Evaluation of Mobile Systems – An Integrative Framework

Full paper

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Abstract

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.

Keywords

Evaluation, Mobile Systems, Integrative Approach, Systems Theory, Business IT Alignment.

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 (Brynjolfsson and Hitt 1998, pp. 50,51; Brynjolfsson and Hitt 1995; Brynjolfsson and Hitt 2000; Brynjolfsson 1993; Robey and Boudreau 1999; Hong and Kim 2002; Al-Mashari et al. 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 (cf. Niehaves et al. 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 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 Venkatramans' (1993) model of business/IT-alignment 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 and 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 (Bartalanffy 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 (Schiller 2000; Isaac and 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 and Versendaal (2014).

Finally, we apply behavioral science in the context of design science research (Hevner et al. 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 et al. 2004, p. 75; March and 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 et al. 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.

A review of ICS Evaluations

In literature a plethora of methods and technologies for evaluating investments in ICS exists (figures 1 and 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 (1997), existing qualitative or non-monetary evaluation methods mostly lack a theoretical basis.

Acknowledged traditional profitability analyses (one dimensional methods) have been examined in terms of their integrative aspects (figure 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 (Horvath 1988; Zahn et al. 1999; Ney 2006, p. 18) 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 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.

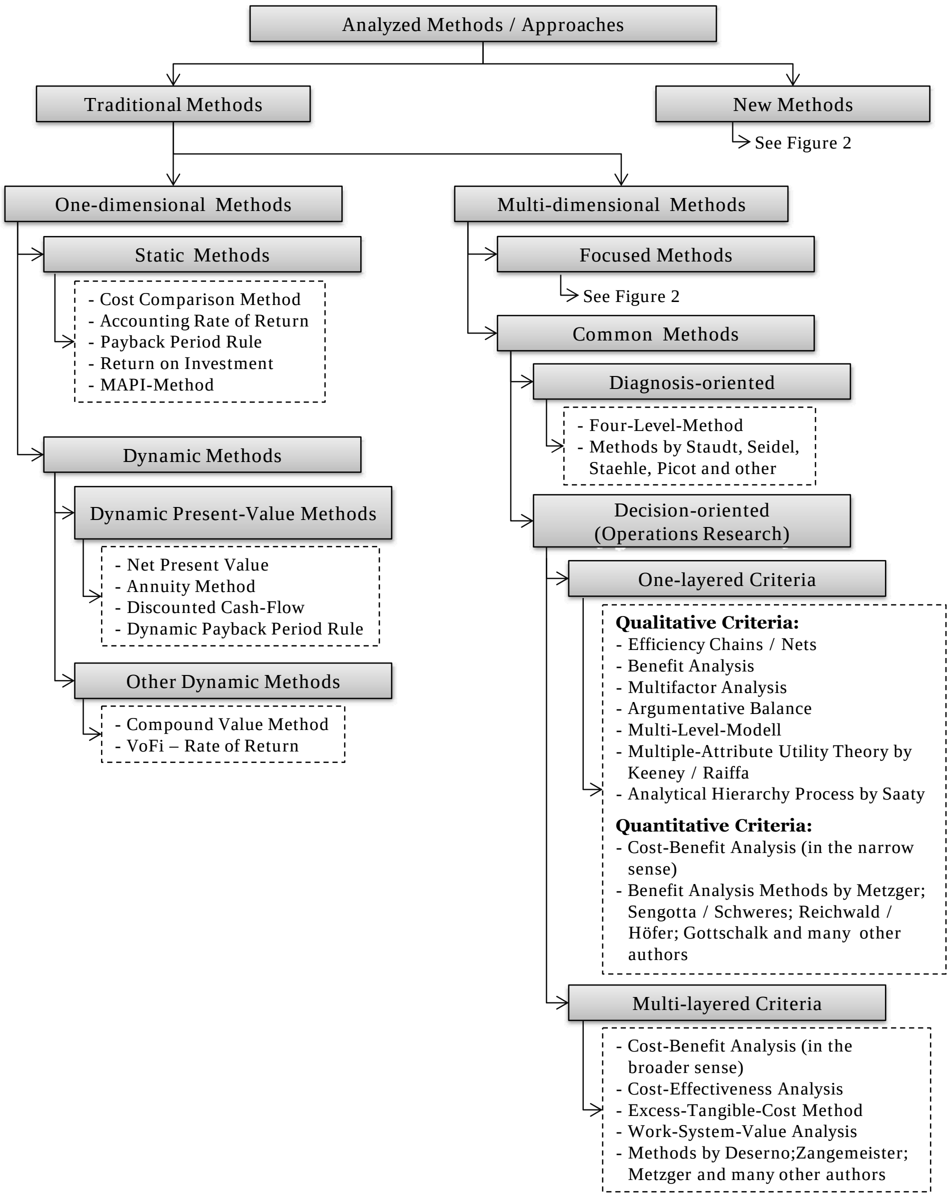

Figure 1. One-Dimensional and Multi-Dimensional, Common Profitability Analyses from Literature (Högler 2012)

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 (Picot et al. 2003, p. 6; Applin and Fischer 2011, p. 288). 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.

Combined approaches evolved during the last decades, like Total Value / Benefit / Cost of Ownership and Target / Activity Based Costing (figure 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.

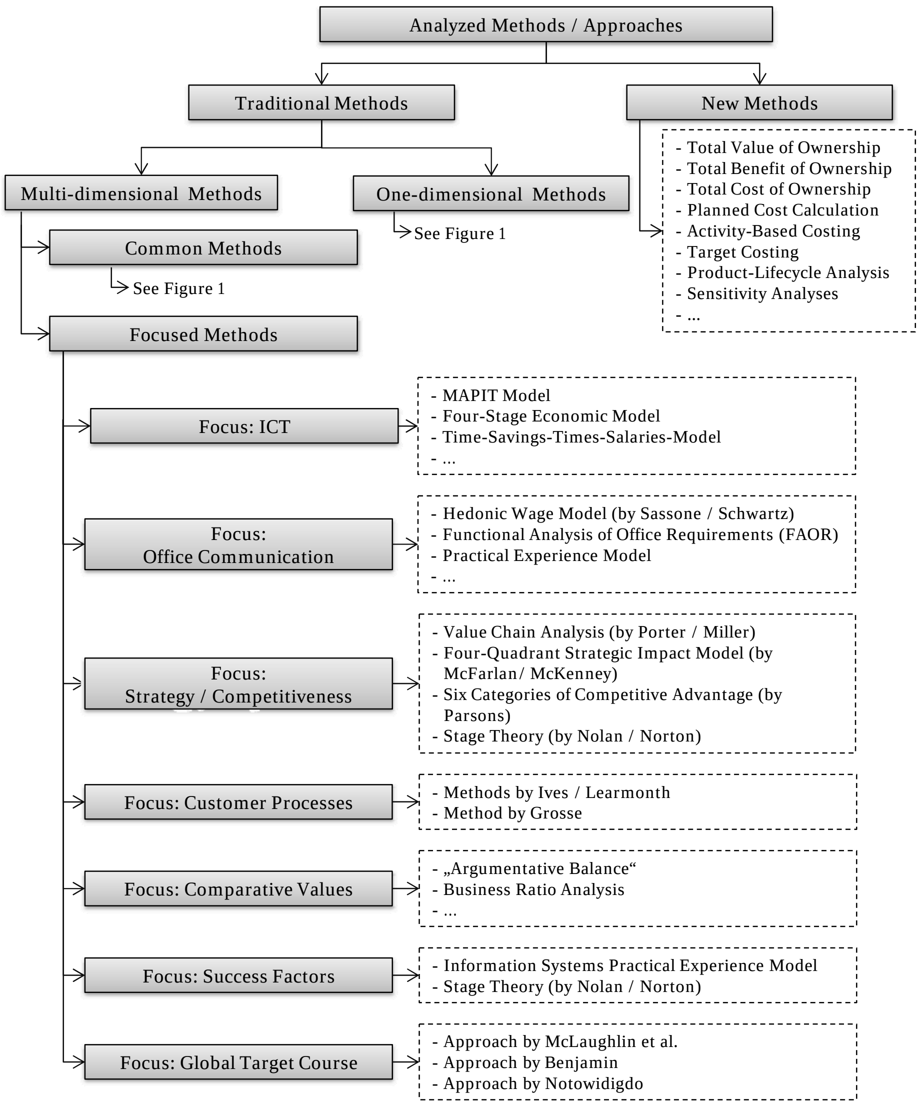

Figure 2. Multi-Dimensional, Focused Profitability Analyses and Newer Approaches (Högler 2012)

The need for a process-oriented approach has already been recognized in the 90s e.g. by Hammer and Champy (1994) 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. Versendaal et al., 2013; Cragg et al. 2002; Peppard and Ward 1999) 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 (see also Orlikowski 2000; Giddens 1989; Bostrom and Heinen 1977) 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 et al. (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 et al. 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.

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), which are characteristic for mobile systems. Multi-dimensional methods require the monetarization 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.

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 3:

- Principle 1 (Ward and 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 and 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 and 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.

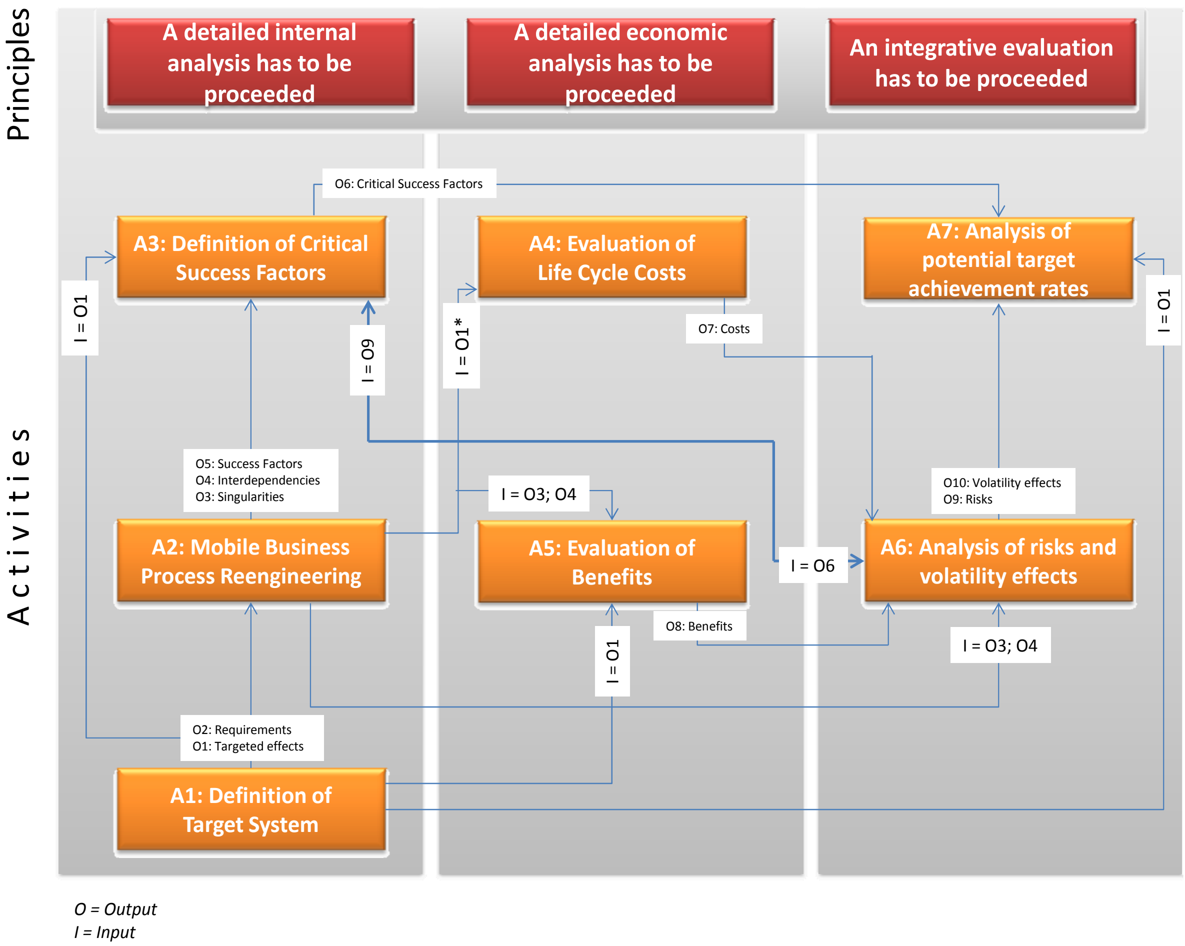

Figure 3. The Integrative Evaluation Framework

The three pillars of the framework are:

- System's theory (particularly activity 2 and 4),
- Business/IT-alignment, through activity 1 (the identification of goals – see Henderson & Venkatraman's 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
- 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.

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 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)

	Objective 1	Objective 2	Objective 3	Objective 4	Objective 5	Objective 6	Objective ...	Objective n	**Active valence (Σ)**
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 (Σ)	**2**	**16**	**22**	**-2**	**9**	**-7**	**8**	**-9**	

Table 1. Calculation of Preference Neutral Weighting Factors

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 1.

On the basis of the prospect theory by Kahneman and Tversky (1979, 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 objective, thus are not high priority candidates. This so-called preference neutral prioritizing of objectives is presented in Figure 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.

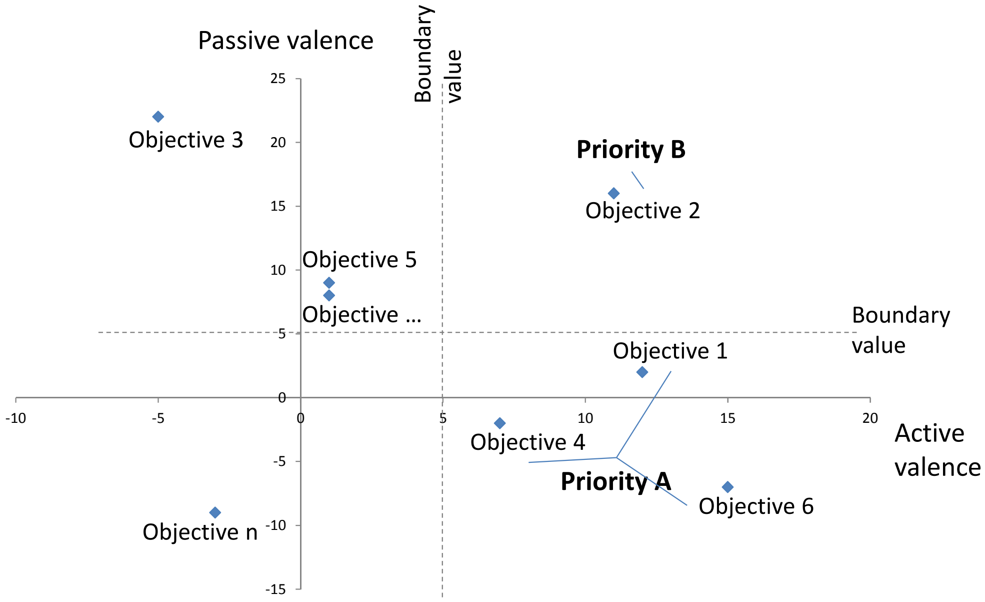

Figure 4. Preference Neutral Prioritizing of Objectives

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 and Gruhn 2004). 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 2).

Tasks	System-related requirements
Management and documentation of tasks & activities	Mobile device - Minimum size & weight of device - Ease of use of device and 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 task) - Standard documents / information directly accessible in / linked to task - 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 resolution / big display -> Tablet - Existence of a well-usable keyboard Application - Application has to have an analysis module (no analysis with ACCESS / Excel or similar tools) - Graphical illustration of results - Automatic tracking of activities (time needed, responsibility (done by…) must not be possible (due to internal regulations / work council) Network - Data has to be accessible online, but also offline -> storage of data on device needed, not only “cloud-based” access

Table 2. Identified Requirements (Examples)

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 in section 3, critical success factors are requirements that are indispensable.

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; Davis et al. 1989, and Venkatesh et al. 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 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 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:

	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**

Table 3. Influence of Critical Success Factors on the Likelihood of Risks

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.

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 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.

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