Critical success factors for mobile field service applications: A case research

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Abstract

This paper presents a multiple case research concerning success factors and issues of mobile field service implementations. Based on Eisenhardt's explorative research design, five successful mobile technology implementations are compared and analysed. Important aspects of the implementation strategy and the used technology are examined and discussed. The results indicate that the success of mobile field service implementations is influenced by the implementation strategy, project management, change management, and technological restrictions of the used mobile technology. The analysis identifies the complexity of technological components and their limitations as well as aspects influencing user acceptance as central challenges for mobile technology implementations.

1 Introduction

Many publications proclaim great potential for efficiency improvements in business processes by using mobile technology [Kala03, Pflu02]. The characteristics of mobile technology like mobility, reachability or localisation offer new possibilities to contact mobile workers and organize their tasks more efficiently [PoTW03, SiSh03]. A typical example of a mobile worker is a field service technician who has to perform maintenance activities at different locations. Due to this mobility of the task, the worker is unable to work at a stationary workplace [KrLj98]. Therefore, efficiency gains could be realised in the coordination and documentation of the work

using mobile technology [VaHe02]. For example, redundant work due to paper-based documentation and manual data input can be reduced.

While the potential impact of the mobile technology is hardly questioned, the realization of these potentials is rarely addressed in IT research. Furthermore, many failed IT projects show that the implementation process is a crucial factor for the success of the integration and use of a new technology [Brow04]. So far, there is only limited research on mobile technology implementations. There are some case studies analysing benefits and possible barriers in multiple case analysis [BrVe05, ScMc04]. Nah, Siau and Shen presented a single case study and derived some fundamental objects and aspects influencing the success of mobile technology [NaSS04]. A more conceptual approach is applied by Wang, van de Kar and Meijer, who try to analyse the implementation process using the method of the way of working, thinking, designing and controlling [WaKM05]. The single case study of this report is enlarged to a multiple case study by Wang [Wang05]. Though these are good descriptions of the application development, a structured description of success factors and potential problems is still missing. To identify success factors and issues of current mobile technology implementations, a multiple case study in the area of mobile technologies is needed.

The goal of this paper is to analyse implementation strategies and critical success factors of successful mobile field service applications comparing different cases in one study. Studying different cases in one study allows drawing more relevant conclusions as a direct comparison between different cases is possible. In this study, we also compare the different success factors between mobile technologies and other standard IS implementations.

In the next section, the general research methodology and analysis framework is described. After a short description of the cases in section three, the key findings of the study are presented in section four. In section five, the main findings are discussed and also related to other studies from the literature. The paper ends with a short summary and some conclusions.

2 Methodology

This section describes the methodology we used in our study. We discussed the analytical framework and the way we conducted our empirical research.

In this study, we identify the strategic patterns of the mobile technology implementation by analyzing some selected real-world cases. For the analysis, we used successfully implemented mo-

bile applications. For the design of our studies we follow the structure of qualitative research proposed in [Kepp00]. The used method of multiple case research is based on Eisenhardt's explorative research approach [Eise89]. For the data collection, we used guided semi-structured interviews [Yin02]. These interviews were conducted either face to face or by telephone. The direct interaction with the interview partner reduced problems of possible misunderstandings [FrMe95]. The impact of the direct contact on the argumentation is minimized in the data analysis [Atte2003, ScHE05]. The different cases are compared using a process-based approach [MaRo88].

We analysed five successful implementations of mobile technology as exemplary case studies. By focussing on one specific type of mobile technology implementation (mobile field services), we reached a homogenous setting of the study. To consider different technologies as well as different stakeholders, we chose cases from three different software providers. We interviewed the project manager of the provider and the customer as well as a user of the application. Overall, we conducted 16 interviews; at least three for each case. The interviews were structured in three parts. The first part consisted of questions concerning the background and the trigger for the implementation of the mobile technology. The second part analysed the proceeding of the implementation and the used technology. The third part evaluated the results of the projects as well as the problems and success factors of the implementation. The length of each interview was about one hour. All interviews were based on a semi-structured interview guideline with open answers. The analysis is based on the transcripts of the interviews and, if available, background material provided by the interview partner.

3 Case Descriptions

In this section, we will shortly depict the five cases under consideration for this research paper. First, general aspects will be explained. In addition, a tabular listing will take a closer look on the different examples.

For this research five different companies in the German speaking area which recently implemented a mobile solution have been analysed. In three cases the analysed implementation of the mobile solution was a technological novelty. For the other two companies the analysed projects were replacements for already existing mobile solutions. Installing mobile solutions for the first, the goals of the solution were basically reductions of media disruptions and process efficiency,

the replacements should lead to a cost reduction concerning the maintenance of the mobile solutions.

Though all five solutions are implemented to facilitate field service activities of the field service technicians the solutions differed concerning the standardization of the application, the mobile device and the synchronisation of the mobile application and the back-end system. Table 1 shows some central aspects of the five case studies.

	Case A	***Case B***	***Case C***	***Case D***	***Case E***
Occupation	Heating systems	Facility managment	Utility	Heating systems	Industrial gas
Type of usage	Field services	Field services	Field services	Field services	Field services
Existing mobile solution	No	No	Yes	No	Yes
Count of users	130	1000	100	200	100
Offline/Online	Offline	Offline	Offline	Offline	Offline
Synchronisation	GPRS/GSM	GPRS	LAN, DSL, ISDN	GPRS	LAN, DSL, ISDN, GPRS
Type of solution	Individual	Individual	Standardized	Standardized	Standardized
Mobile devices	Pocket PC	PDA and Laptop	Laptop	Tablet PC/Laptop	Laptop
Reason for the mobile solution	- Elimination of media disruptions - Process efficiency - Centralisation of administration	- Elimination of media disruptions - Process efficiency	- Reduction of the maintanance costs - New functions	- Effiency of documentation - Elimination of media disruptions - Process efficiency	- End of maintenance contract - Low user accep-tace of old solution

Table 1 – Description of the analysed cases

4 Key Findings

This section depicts the key findings of the case research. The results address factors that are important during implementation and which are critical for the success of the implementation. First, as the mobile technology is a key aspect for our research, we will analyse the technological situation and identify success factors and problems regarding the different components of the mobile solution. In section 4.2 we analyse the implementation strategy of the projects. Therefore we describe the key strategy and identify critical success factors.

4.1 Technology

A mobile solution is a complex system consisting of different components. In this subsection, we analyse success factors and issues of the mobile solution and some of its components. As this is no technology analysis but an implementation research, we focus on the most important issues mentioned in the interviews:

- interfaces to back-end systems,
- mobile middleware,
- mobile application,
- synchronisation medium/network,
- mobile device, and
- mobile solution.

As all cases intend to use the data and information from the mobile application in the back-end system, *interfaces between mobile solution and back office system* have to be designed. All cases state this aspect as important and were satisfied with their application. Therefore, the design of interfaces is not viewed as a major problem. One reason for this aspect might be that all cases use standardized back-end systems and these are designed by the same provider (three out of five cases).

The next component of the solution is the *mobile middleware* which is used in a standard version. Therefore, the middleware was not viewed as a challenging aspect in most cases. However, in one case about 300,000 equipments should be provided by the mobile middleware. This *amount of data* could not be executed by the middleware the provider distributed with the solution. As the provider could not offer a different middleware a preliminary CD-based procedure had to be added to the solution to circumvent this problem. This solution offers the possibility to provide the necessary data for the equipments and changes can be quickly included by a new version of the CD. A final solution is intended to be implemented soon.

The counterpart to the middleware is the mobile application which runs on the mobile device. We can split the mobile application in two parts. The first part is the business logic that is implemented on the mobile device. The second part is the user interface for the data input. The features and the flexibility of the business logic design depend on both, the standardization of the software and the flexibility of the solution provider. In the five cases missing functionalities and/or software problems were viewed as challenging for the implementing process of the mobile application. However, with updates and new releases most of those problems are solved. Although the *stability of the business logic* is essential, the *user interface* is the most important aspect for the interview partners. For them, the design of this part of the solution is most critical for the acceptance of the user. It should be intuitive, easy to use, and only few clicks should be needed. This is important because field service technicians are usually not used to work with computers. Therefore, the ease of use is viewed as crucial for the acceptance of the whole appli-

cation. In all cases, the user interfaces are customer-designed and often inherit components known from the paper-based process to help the user to accustom to the new technology.

The data has to be transmitted from the application to the back end; hence the *synchronisation* is also mentioned as an important aspect by the interview partners. The field service technicians often work in cellars and other areas without constant network access. Consequently, none of the cases used an always-online solution. All applications are basically offline solutions with a synchronisation mechanism to update the information. The synchronisation mediums differ among the cases. While two companies use wired connection like LAN, DSL, ISDN, or WLAN for synchronisation, the other three solutions synchronise via GPRS. The medium, frequency, and initiation of the synchronisation depend on the need for actuality. Among other reasons, failed synchronisations can have their origin in network problems since the *availability of the mobile network* (GPRS) is limited. It might be worthwhile to test different telecom providers and network cards as the availability and the operational functions can differ. For example, in two cases the replacement of the network card resulted in more reliable communication.

In most interviews, the *mobile devices* are seen as critical success factors. It is important to select a mobile device that fits well to the task and the environmental circumstances. The interview partners suggest to carefully analyse the working environment and the previous working process and then to decide which device meets these requirements. In all cases, problems with mobile devices occurred. In two cases the problem occurred due to the insufficient *robustness of the devices* which resulted in a high failure rate. Additional equipment for robustness like a special plastic cover or replacing the device by a more rugged device was needed to reduce this problem. Another problem was the limited *screen size* of the mobile devices which result in problems for inexperienced users. This makes the data input complicated and cumbersome. Even with devices specially manufactured for the customer, there might be problems as one case showed. The provider of the device was not able to provide an acceptable solution in time. Consequently, the scheduled time of the implementation had to be postponed. Finally, the customer had to use a different device from a different provider.

Another problem related to mobile devices is the limited *amount of data* which can be synchronised or stored on the mobile device (especially when dealing with “mass data”). A recommendation to reduce this problem is to focus on the relevant information needed for the process.

In the analysed cases, the applications using laptops seem to have fewer problems than the cases with PDAs and tablet-PCs. This may be because of fewer restrictions regarding size and capac-

ity. However, this does not mean that laptops are always the better solution. Limitations concerning data input, size, and weight might not allow using laptops.

Finally, an integrated view on the complete mobile solution and the *interoperability of the different components* is important. A fundamental expectation of all cases is that *the application should run stable and secure* without much effort for support and maintenance. Depending on the confidentiality of data, different encoding mechanisms and systems are used to guarantee data and system security in all five cases. The stability of the systems is seen positive in all cases (this is expected as we only study successful applications). However, the *complexity of the different components* led sometimes to difficulties in the traceability of the origin of failure. To solve such problems, a high knowledge on the different components and the underlying business processes was seen to be important.

4.2 Implementation Strategy

This subsection discusses the strategy of the mobile technology implementation. Different strategies are compared and critical success factors and issues of the implementation are identified. Furthermore, we study the influence of user experience on the *implementation strategy*.

We have been able to identify the following phases in the implementation strategy: analysis of the current situation, conceptual design, business blue print, software engineering, software tests, pilot phase, roll-out and adoption. These are typical steps of *phase models known from standard software implementations* [Balz82, Boeh86, StHa05]. Although the phases slightly vary between companies and projects, the key procedure is the same. We have not identified any differences between standard software solutions and individually-engineered software. This might be due to the fact that two of the cases with standard software solutions were projects in the launching period of a new software version and all providers had at least a standardized technological framework. Furthermore, the need for individual designs of user interfaces and adjustments based on the individual business processes might have led to the similar approaches. This aspect is supported by statements of most providers that two mobile technology implementations can hardly be compared to each other.

In the following paragraphs, we describe the success factors and problems of the implementation process observed in the five cases. We discuss differences in the process and split the analysis in four parts by aggregating some of the phases identified above. These are:

- concept,

- development and testing,
- roll-out, and
- adoption.

4.2.1 Concept

The first stage of a mobile technology implementation is the conceptual phase. In this part a proper setting for the whole implementation has to be defined. The interview partners regard this stage as the most important part of a mobile technology implementation. Hidden problems and not included functionalities can result in severe consequences for the rest of the implementation as later adjustments will be complicated and expensive.

The interview partners started with a *detailed description of the relevant processes* by analysing the present situation and describing the expected new situation. All relevant processes and sub-processes are verified and, if necessary, synchronized. In some cases not every process was modelled in full detail. This resulted in adjustments and extensions in the pilot phase. These adjustments were time and cost intensive.

Furthermore, the *cooperation between the provider and the customer* was estimated to be essential for the success in all cases. Issues and problems have to be solved together and a common idea of the goals and needs regarding the solution has to be developed. This demands flexibility on both sides and the provider has to understand the way of working and thinking of the customer to create a satisfactory solution.

In all cases a new mobile solution was introduced the first time, a large portion of users existed which are not used to work with mobile devices. Many of them were afraid of the new technology. Concerns were possible supervision by the management based on the characteristics of the mobile technology or to loose their jobs based on the streamlining of the business process. There were also concerns of not being able to cope with the new technology. Some *user resistance* was also based in the unwillingness of some employees to change their way of working. *Communication and information* was estimated as necessary to reduce these fears and resistances. The goals and background of the implementation have to be explained to the users as early as possible and in direct conversation. In addition, as much information as possible should be spread during the project. The information has to be accessible for all users. In one case, there was the problem that relevant information was available in the intranet but not all users had access to this. In those cases mobile solutions have already been used for some years, no

fears or resistances have been observed as users were used to work with mobile devices and hoped for efficiency gains.

The following aspect is also related to user acceptance. According to some of the interview partners, the *user should be involved in the project* already in the conceptual design of the solution. The users know the environment and workflow and have their own expectations and needs concerning the mobile application. In the first draft, the integration is essential for a good solution in the first draft and results in fewer later adjustments of the application. Furthermore, users integrated in an early stage were more devoted to "their" project and experiences from motivated users helped to prevent resistances and to reduce fears of their colleagues. However, the level of user integration strongly varied among the cases. While some cases integrated selected users from the very beginning as fully accepted team members, other cases include the users just for advisory comments on the user interfaces and for software tests. The reason of these different approaches is not based on technology, but on the philosophy of the project leaders. The interviews showed that involved users show a higher commitment towards the solution and interest in a further development and extensions.

The project managers emphasized that, besides user involvement, it is necessary to either integrate or to regularly *inform all stakeholders* that are affected by the implementation. This also includes those departments in the back-office which are indirectly affected by the implementation of a mobile solution. Especially the management board and the workers' council should be kept updated. In two cases, the information flow to the workers' council was not sufficient. Consequently, they tried to stop the project which resulted in a prolongation of certain phases.

There are many persons involved in such an implementation, thus the task for the project leader is quite demanding and therefore *a detailed project plan* with *strict deadlines* and *defined milestones* is important. Furthermore, the interview partners demand enough *power for the project manager*. The quicker a project leader can decide the better he/she can react on problems and necessary adjustments. In the cases observed, there existed minor problems concerning deadlines, which could be solved due to buffer periods and the flexibility of the parties.

4.2.2 Software Engineering and Tests

When the concept is finished, the software has to be engineered or adjusted according to the needs of the customer. Then, the final version has to be tested, first by the provider and then by the customer. In almost all cases, the customer was already able to test preliminary versions and check if the expectations are matched, especially regarding the user interface.

In all cases, the most relevant test was a *pilot period*. Therefore, some user had to test the new solution in real-world environments. Based on the high number of settings and equipments of the field service activity, the pilot phase was essential to early identify problems and eliminate these. The interview partners suggested using a hand-selected group of users, consisting of some who are used to work with computers and some inexperienced users. They should test the solution and report problems. As aforementioned, a stable solution is vital for the success of the implementation, therefore software problems and other issues have to be eliminated in the pilot period. To guarantee this, a vital cooperation between pilot users, IT department and the solution provider is necessary as the improvements have to be realized quickly.

The cases revealed two problems based on strategic decisions. In one case, the customer's *decision for a mobile device* was not made until the test period of the software started. Thus, the test of the mobile device process was parallel to the test period of the software. Consequently, the error tracing was sometimes difficult, as the problem might have originated in the different settings of the hardware as well as in the software. This ended in additional effort for testing and a prolongation of the test period. Thus, the hardware has to be chosen either before the test period or before the software engineering is about to start.

In another case, ill-defined *responsibilities* between the provider and its subcontractor caused some problems, as both tested their own part separately, but none took the responsibility for the whole solution. This led to problems in software testing, as the components worked fine alone but did not work properly when combined. This incident resulted in a prolongation of the whole test period as neither of the parties wanted to be responsible for the malfunction and blamed the other party. Therefore the responsibilities have to be well-defined at the very beginning.

4.2.3 Roll-Out

After eliminating problems in the pilot period, the application has to be rolled-out. An essential part of this is the *training of the user*. The experiences from the case examples showed that it is useful to educate computer inexperienced users first on the new device and the operating system before starting with the training for the mobile application. To separate groups with respect to their technological knowledge might also be reasonable, however, not always possible. The users should be trained with the interfaces they will actually use. The time necessary for training increases with the complexity of the application. In addition to trainings, almost all cases introduced *key-users* to help their colleagues with operational questions. Especially inexperienced users accept the help of a colleague more easily than an advice of an IT-specialist. These per-

sons have to be selected carefully, as the interview partners state that certain users caused a lot of additional work. An impatient treatment would discourage the user and reduce the acceptance of the new technology.

One case example allowed inexperienced users to use their old paper-based documents parallel to the new technology. Furthermore, the technicians started with using only parts of the functionalities and extend the use of the new solution step by step. This *slow changeover* allows the user to slowly adapt to the new solution and to get more confidence in their technological capabilities.

Problems in this stage of the implementation were mainly based on an overly optimistic estimation of the capabilities of the users. In some cases the length of training sessions was too short and had to be extended. In one case, due to software problems, the training period started about two weeks before the actual go-live. This delay between the trainings and the actual use of the new knowledge resulted in additional support from their colleagues to use the new application, as some of the users could not remember all aspects concerning the new application. Thus, trainings should not be conducted until the software is stable enough to go live.

4.2.4 Adoption

The interviews revealed that the users accepted the new tool if it does not impede his/her daily life. Ideally, it offers some improvements in comparison to the situation before the solution was implemented. Consequently, the *speed of eliminating problems and difficulties is essential* for the acceptance of the application of the user. Problems that occur must be solved rapidly. On the one hand software problems have to be fixed on short-hand notice by the IT department and the provider, respectively. On the other hand, *fallback scenarios* should be planned for hardware problems and alternative devices should be available in short period of time. Unproductive waiting and driving times to get the system running again will reduce acceptance, especially among critical users. Problems with user support were low. In one case, the late assignment of the person responsible for support and maintenance represented a challenge. Although the application was defined at the beginning of the project, in one case it was not possible to find a suitable person for support until the pilot users started. This could have resulted in major problems as at this time usually the new application needs the highest amount of support. However, in the actual case, other persons from the project team could fill the gap. Nevertheless, this person should be assigned at the very beginning and be an important part of the project team. The key aspects of the last section are summarized in figure 1.

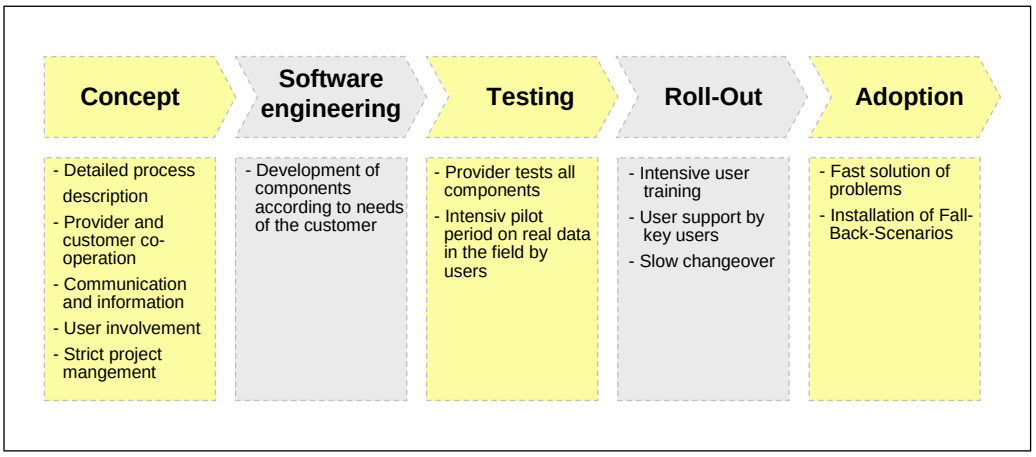

Figure 2 – Aspects of the implementation procedure

5 Discussion

We discuss the key findings of the case research on mobile field service implementations. The previous listing of the success factors and problems might be helpful as guideline, but we also relate the findings to existing observations from literature. We also examine the limitations of the study due to the research design.

The implementation strategies for the mobile applications in our cases are based on standard phase approaches [Balz82], [Boeh86] [StHa05]. The cases do not indicate any peculiarities which would suggest a special implementation strategy for mobile technology.

Regarding the success factors for a mobile technology implementation, the analysis revealed a number of issues and problems originating from different aspects. According to Riemenschneider [Riem01], success factors could be classified into the groups implementation research, project management, change management and technology specific aspects. We can use this categorization for classifying the results observed in the study.[1] Figure 2 shows some aspects according to this classification.

[1] Riemenschneider studied the implementation of integrated management systems. In his work the technological aspects are labelled as issues concerning integrated management systems instead of technological aspects.

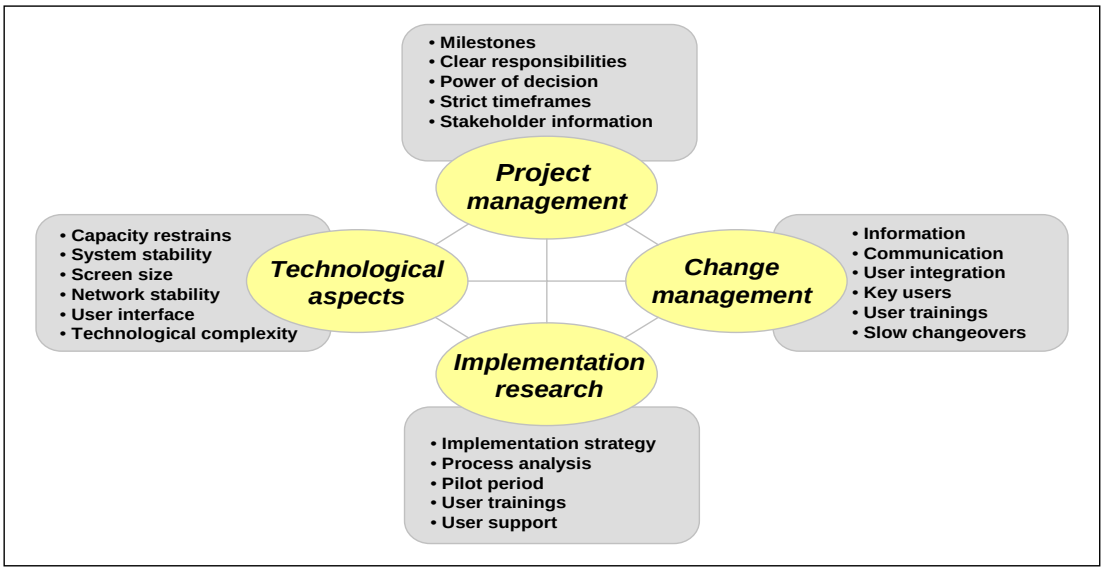

Figure 2 – Important aspects for mobile field service implementation

The identification of these success factors and the different influential areas is not surprising. Regarding the situation when the implementation research started, computer and information systems represented technological innovations and potential users were not used to work with computers. Therefore the implementation research for information systems was often centred on user acceptance [MaOp83, Riem01]. The situation for first-time mobile technology implementations for field service technicians is similar because most of the technicians are also confronted with the new technology for the first time. These service technicians experience the mobile solution as change in their way of working. Change management is focused on such aspects as it addresses the resistance of users against organizational changes [Reis97ab], [BoPi92]. Reiss describes four aspects that influence the resistance towards organizational change. These are lack of information, lack of knowledge/capabilities, lack of motivation and organizational boundaries [Reis97a]. As described above, the studied cases of first time implementation showed a great amount of resistance originating from all four areas. In some cases, the percentage of users with a negative attitude towards the new solution was up to seventy percent. However, it was possible to reduce these resistances by communication, training, support, creation of personal benefits, and integration [Reis97b]. Although the user resistance was lower in the two cases with technology replacements, the interview partners remarked that the expectations of the users concerning the stability and usability of the solution still define the central and most crucial aspect for a successful application. As all cases used a project organization for the im-

plementation, the management and coordination of the different persons and interests involved in this temporary collaboration also represents a success factor [Lech96].

Analysing the specific aspects of mobile technology, we identified a couple of restrictions and limitations based on the different components like capacity restrictions, connection problems, or size and usability of the mobile device. These effects are already observed in previous publications [KrLj99, LeBe04]. The case examples showed that a central aspect for a successful mobile technology implementation is to master the restrictions of the devices based on the mobile technology. This means to accept the limitations of the different components and create a stable solution suitable to the specific requirements of each company. In addition, the design of the user interface signifies a central aspect for a successful mobile field service implementation.

Therefore, the main challenge of a mobile technology implementation is the high complexity of the different components and the interaction between technology, user and other stakeholders in the implementation process.

This study offers an overview on success factors and issues of mobile technology implementations based on five case studies. However, there are some limitations due to the used research design: based on the explorative research there is a potential bias due to the direct influence of the interviewer [Atte2003]. We tried to eliminate the distortion in the data analysis; however, it is difficult to fully eliminate this bias.

Furthermore, the used information is a significant issue. As the results of our study are based on the answers of the interviews, we could only make use of information provided by the interview partners. Therefore, problems or success factors that are not addressed in the interviews are not included. In addition, the different interview partners were not integrated into the project to the same amount.

The setting of the study offers two other problems. First we analysed only successful mobile technology implementations. This eliminates the possibility to study which factors lead to a failure of projects. The second problem of the setting is that in most of the projects the mobile applications were used mainly for reporting. Therefore, the consequences of a system breakdown are limited as the information as not time critical and technicians perform most of his work without the solution.

6 Summary and Conclusions

This case research illustrates success factors and issues of mobile field service implementations. The paper describes the lack of such an analysis and motivates the need for a direct comparison of different mobile field service implementations. We discussed the explorative research methodology based on multiple case studies. After a short description of the cases and the situation before the mobile technology was implemented, we presented the key findings of the case studies. We illustrated success factors and issues of a mobile technology implementation originated from the technology and the implementation strategy. Finally, the key findings are discussed and compared to existing results from the literature on software and innovation implementations.

We summarize the key findings of this study: first, the results can be used as a guideline for implementing mobile applications. We showed relevant success factors, issues, and actual problems of implementing mobile technology. Second, a mobile field service implementation is based on aspects regarding project management, implementation research, change management, and mobile technology. A successful implementation addresses success factors from the different fields and respects the existing limitations. Especially the technological limitations have to be mastered as the mobile technology is still a developing area. Third, a first time implementation often has to face resistances of the users against the new technology. These resistances have to be encountered by communication, integration, trainings, and support. We found resistance lower if the users do not view the introduction of mobile applications as an organizational change (e.g. when replacing existing mobile solutions).

Further research including failed implementations is necessary to confirm the results of this study. Furthermore, we develop in future research a ranking of the importance of the different aspects regarding a failure of the introduction of mobile applications.

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