-long learning more conntected to initial learning)

4.3 Step 3-5: Creating the Dependency Matrix

This procedure was performed by the fire brigade secretary in parallel with Step 2, taking the objectives from Table 2 (not Table 3 or 4) as starting point. Tables 5 and 6 show the results as entered by the secretary for the strengths of possible interdependencies between objectives and their likelihood of occurrence.

Table 5: Snapshot of Strengths of interdependencies between objectives (In Dutch)

	Uniformiteit in verblende producten tussen r	Eenduidige context van opleiden	Content meer delen met regio's; inhoud/con	Verhoging kennisniveau door gebruik kennis	Ontwikkelen content door en voor meerdere	Landelijk ontwikkelen van leertraject ipv regi	Zelfde niveau opgeleid over regio's	Samenwerking intensiever mbt vakbekwaam	Leuk en uitdagende leeromgeving	State-of-the-art leeromgeving	Hoge kwaliteit leerproducten	Inspirerende leeromgeving
Uniformiteit in verblende producten tussen regio's		2	3	2	3	3	2	2	2	1	2	1
Eenduidige context van opleiden	2		3	3	3	3	3	2	2	1	2	1
Content meer delen met regio's; inhoud/content gelijk over regio's	3	2		3	3	2	2	2	2	1	2	2
Verhoging kennisniveau door gebruik kennis verschillende regio's	2	1	3		3	2	1	2	2	2	2	2
Ontwikkelen content door en voor meerdere regio's	3	2	3	3		1	2	2	2	2	2	1
Landelijk ontwikkelen van leertraject ipv regionaal	3	2	3	1	-1		2	0	1	0	0	1
Zelfde niveau opgeleid over regio's	2	3	3	2	3	1		1	0	0	0	0
Samenwerking intensiever mbt vakbekwaamheid	2	2	3	2	3	-1	1		1	1	1	1
Leuk en uitdagende leeromgeving	1	0	1	2	2	1	1	1		3	2	2
State-of-the-art leeromgeving	0	0	0	0	0	0	0	0	2		1	3
Hoge kwaliteit leerproducten	1	1	1	1	0	0	1	1	1	1		1
Inspirerende leeromgeving	0	0	1	1	1	0	0	0	2	2	1	

Table 6: Snapshot of Probability of interdependencies between objectives (in Dutch)

	Uniformiteit in verblende producten tussen regio's	Eenduidige context van opleiden	Content meer delen met regio's; inhoud/content gelijk over regio's	Verhoging kennisniveau door gebruik kennis verschillende regio's	Ontwikkelen content door en voor meerdere regio's	Landelijk ontwikkelen van leertraject ipv regionaal	Zelfde niveau opgeleid over regio's	Samenwerking intensiever mbt vakbekwaamheid	Leuk en uitdagende leeromgeving	State-of-the-art leeromgeving	Hoge kwaliteit leerproducten	Inspirerende leeromgeving
Uniformiteit in verblende producten tussen regio's		2	3	3	3	3	2	3	2	2	2	2
Eenduidige context van opleiden	3		3	2	2	3	3	2	2	2	2	2
Content meer delen met regio's; inhoud/content gelijk over regio's	3	2		3	3	3	3	3	2	2	2	2
Verhoging kennisniveau door gebruik kennis verschillende regio's	3	2	3		3	3	3	3	3	3	3	3
Ontwikkelen content door en voor meerdere regio's	3	2	3	3		2	2	3	3	3	3	3
Landelijk ontwikkelen van leertraject ipv regionaal	3	3	3	3	3		3	2	2	2	2	2
Zelfde niveau opgeleid over regio's	2	2	2	2	2	3		3	2	2	2	2
Samenwerking intensiever mbt vakbekwaamheid	3	3	3	3	3	2	3		2	2	2	2
Leuk en uitdagende leeromgeving	2	2	2	2	2	2	2	2		3	3	3
State-of-the-art leeromgeving	2	2	2	2	2	2	2	2	3		3	3
Hoge kwaliteit leerproducten	2	2	2	2	2	2	2	2	3	3		3
Inspirerende leeromgeving	2	2	2	2	2	2	2	2	3	3	3	

4.4 Step 6: Preference-Neutral Prioritization

The two involved researchers discussed via telephone (synchronously) and via e-mail (asynchronously) with the secretary how to take the results from Step 2 (objectives hierarchy) and Step 3-5 (dependency matrix) into an objectives prioritization. First the secretary agreed to take the process objectives of Table 4 as the starting point for showing the active and passive values per objective. Table 7 shows just this. Process objectives are listed in differently colored rows per key objective.

Table 7: Active and passive values for Process objectives

Key objective	Basic objective	Process objective	Active value	Passive value
Uniform context for learning	Firemen equally educated in different regions	Uniformity in learning material between different regions	107	87
		Shared similar content between regions	107	112
		Improved knowledge level by sharing knowledge between regions	106	83
		Develop content by and for different regions	99	93
		More intensive cooperation with regard to life-long professional skills	95	77
Measurable quality level of skills	Quality in outcome	Define a (standardised) country level learning process (instead of regional)	48	84
Reduce stress & strain for firemen	More own responsibility (intrinsic motivation) for employees for their own learning activities / Learning process	Effective learning leading to life-long professional skills	26	37
		Flexibility in time and place of learning	39	42
		Place independent (Mobile!) learning so that employee can learn time independent	28	47
		Taylormade training for employee - learn what you need	83	50
		Taylormade learning style	85	39
		Flexible learning for firemen	56	62
		Learning what is needed not what is planned	63	60
Efficiency for organisation regarding training	Efficiency in firemen and means	Currentness of learning material	48	42
		Speed (learn quickly new learning material because of country wide developments in firebrigade	28	46
		Efficient learning for firemen	58	56
		Connection of initial with life-long learning (staying professional / life-long learning more conntected to initial learning)	53	56

Subsequently the Active values (X-axis) and Passive values of each of the Process objectives were put in a graph. Objectives were suggested to be categorized (=prioritized) in 4 quadrants:

- Priority A quadrant identifying objectives with a high Active value, and low Passive value;
- Priority B quadrant identifying objectives with a high Active value, and a high Passive value;
- Priority C quadrant identifying objectives with a low Active value, and a low Passive value;

- Priority D quadrant identifying objectives with a low Active value, and a high Passive value.

The horizontal and vertical lines making the division between the quadrants were inserted during a call with the secretary: the secretary was asked to compare two different objectives in terms of their importance to each other (more important or same importance). Within 4 iterations the lines were fixed.

First, a vertical and a horizontal line were inserted into the figure. The point of intersection was circa in the middle of the figure. The following procedure was executed as follows for both, the vertical and horizontal line:

a) Two objectives nearby the center of the figure were taken as starting point.

b) The secretary was asked, if these objectives have the same importance (example in Figure 13: “Efficient learning for firemen” and “Learning what is needed not what is planned”).

c) If they had the same importance, the vertical line was shifted to the left / the horizontal line was shifted up.

d) The left / upper objective of the previous group was then compared to the next objective that had the next lower active value / higher passive value. Again the secretary was asked if these objectives have the same importance.

e) This procedure was repeated until the lines there was no more adjustment needed which means that there was always a more and a less important objective.

The result is shown in Figure 13. Note that there is no priority D objective.

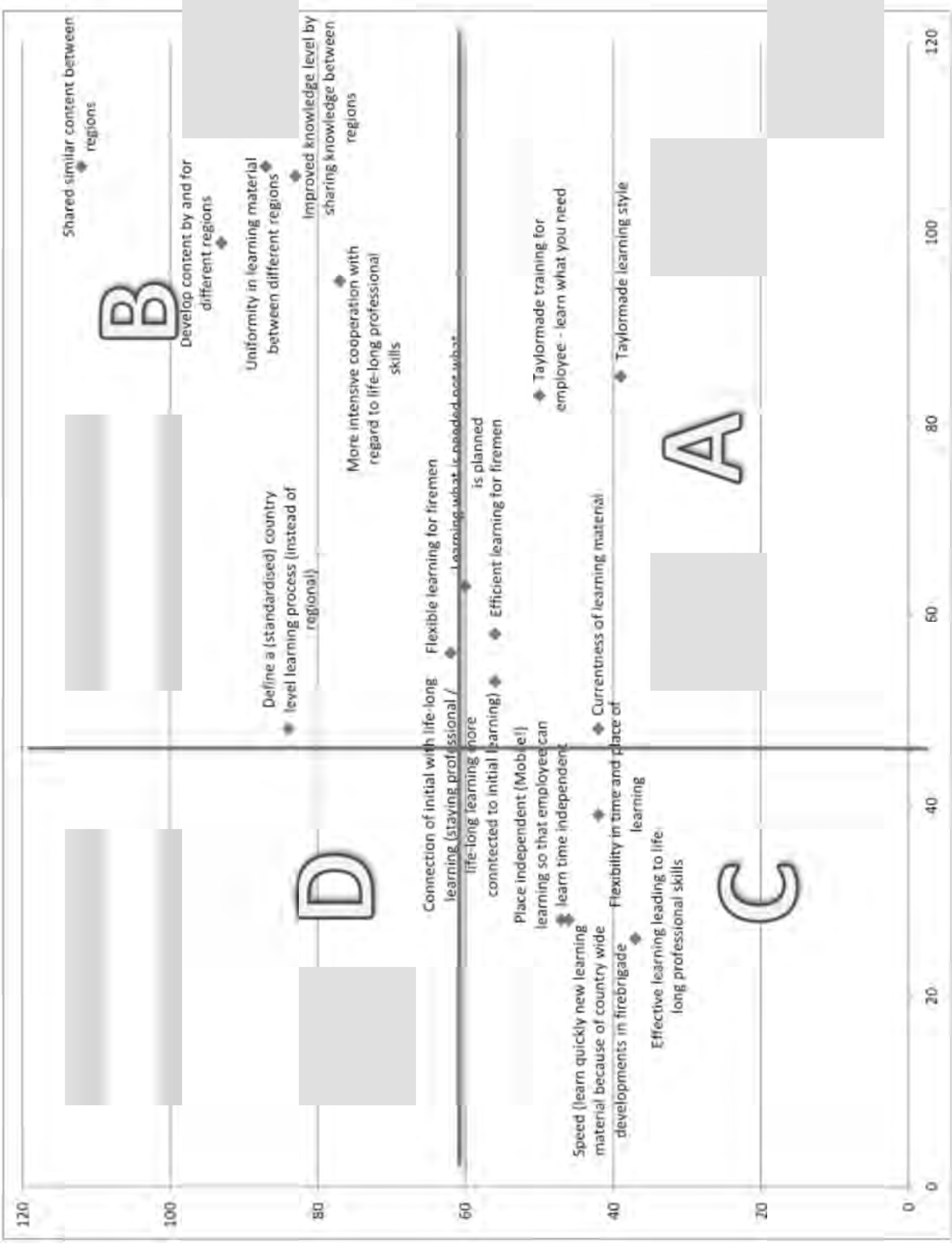

Figure 13: Setting the priority groups regarding the process objectives

4.5 Step 7: Defining the Final Target System

Table 8 shows the final resulting target system, containing the prioritization of objectives.

Table 8: Target system definition for implementing an ELE at 6 fire brigade regions in the NL

Priority A (highest)	Taylor-made learning style
	Taylor-made training for employee (firemen) – learn what you need
	Learning what is needed not what is planned
	Efficient learning for firemen
	Connection of initial with life-long learning
	Currentness of learning material
Priority B	Shared similar content between regions
	Uniformity of learning material between regions
	Improved knowledge level by sharing knowledge between regions
	Develop content by and for different regions
	More intensive cooperation with regard to life-long professional skills
	Flexible learning for firemen
	Define a (standardized) country level learning process (instead of regional)
Priority C (lowest)	Uniform context for learning
	Place independent (Mobile!) learning so that employee can learn time independent
	Speed (learn quickly new learning material because of country wide developments in fire brigade
	Effective learning leading to life-long professional skills

5 Some Further Analysis

Not anticipated in the case study protocol, but useful for validation: one of the firemen (a team manager, reporting to the head of one of the regions) who was also present during the initial brainstorm independently made his own ad-hoc prioritization from the list of objectives as depicted in Table 2. His priority list was as follows (see Table 9, which also includes the target system definition priority for comparison):

Table 9: Ad-hoc prioritization by fire brigade's team manager

Row no.	Priority according to team manager	English translation	Priority according to Target system definition method
1	1 (highest)	Uniformity of learning material between different regions	B
2	1	Uniform context for learning	C
3	1	Shared similar content between regions	B
4	1	Improved knowledge level by sharing knowledge between regions	B
5	1	Develop content by and for different regions	B
6	1	Country level learning process (instead of regional)	B
7	1	Firemen equally educated in different regions	n/a
8	1	More intensive cooperation with regard to life-long professional skills	B
9	2	Speed (learn quickly new learning material because of country wide developments in fire brigade)	C
10	2	Efficiency for organization regarding training	n/a
11	2	Efficient learning for firemen	A
12	2	Efficiency in firemen and means	n/a
13	3	Taylor-made training for firemen - learn what you need	A
14	3	Taylor-made learning style	n/a
15	3	Learning on basis of need & necessity	n/a
16	3	Reduce stress & strain for firemen	n/a
17	3	Learning what is needed not what is planned	A
18	3	More own responsibility (intrinsic motivation) for firemen for their own learning activities / learning process	n/a
19	4	Measurable level of professional skills	n/a
20	4	Effective learning leading to life-long professional skills	C
21	4	Quality of firemen´s skills demonstrably good	n/a
22	4	Quality in outcome	n/a
23	5	Flexibility in time and place of learning	n/a
24	5	Flexible learning for firemen	B
25	5	Place independent (Mobile!) learning so that firemen can learn time independent	C
26	6	Connection of initial learning to life-long learning (becoming professional / staying professional as for content and trainers involved	A
27	6	Initial learning materials will be used for life-long learning	n/a
28	6	Staying professional / life-long learning more connected to initial learning	n/a

Row no.	Priority according to team manager	English translation	Priority according to Target system definition method
29	n/a	Nice & challenging learning environment	n/a
30	n/a	State of the Art learning environment	n/a
31	n/a	High quality learning material	n/a
32	n/a	Inspiring learning environment	n/a
33	n/a	Currentness of learning material	A

The two prioritizations are quite different. Here are some explanations and observations as for these differences:

- Some differences can be explained by our explicit execution of step 2: the introduction of the objectives hierarchy and the combining of several objectives into one objective (see our above description on the execution of step 2). This concerns row numbers: 7, 10, 12, 14, 15, 16, 18, 19, 21, 22, 23, 27 and 28;
- As for row numbers 1 to 6 and 8: obviously the team manager rates the objectives categorized under 'cooperation' higher than the secretary. In a reflection the secretary stated that the team manager values regional development probably more than the secretary does. The secretary emphasized that striving for objectives directly related to the benefits for firemen themselves will increase the chance of success of the ELE implementation;
- As for row numbers 13 and 17: obviously the secretary values 'personalized learning' of higher importance than the team manager. See also the argumentation in the previous bullet: reflecting on this, the secretary stated that the benefits related to the firemen themselves will increase the chance of success of the ELE implementation;
- As for row number 26, the team manager considers this objective as something that should be strived for by the country-wide organization, not by the 6 regions per se;
- As for row number 33: the team manager considers this as a constraint, in contrast to the secretary, who interprets this as a genuine objective;
- As for row number 9, in a reflection with the secretary, he mentions that currently country-wide developments are not easily agreed upon by the different fire brigade regions, and therefor he considers focus on quickly adopting those into an ELE as less important.

Degree of agreement regarding the two prioritizations relates to:

- Row numbers 29 to 32 are in both prioritizations 'n/a', as both the team manager and the secretary consider those not as objectives, but as constraints/requirements for the implementation of the ELE;
- One could interpret row numbers 11, 20, 24 and 25 as having a moderate to high degree of agreement.

The different prioritizations triggered the fire brigade of the 6 regions to carefully reconsider the prioritization, and make a final decision on what to strive for during the implementation of the ELE, and what to consider as less important.

6 Conclusions

With the validation of the first activity at the fire brigade we looked specifically at:

1. Can all steps of the first activity of the integrative framework be performed successfully?
2. Is the execution of the first activity of the integrative framework considered to be accurate?
3. Is the execution of the first activity of the integrative framework considered to be useful?

ad 1) The fire brigade case shows that indeed all steps can indeed be applied. Both the secretary and the team manager were involved in performing the steps 1-7 successfully.

ad 2) In a reflection the fire brigade's secretary states that he considers the model highly accurate, if applied following a robust procedure: he suggests to undertake step 3-5 with multiple employees, so that consensus on the resulting objective priorities can be made. This confirms the procedure as applied by Högler & Versendaal (2016), in which multiple user groups created multiple dependency matrices, which were consolidated in step 7 of the framework's first activity. In addition, as demonstrated at the fire brigade's validation, an extra adhoc prioritization helps in providing a reference for discussion on the prioritization through the dependency matrix.

ad 3) In relation to especially step 3-5 the remark of the secretary was that it was a "useful, yet extremely time-consuming execution; [...] it lets you focus on what is really of importance, but it costs a lot of effort. Yet at the same time I admit it is very useful: it will help during the actual execution of the implementation project for the ELE to concentrate on the really important things!". It shows that the creation of an objectives prioritization was expected not to take too much time; in our steps, however, it does take quite some time, especially when there are many objectives. What helps is determining the object hierarchy before (instead of 'in parallel') step 3, so that the dependency matrix is only consitst of process objectives (the lowest level objectives, that are drilled down from key objectives and basic objectives, see Table 7). Also presenting the dependency matrix in another format (e.g. as a list) may contribute to the speed with which values can be entered in the matrix.

We end with the statement of the secretary who mentions that "although creating the objectives prioritization through the dependency matrix was timeconsuming, the investment at the start of the project (in defining thoroughly the target system) would definitely pay itself back during the execution of the actual ELE-implementation".

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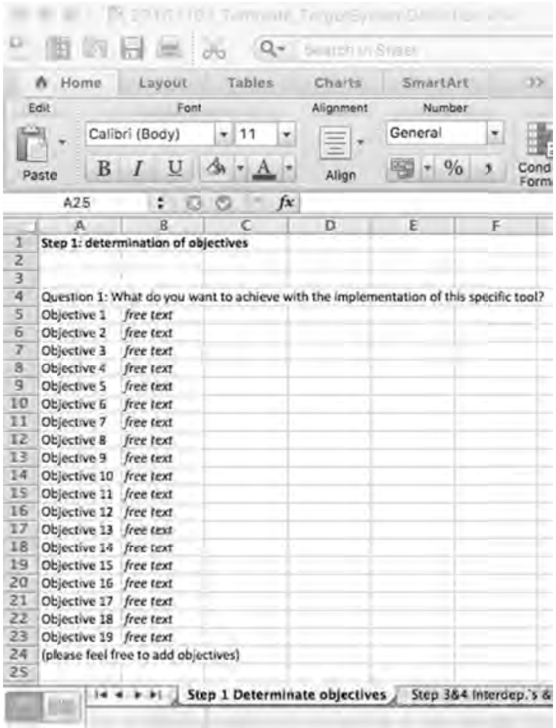
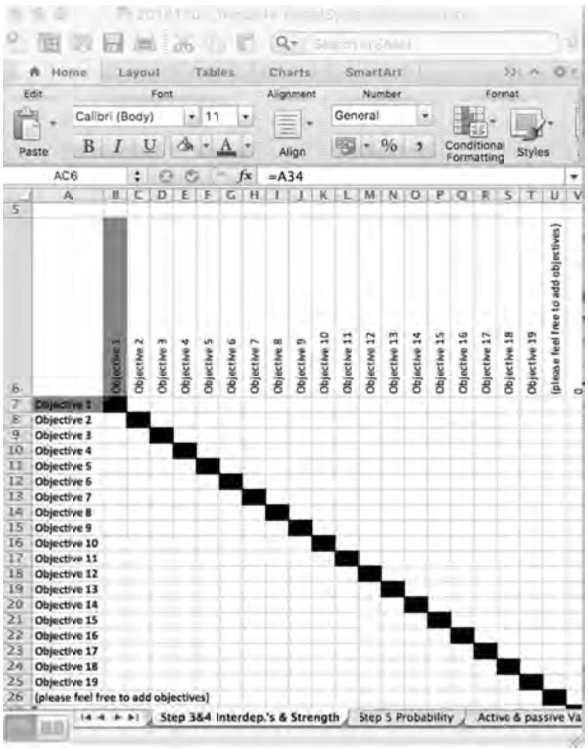
Annex 1: Template Excel-Workbook for Defining Target System Definition

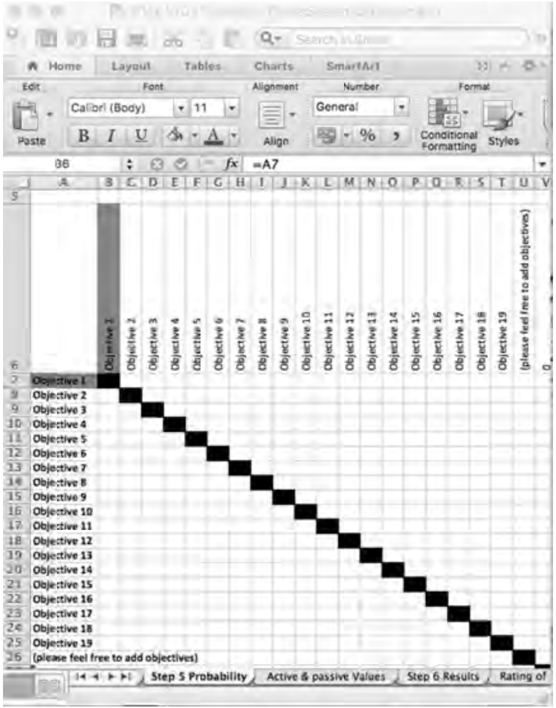
Step 1: Determination of objectives



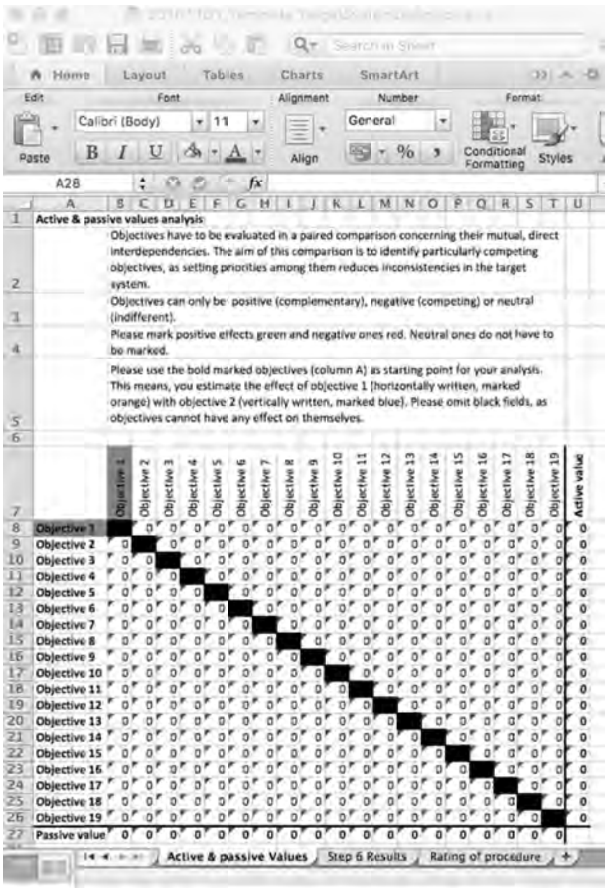
Step 3&4: Determination of interdependencies (between objectives) and their strengths

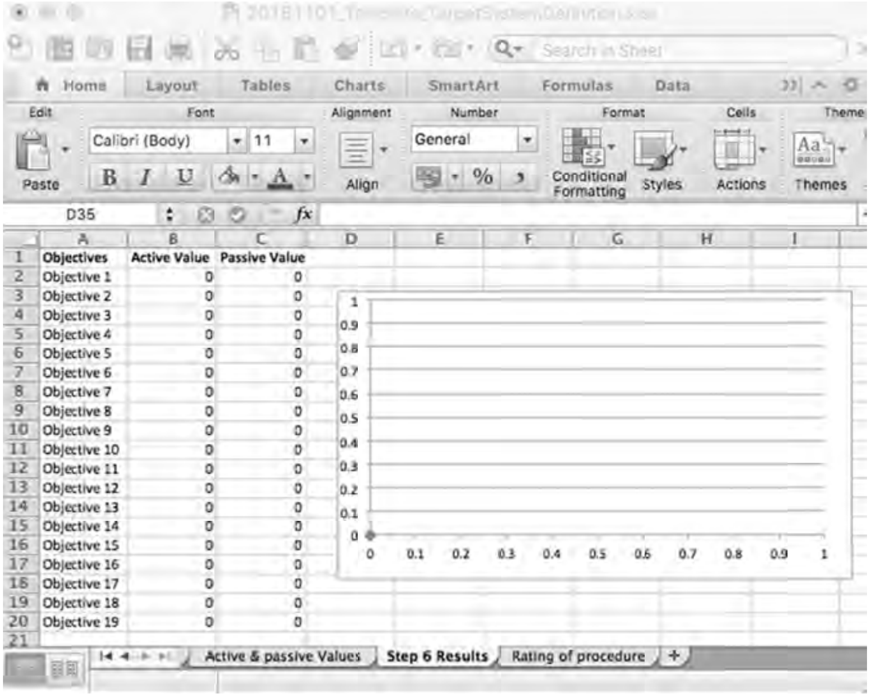


Step 5: Determination of likelyhood of interdependencies between objectives



Step 6: Preference-neutral prioritization using active and passive values




Home
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Formulas
Data
Edit
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Alignment
Number
Format
Cells
Themes
Paste
Calibri (Body)
11
Align
General
Conditional Formatting
Styles
Actions
Themes
D35
Objectives
Active Value
Passive Value
Objective 1 0 0
Objective 2 0 0
Objective 3 0 0
Objective 4 0 0
Objective 5 0 0
Objective 6 0 0
Objective 7 0 0
Objective 8 0 0
Objective 9 0 0
Objective 10 0 0
Objective 11 0 0
Objective 12 0 0
Objective 13 0 0
Objective 14 0 0
Objective 15 0 0
Objective 16 0 0
Objective 17 0 0
Objective 18 0 0
Objective 19 0 0
1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Active & passive Values
Step 6 Results
Rating of procedure

Appendix C: On the validation of an evaluation framework: the case of Nursemapp[81]

1 Introduction

Högler et al. (2015) describe a framework that delivers insight into the tangible and intangible effects of a mobile (IT) system, before it is being implemented. The framework has been developed because of a lack of such insight (other frameworks merely focusing on monetary effects, neither taking into account singularities of mobile technologies). The framework consists of 3 pillars with 7 included activities. Figure 1 shows the framework, also identifying interdependencies between the activities and their inputs and outputs.

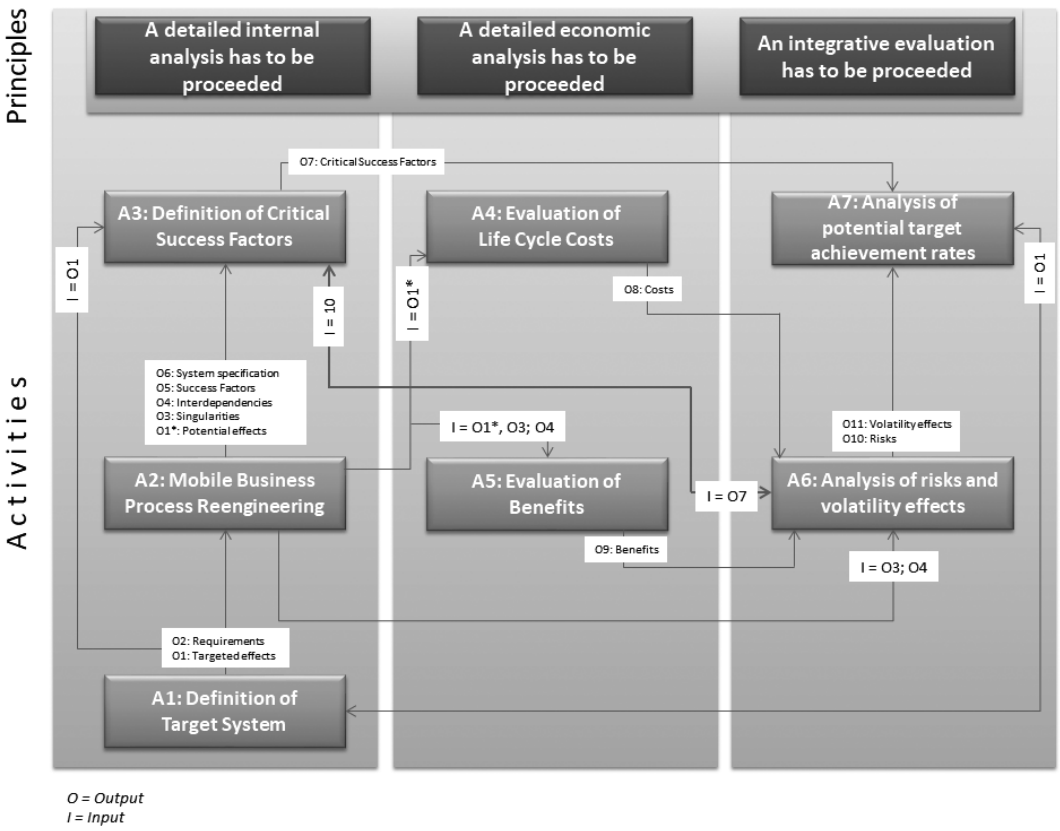

Figure 1: Integrative Framework for Mobile Systems (Högler et al., 2015)

81 This paper was originally published as: Versendaal, J., Högler, T., & Batenburg, R. (2016). *On the validation of an evaluation framework: the case of Nursemapp.* Technical Report Open University of the Netherlands. TR-OU-INF-2016-01.

A description of each of the activities from figure 1 is taken from Högler & Versendaal (2016):

1. "Activity 1: Definition of the target system by following the multi-attribute decision making (Hwang & Yoon 1981); this activity outlines a procedure for defining the target system leveraging the Analytical Hierarchy Process (AHP) (Saaty 1996) which is extended by following activities, differing fundamentally from previous approaches:
   - interdependence analysis between individual objectives (Kirchmer 1999; Drews & Hillebrand 2010; Rückle & Behn 2007);
   - consideration of the effective strength of the objectives and the probability of occurrence of interdependencies (Klabon 2007; Charette 1991) and thus their respective value; and
   - weighting of objectives in the context of these latter two aspects.

   [...]
2. Activity 2: Mobile Business Process Reengineering as proposed by the authors builds upon Mobile Process Landscaping (Gruhn & Wellen 2001; Köhler & Gruhn 2004).
3. Activity 3: Definition of critical success factors, their interdependencies, correlation analysis and weighting (Iqbal et al. 2015; Nysveen et al. 2015; Hway-Boon & Yu 2006).
4. Activity 4: Evaluation of life cycle costs (Wild & Herges 2000; Berghout et al. 2011), performed by identifying costs during the whole lifecycle of mobile systems including the preliminary phase, utilization phase and disposal phase.
5. Activity 5: The evaluation of benefits, based on the total benefit of ownership model (Gadatsch & Mayer 2004), involves the capture of cost savings and non-monetary benefits or qualitative and strategic variables which are not considered in the traditional approaches of economic evaluation.
6. Activity 6: Sensitivity analysis: As an uncertainty of the results achieved in the previous steps remains, a sensitivity analysis is conducted to check the stability of results. Particularly the variables success factors (Corsten 2000; Rockart 1979), risks (Kronsteiner & Thurnher 2009) and the accompanying volatility effects (Kulk & Verhoef 2008; Singh & Vyas 2012) are analysed.
7. Activity 7: Analysis of potential target achievement rates: Based on the results of the sensitivity analysis, the potential achievement rates can be determined. To do so, results of activity 1 (target system), activity 2 (current and target processes incl. key (performance) indicators) and activity 6 (volatility effects) are merged." (pp 3-4).

Although both papers (Högler et al., 2015; Högler & Versendaal, 2016) provide an evaluation of this integrative framework for mobile systems to some extent, in both papers it is suggested that effort is needed in validating it more extensively. In this report we test the validity of the framework through a retrospective case study. As criteria for choosing such a case, we define:

- it should address a framework-wide validation;
- it should be a validation of an existing implementation (retrospective case);
- it should be representative
- the implementation should be considered successful;
- source material of the preparation of the implementation of the mobile system should be easily available for this case.

Nursemapp is a mobile app for nurses that allows for directly entering vital body functions of patients in hospitals, while nurses do their 'patients-round'. Nursemapp fulfills the mentioned criteria:

- In the Netherlands, Nursemapp is proclaimed as a show case of a native mobile app for the major Dutch hospital information systems vendor Chipsoft (https://www.zorgvisie.nl/ict/nieuws/2015/9/chipsoft-breidt-epd-uit-met-native-apps-2692177w/ and https://www.chipsoft.nl/oplossingen/147).
- Nursemapp has been developed and successfully implemented at Utrecht's academic hospital in the Netherlands (UMC Utrecht).
- The suggested implementation has been described in detail by Heerink (2014), with the addition that Heerink describes Nursemapp as a case study herself in the context of broader research.

In taking Nursemapp as our retrospective case study, we check the following:

1. Are all activities of the integrative framework identifiable in the Nursemapp implementation? Which activities are not explicitly mentioned? What does this imply?
2. To what extend are activities differently elaborated in Nursemapp, as compared to the integrative framework? What does this imply?

2 Validation Protocol

We take the standard research design template of Maimbo & Pervan (2005) for describing our validation protocol, see Table 1.

Table 1: Validation protocol, using the template of Maimbo & Pervan (2005)

Section	Protocol details regarding the Nursemapp case
Preamble	No particular preamble regarding confidentiality, publication etc. is set up for Nursemapp. We merely leverage existing already published documentation of Nursemapp.
General	Högler et al. (2015) describes an integrative framework for a priori evaluation of the effects of (mobile) IT system implementation. For further validating the integrative framework we choose an existing successful implementation of a mobile system (Nursemapp in this case), that was precisely described and that was implemented independently from Högler et al.'s (2015) integrative framework.
Procedures	In determining to what extent the activities of the 'integrative framework for a priori mobile system implementation' can be recognized in the preparation of the Nursemapp implementation, we study a thesis (Heerink, 2014; only its main text, not the appendices). First one researcher studies the thesis and codes the thesis; subsequently a second researcher checks the coding from the first researcher. If the second researcher questions a certain coding (or the absence of a certain coding), then the two of them discuss the discrepancy and make a decision to change that particular coding, or not.
Research instrument(s)	We perform a qualitative analysis of Nursemapp by coding the thesis of Heerink (2014). Therefor the marker-facility of Adobe Acrobat is used.
Data analysis guidelines	For coding the thesis we use the following a priori codes (in italics) that reflect the 7 activities of Högler et al.'s (2015) integrative framework: Initial identification of *targets* for Nursemapp (Mobile) *business process reengineering (BPR)* *Success factors* for the implementation and usage of Nursemapp Evaluation of life cycle *costs* Evaluation of *benefits* *Risk analysis* Determination of the degree of *target achievements* While coding we intend to apply a most detailed granularity. This implies that whenever a larger amount of text is coded, we investigate whether this code can be reasonably subdivided in multiple separate codes, e.g. when it deals with different sub-concepts for the same code.
Appendix	As there are no interviews held (only consultation of Nursemapp documentation), no participation request letters are provided.

So we code Heerink (2014) in searching for answers to our two major validation questions: 1) are all activities of Högler et al.'s integrative framework identifiable in Heerink's (2014) description of Nursemapp, and 2) to what extend are there differences in the activities' details?

3 Validation Results and Analysis

The coding by the first researcher was in almost every situation confirmed by the second researcher. In the few situations that there was some discrepancy, this was always quickly solved, by, in general, following the second researcher's opinion, who is also the author of the integrative framework (Högler et al., 2015).

Table 2 describes the agreed upon results of the coding of Heerink's (2014) observation of the Nursemapp implementation.

Table 2: Coding overview of Heerink (2014)

A priori code	Times a code is identified through a text fragment	Text fragments referring to the particular code in Heerink (2014), examples
Targets	25	"To make work processes predictable and manageable [...]" (p 27) "[...] and provide information access at the point of care [...]" ((p 27)
BPR	47	"During a patient assessment, nurses inspect at least one patient. Vital values like blood pressure, temperature and saturation are being measured. During the traditional way of working nurses generally use an A4 printed patient list, sometimes accommodated with a pad, to write down their measurements. After every patient in a round was checked upon, nurses walk to a workstation, log on to the electronic health record and enter all scores per patient. With the use of NurseMapp, a nurse will log on in the beginning of a clinical round of assessments. While assessing a patient, the nurse will select the respective patient and enters every vital value. The input will automatically be imported in the electronic health record." (p 18) "Users saw potential for mobile [Nursemapp] documentation during rounds, where paper-based methods are currently in use." (p 38)
Success factors	212	"[...] obstacles concern the Wi-Fi connection and choice of device [...]" (p 91) "[...] projects fail due to the lack of a high-esteem physician buy-in." (p 28)
Costs	0	
Benefits	90	"Almost one and a half minute per patient was won by using NurseMapp and health records are more complete since its release." (p 91) "Using NurseMapp, compared to using pen and paper, significantly differs in the amount of vitals entered in ward A (0.734, $p < .0005$, $d = 0.29$) and in ward B (0.184, $p = .042$, $d = 0.10$)." (p 83)
Risk analysis	57	"[...] technical inabilities as crashing or freezing is seen as obstacle and unusable and will cause frustration." (p 94) "[...] inaccurately or omitted vital sign data can result in inappropriate, delayed or missed patient treatment." (p 19)
Target achieve ments	7	"To what extent [...] can a mobile health record application support process and quality improvement within hospitals?" (p 9) "The more obstinate obstacles are, the less strong the effects experienced." (p 89)

We observe the following from Table 2 and the coding in the original work of Heerink (2014):

1. Except for 'Costs', which is not explicitly found in the text of the thesis, all other activities are found in text fragments of the thesis;
2. Some codes are only found few times (particularly 'Target achievements'), whereas others are much more often found (e.g. 'Success factors');
3. The first three activities of Högler et al.'s (2015) integrative framework can be particularly found in the early chapters of Heerink (2014);
4. The activities' details as described by Heerink (2014) are in many cases comparable to what is described and exemplified in Högler et al. (2015) and Högler & Versendaal (2016); e.g. by Technology Acceptance Model is in both cases used for the activity related to success factors. Yet, particularly the first activity (identification of targets/goals), is quite differently worked out by Heerink for the Nursemapp case.

ad 1) This is probably due to the character of Heerink's (2014) thesis: the research question of the work of Heerink (also defined under 'Target achievements') is defined as "To what extent, and how, can a mobile health record application support process and quality improvement within hospitals?"; this makes costs not an explicit searched for factor. On the other hand, the coding of text fragments related to *funding* (7 times coded) are now categorized under 'Risk management' and 'Success factors). One could argue that these might also be categorized under 'Costs'. This identifies a possible weakness of the integrative framework: the difficulty in determining what is precisely meant by an activity as shown in the published papers, and consequently, how to exactly execute on the activities.

ad 2) The limited number of references to 'target achievements' can be explained as follows: the integrative framework differentiates between different hierarchy levels of objectives: Key, Basic and Process objectives. Key objectives are seen as benefits that should be achieved and Process objectives describe *how* to achieve the benefits. In contrast, Heerink´s thesis does not clearly distinguish between benefits and targets / target achievements.

ad 3) The broader context of Heerink's (2014) work (the Nursemapp implementation is for Heerink just a case study for validating her own defined framework of adoption and implementation drivers/barriers for effective implementation of e-health systems) could explain finding that many references in the first chapters of the text, related to the first three activities of Högler et al.'s (2015) framework.

ad 4) Especially the operationalization of the first activity by Högler et al. (2015) should be further investigated; it may result in the fact that the contribution to both science and practice is especially in this first activity.

4 Conclusions

Nursemapp is a mobile app for helping nurses in registrating patient's vital functions, when they are doing their patients rounds. Heerink (2014) has investigated the effects and drivers and barriers of such mobile apps, taking Nursemapp's implementation as a case study.

For validation of Hölger et al.'s (2015) integrative framework for mobile system evaluation, Heerink's (2014) thesis was successfully coded. Based on the two questions we addressed for validating the integrative framework (i.e. 1) “are all activities of the integrative framework identifiable in Heerink's (2014) description of Nursemapp”, and 2) “to what extend are there differences in the activities' details?”) we conclude that:

- The activities as mentioned in the integrative framework are no awkward activities; they are activities that are easily identifiable in Nursemapp;
- The operationalization and detailing of the activities of the integrative framework are to some extent identifiable in Nursemapp. The specificity of the first activity ('Defining upfront targets/objectives/goals' of the mobile system) as described by Högler et al. (2015) makes it a candidate for further explicit validation.

5 References

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Summary

The world is becoming increasingly complex and so do the associated information and communication systems (ICS). While in former times ICS merely executed transactions, during the last decades they turned into management and strategic information systems that aim at increasing business value. Business value can be seen as the measure that describes how much a specific ICS contributes to the objectives of an organization, including up-front unintended or unforeseen strategic, transactional and transformational effects.

The increasing complexity of such systems turned their evaluation into a so-called 'wicked' problem: Existing evaluation approaches do not reach far enough as they were developed for assessing traditional key performance indicators while ICS have fundamentally different characteristics, particularly with regard to technical and organizational aspects. In contrast to industrial goods and machines they are strongly linked to strategic and thus to business value.

In the present work we address this gap by producing and evaluating an applicable artifact – which includes components of the organization and people involved in the use of technologies, in our case mobile technologies – in the form of a model inheriting a method: The integrative framework for evaluating the business value of ICS with mobile components (i.e. mobile systems). The particular focus on mobile systems was chosen due to their strategic value for organizations: mobile technologies are applied in business processes, providing ubiquitous access to information, enabling fundamentally new business processes and opportunities and becoming large-scale enterprise-wide strategic tools that enable businesses to gain and sustain competitive advantages. The evolving mobile systems -sets of mobile technology and human (system) components- turn increasingly complex as they offer a broad variety of fields of application as their components can appear in many combinations. These findings lead to the main research question “How can mobile systems be evaluated in an integrative way?”. To answer this question, we define three main objectives that guide our research work: 1) to have shown the necessity of an integrative evaluation model for mobile systems by surveying why existing approaches are not appropriate for evaluating the business value of this type of systems, 2) to have defined an integrative framework for evaluating mobile systems, in particular for evaluating their business value, and 3) to have validated this integrative framework as for its completeness, correctness and its usefulness using different validation methods.

To illustrate the necessity of an integrative evaluation framework, a literature analysis was conducted. It shows that existing evaluation approaches for ICS and mobile systems do not explicitly address singularities of mobile systems that they insufficiently consider interdependencies, particularly between system components, between objectives, risks and success

factors, which eventually affect implementation effects, and that they insufficiently focus on business value and consequently insufficiently take an integrative view.

For the development of the integrative framework, we have chosen concepts of design science research as research design and strategy of this thesis. The integrative framework is our proposed artifact that is constructed considering business needs and the scientific body of knowledge. The two main design processes we used are to build the artifact and to validate the artifact in case studies and by experts´ interviews. The applied validation criteria are relating to the framework´s completeness, correctness and usefulness.

In order to build a framework that allows evaluating mobile systems in an integrative way, it is understandable to consider them as socio-technical systems whose individual implementation affect the whole organization, including its business processes and users of the technologies. Taking a socio-technical systems theory perspective implies that technologies on their own have no value – they can generate value only when being used or applied by humans. Consequently, especially interactions between the single system components, including users, have to be considered. Effectively implementing mobile systems calls not only for a more in-depth understanding of mobile technologies, but particularly for a better understanding of user behavior and his needs with regard to the applied technologies. This cognition encourages a proper alignment between the single system components when discussing its business value. As a consequence, Henderson and Venkatraman´s principles of business/IT alignment seem usable for the evaluation for mobile systems.

Taking the above said into account, we draw principles from several theoretical foundations to design our framework and propose that the scope of evaluation of mobile systems needs to leverage (socio-technical) systems theory principles and needs to be amplified towards including the alignment of IT with the business (business/IT alignment) and considering singularities of mobile systems. We propose that the integrative approach is an innovative, unprecedented approach for ex ante evaluation of mobile systems. Novelty is given by the development of the following artifact components: First, by the definition of a target system that takes structurally into account interdependencies of the single objectives of mobile systems, and that applies risk analysis in a unique way. Second, by a definition of success factors which are derived from singularities of mobile systems. Third, by extending a traditional risk analysis by integrating critical success factors. Last by combining results of all activities of the integrative framework in order to take an integrative perspective. The generality of the artifact and the artifact components was supported in several case studies where they have been applied in different contexts, and by expert interviews.

Samenvatting

De wereld wordt steeds complexer, net als de bijbehorende informatie- en communicatiesystemen (ICS). Terwijl ICS vroeger met name zorgdraagden voor rechttoe rechtaan transactieverwerking zijn het nu veel meer managementinformatiesystemen en strategische informatiesystemen waarmee verhoging van business value wordt beoogd. Daarbij kan business value beschouwd worden als de mate waarin een specifiek ICS bijdraagt aan de doelen van een organisatie. Dit is inclusief van tevoren onbedoelde of onvoorziene strategische, transactionele en transformatieëffecten.

Door de toenemende complexiteit van dergelijke systemen is het evalueren van de business value een zogenaamd 'wicked'- probleem. Bestaande evaluatiemethoden gaan niet ver genoeg, omdat ze zijn ontwikkeld om met traditionele prestatie-indicatoren te werken, terwijl ICS tegenwoordig vaak fundamenteel verschillende karakteristieken hebben, vooral waar het de technische en organisationele aspecten betreft. In tegenstelling tot veel productieautomatisering zijn ICS sterk verbonden met de strategische waarde van een organisatie, en raakt het daarmee de business value.

In dit werk adresseren we deze lacune door een artifact te ontwikkelen en te evalueren. Dit artifact beschouwt zowel organisatieaspecten als mens gerelateerde aspecten bij de introductie van technologieën, in ons geval mobiele technologieën. Het artifact is een model dat een methode met activiteiten bevat: Het integratieve raamwerk om de business value van ICS met mobiele componenten (zogenaamde mobile systems) te evalueren. De focus op mobile systems is gekozen vanwege hun strategische waarde voor organisaties: mobiele technologieën worden toegepast in bedrijfsprocessen, daarbij de ontsluiting tot informatie gemakkelijk makend. Mobiele technologieën maken nieuwe bedrijfsprocessen mogelijk en worden daarbij strategische gereedschappen die organisaties een competitief voordeel kunnen geven en kunnen laten behouden. De zich immer ontwikkelende mobile systems zijn samengesteld uit mobiele technologieën en mensen die ze gebruiken. Ze worden daarbij steeds complexer, omdat mobiele technologieën een breed spectrum van toepassingen hebben in veel combinaties. Een en ander heeft geleid tot onze volgende hoofdonderzoeksvraag: "Hoe kunnen mobile systems worden geëvalueerd op een integratieve manier?" In de beantwoording van deze vraag stellen we ons in dit werk drie doelen: 1) de noodzaak aangetoond te hebben voor een integratief evaluatiemodel voor mobile systems omdat bestaande benaderingen van de evaluatie van business value onvoldoende zijn, 2) een integratief raamwerk gedefinieerd te hebben voor evaluatie van mobile systems, in het bijzonder voor wat betreft hun business value, en 3) dit integratieve raamwerk gevalideerd te hebben voor wat betreft compleetheid, correctheid en bruikbaarheid, via verschillende validatiemethoden.

Om de noodzaak van een integratief evaluatieraamwerk te illustreren is een literatuuronderzoek uitgevoerd. De uitkomsten ervan geven aan dat bestaande evaluatiemethoden voor ICS en mobile systems de specifieke karakteristieken van mobile systems niet expliciet adresseren. Bestaande methoden houden daarnaast onvoldoende rekening met de onderlinge afhankelijkheden van met name systeemcomponenten, implementatiedoelen, risico's en succesfactoren die de effecten van implementatie beïnvloeden. Ze adresseren onvoldoende de business value en als zodanig nemen ze geen integratief perspectief in beschouwing.

Voor de ontwikkeling van het integratieve raamwerk hebben we gekozen voor een design science onderzoeksaanpak. Het integratieve raamwerk is ons beoogd artifact dat wordt geconstrueerd rekening houdend met de wensen van de beroepspraktijk en de bestaande wetenschappelijke body of knowledge. De twee hoofdprocessen zijn daarbij de ontwikkeling van het artifact, en de validatie ervan. De toegepaste validatiecriteria zijn de compleetheid, correctheid en de bruikbaarheid van het raamwerk.

Om het raamwerk te ontwikkelen op een integratieve manier, is het niet vreemd om mobile systems te beschouwen als socio-technische systemen waarvan de implementaties invloed hebben op hele organisaties, inclusief hun bedrijfsprocessen en de gebruikers van de technologieën. Vanuit een socio-technisch perspectief hebben technologieën an sich geen waarde: ze kunnen alleen waarde creëren als ze gebruikt worden door en toegepast worden voor mensen. Dientengevolge zouden juist ook de interacties tussen de verschillende systeemcomponenten, inclusief gebruikers, moeten worden beschouwd. Effectief implementeren van mobile systems vereist niet alleen een beter begrijpen van de mogelijkheden van technologieën, maar ook een beter begrijpen van menselijk gedrag, en helderheid over welke behoeften gebruikers hebben. Dit besef moedigt aan om de verschillende systeemcomponeten van mobile systems in alignment met elkaar te beschouwen, als we het over de business value van mobile systems hebben. Als zodanig lijken de principes van Henderson en Venkatraman's met betrekking Business/IT-Alignment goed bruikbaar.

Bovenstaande in beschouwing nemend, gebruiken we uiteindelijk principes van verschillende theoretische bases om ons raamwerk te ontwikkelen: we benutten principes van (sociotechnische) systeemtheorie, waarbij we ook principes van Business/IT-Alignment gebruiken, rekening houdend met de specifieke karakteristieken van mobile systems. We stellen dat de integratieve aanpak (ons raamwerk) innovatief en tot nu toe onvoldoende ontgonnen was voor de up front evaluatie van mobile systems. Vernieuwend is de definitie van het (mobiele) doelsysteem dat de onderlinge afhankelijkheden van individuele doelen beschouwd, waarbij ook een risicoanalyse uniek wordt toegepast. Ook de afleiding van succesfactoren (voor de succesvolle implementatie van mobile systems) aan de hand van de specifieke karakteristieken van mobile systems was voorheen onontgonnen. Daarnaast was de toepassing van risicoanalyse, in beschouwing nemend de succesfactoren, tot dusver onbekend. Tot slot is de integratieve beschouwing van alle onderdelen van het raamwerk uniek te noemen. De generaliseerbaarheid van het raamwerk wordt ondersteund door de in dit werk beschreven case studies en de expert interviews.

Curriculum Vitae

In 2001, Tamara Högler started her research career at the Research Centre for Information Technologies (FZI) as research assistant. During her time at FZI she was deputy head of the department “Business Process Engineering and Management” and board and chairman of the personnel board. Additionally, she was Ombudsman for the quality assurance of research activities of FZI researchers. From 2003-2006 Tamara worked as research assistant at the Karlsruhe Institute of Technology (KIT), department for Applied Informatics and Formal Description Methods.

In 2006 Tamara left research to become a Product Manager for Mobile Industrial Solutions at a private company. She had projects with global players of the chemical and process industry in Germany, but also with SMEs in the manufacturing trade sector and public administrations, all focusing on mobile maintenance management systems. During her projects she gained a deep insight into practical problems that occur when evaluating the economic efficiency of mobile systems. The faced real-life challenges and requirements motivated this research work.

Tamara joined CyberForum e.V. in 2010, a business network for high-tech and IT companies. As Head of Innovations and International Affairs Tamara was responsible for the management of European research projects and the establishment of international cooperation with clusters. As Tamara worked since 2001 in EU projects, she has long-time experience as project manager, but also as LEAD partner in FP7, Horizon 2020 and Interreg projects.

In August 2018, Tamara started her work as research project manager at WIBU-SYSTEMS AG. Here, she is responsible for the application of project proposals, the proper implementation of research projects and their sound financial management.

In spring 2015, Tamara started to work also on a self-employed basis. As a private consultant, Tamara mentors cluster associations and similar institutions worldwide in order to become sustainable and assists them in strategic planning and management. In addition, she supports particularly SMEs towards digitalisation, by focusing on users´ needs and long-term effectiveness of the company´s digitalisation strategy, including decision support regarding appropriate technologies. In addition, she supports organisations and companies in project applications on national and European level and in project management and administration.