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Identification of Success Factors for Mobile Systems Deployment: A Method

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Identification of Success Factors for Mobile Systems Deployment: *A Method*

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Abstract

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.

Keywords: Mobile Systems, (Critical) Success Factors.

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 out-put 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 and Yang 2002). 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 ment 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 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 behaviour, whereas it does not focus on a separate consideration of each component (see Bartalanffy 1976). Following these reflextions, 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 TabletPCs), appropriate applications as well as mobile operating systems and middleware (if necessary). Additionally, they include wireless communication technologies like UMTS, GPRS and WLAN.*

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 1979) 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". 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 behaviour of the system with a given structure (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 behaviour of a system. In order to predict the behaviour 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 3. Through a case study we judge the validity of the framework in section 4. We end our paper with summarizing our results, and providing implications and anticipated further research.

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 et al. 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 et al. 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 1 shows the the relationship between the three main distinguishing features and flashlights resulting 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 • …

Table 1: Singularities of mobile systems

Despite intensive research, mobile devices still face many restrictions (see also Schach et al. 2007; Lonthoff & Ortner 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.

The usage of mobile devices is hindered by the relatively small displays, which have limited facilities for the reproduction of contents (Rawolle, Kirchfeld and 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 (see also 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 (see also Frolick & Chen 2004; Gluschke 2001; Day et al. 2000), 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 2004). 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?

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 (Horvath 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 & 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 & Norton's (1996) balanced scorecard (Ward & Peppard (2002), p. 206). The findings of Ward & Peppard (2002) build the basis for the authors´ method to identify critical success factors for mobile systems from a multi-dimensional perspective. Nevertheless, Ward & Peppard (2002) proposed methodology does not take into account the singularities of mobile systems which is 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. Allweyer 2005; Becker & Vossen 1996; Davenport 1993, Hammer & Champy 1993). The present work defines a process according to Richter-von Hagen & Stucky (2004, p. 23): “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.”

3.1 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 (see also Walter 1995, p. 285, he explains the topic „Hierarchy of success factors” in detail).

The authors propose the following procedure for identifying critical success factors (figure 1):

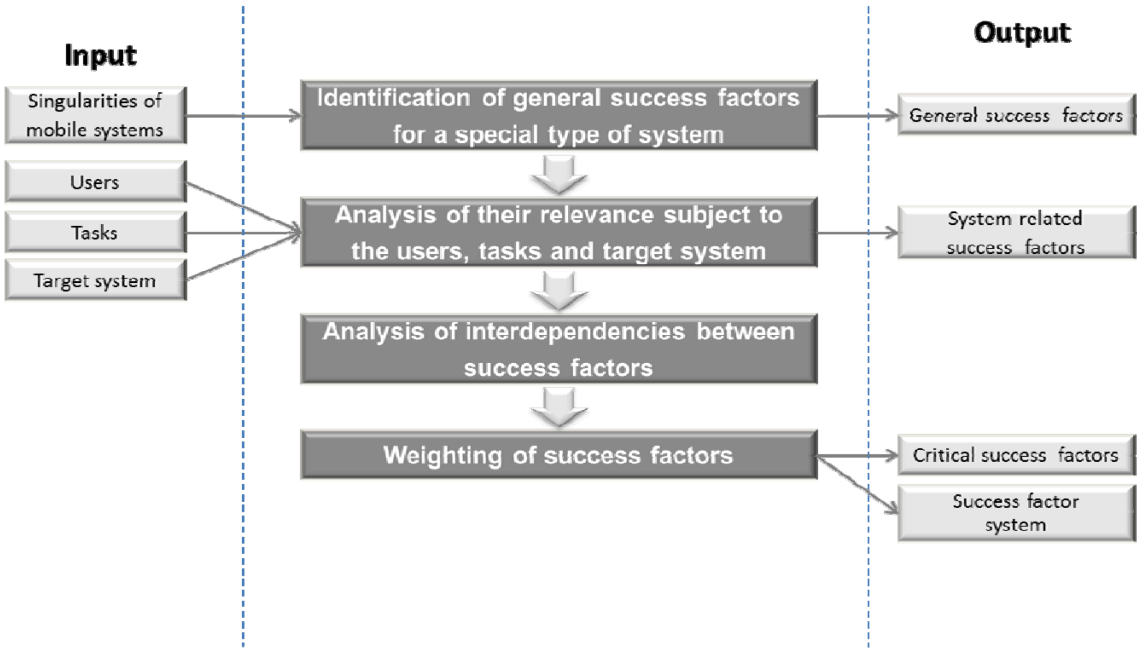

Figure 1: Method for the identification of success factors

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 a.o. singularities of mobile systems as shown in Table 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.

For relevance determination the Task-Technology-Fit-Model by (Goodhue & 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 et al. 2005). Their Task-Technology-Fit-Model is based on the general theory of Task-Technology-Fit by (Goodhue & Thompson 1995) and the specific theory of Task-Technology-Fit for group collaboration support systems by (Zigurs & 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 pro-cessing; form factors; and location-awareness), and individual use context (operationalized by distraction, movement, quality of network connection, and previous experience)" (Gebauer et al. 2005). 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 analysed. The authors suggests the Analytical Hierarchy Process (AHP) by Saaty (1980, 1996)(see also 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.

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 analyse 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. Birkhofer et al. 2007; Brodt & Verburg 2007; Gebauer & Shaw 2004) and as a result of personal professional experience of the authors. Table 2 shows some general success factors for the chosen project as examples:

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

Table 2: General success factors for mobile maintenance management systems

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 3:

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

Table 3: Tasks of different kinds of employees / roles

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, 1995) is based on the general theory of task-technology fit by (Goodhue & 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 4:

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

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

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 5 shows some of the main success factors analysed during the above mentioned project:

Tasks	Maintenance engineer	Decision maker	System-related success factors
Documentation 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 data		x	• High security / privacy • Speed of processing data • High resolution / big display • Existence of a well-usable keyboard

Table 5: Success factors subject to different tasks and roles

In order to finish the definition of system-related success factors, the influence of the general success factors on the targets set was analysed which is shown in table 6.

A profound discussion of table 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 (Saaty 1980; Saaty 1996) mentioned above.

	Effect on target…						
System-related success factors	**Minimi-zing errors (gathering data)**	**Minimizing errors (task definitions)**	**Reduction of general informa-tion loss**	**Documen-tation of all steps**	**Data analysis / inter-pretation**	**Improve control**	**Critical**
Minimum size & weight of device	none	none	medium	medium	none	none	**no**
Always-on connectivity	medium	high	high	medium	none	medium	**yes**
Usability of device and programs	high	none-medium	high	high	medium	none	**yes**
Ruggedized device	none	none	medium	none-medium	none	none	**no**
Explosion prevention and protection class II	none	none	none	none	none	none	**no**
No "pen" needed (usable only with fingers)	high	none	high	high	none	none	**yes**
High security / privacy	none	none	none-medium	none	medium	none	**no**
Speed of processing data	none	none	medium	none	medium	medium	**no**
High resolution / big display	none	none	none	none	high	none-medium	**no**
Existence of a well-usable keyboard	high	none-medium	high	high	medium	none-medium	**yes**

Table 6: Influence of success factors on targets

Legend	
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"
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).
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 less 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.

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 behaviour, 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 focussing on a multi-dimensional evaluation of mobile systems.

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