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Towards a Reference Model for Agile New Service Development using the Example of E-Mobility Service Systems

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Abstract

Electric mobility (e-mobility) is currently an intensively discussed topic in research and business practice. While there are both clearly defined physical products, such as electric vehicles, batteries, and charging components, and clearly defined services, we often also see a combination of both in service systems, charging services being one example. This means the relatively young e-mobility market offers excellent potential to develop and implement integrated solutions with a focus on delivering mobility as a key value proposition to users. From the point of view of new service development (NSD), creating service systems in an integrated way represents a major challenge: complexity emerges as a key characteristic from the ecosystem setup, mainly caused by the need for cross-company collaboration and the development of combined solutions (physical products, software, services). This article is based upon the hypothesis that existing NSD models and practices are not sufficiently applicable to this kind of innovation environments and thus need to be adapted and modified. The aim is to make the initial steps towards an agile reference model for NSD.

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Keywords: Agile development; electric mobility; new service development; project management; service systems

1. Introduction

Electric mobility (e-mobility) is currently an intensively discussed topic in research and business practice, especially when it comes to the spread of electric vehicles (EVs). Three main drivers for the spread of EVs are mentioned in current studies: Consumer demand (e.g. key motives for early EV adoption), industry developments (e.g. major OEMs releasing or announcing EV models), and government stimulus (e.g. subsidies) [1]. These drivers are flanked by the often-stated advantages and disadvantages of EVs and the system facilitating e-mobility. For EVs, the stated benefits include technical advantages such as high efficiency of the powertrain, rechargeability of the battery system, outstanding acceleration and power transfer compared to combustion-engine technology, advantages concerning new vehicle concepts, decreasing lifecycle costs, local zero emissions from electric drives, and smart energy solutions emerging on the market. The drawbacks of EVs include the heavy weight of many electric propulsion systems, limited cycle time and complex cell technology in batteries, limited electric range, high effort regarding new vehicle design concepts, the high cost of components, today's overall carbon footprint, and today's infrastructure [2].

To make effective use of EVs, a systemic view is clearly needed. First, it must take into account components such as the users' perspective (e.g. price, range, and charging infrastructure), vehicle technology (e.g. powertrain technologies and vehicle integration, battery technology, and lightweight design), charging infrastructure, regulation and standardization, information and communication technology (ICT), energy and the environment, urban planning and intermodality, as well as education and training [3]. Second, while the focus of the discussions concerning e-mobility is often on plug-in hybrid vehicles (PHEV), range-extended electric vehicles (REEV), and battery electric vehicles (BEV), as shown for

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instance in [4], and on technical components regarding batteries and charging points, in fact e-mobility can be defined far more broadly if we assume a broader view of related concepts such as sharing, housing, public transport, and the smart grid. The term “ecosystem” is often used to describe the complexity inherent in setting up and maintaining successful e-mobility businesses, for instance collaboration between different organizations or integrated ICT platforms [5,6]. While there are clearly both defined physical products, such as EVs, batteries, and charging components, and clearly defined services of different types, we often also see a combination of both in service systems, charging services being one example. This means the relatively young e-mobility market offers excellent potential to develop and implement integrated solutions with a focus on delivering mobility as a key value proposition to users. From the point of view of new service development (NSD), creating service systems in an integrated way represents a major challenge: complexity emerges as a key characteristic from the ecosystem setup, mainly caused by the need for cross-company collaboration and the development of combined solutions (physical products, software, services). This article is based upon the hypothesis that existing NSD models and practices are not sufficiently applicable to this kind of innovation environments and thus need to be adapted and modified.

Thus, the aim of this paper is to make the initial steps towards new flexible NSD models and to introduce an agile reference model for NSD, to extend traditional approaches by rather modern practices.

2. Research background

2.1. Organization of NSD processes

It is thoroughly explored and well-known that “successful new services rarely emerge by mere happenstance. Rather, they tend to be the outgrowth of an appropriately designed structure and a carefully orchestrated process” [7]. Success factors related to organization and formalization have already been highlighted in earlier NSD research, including aspects such as a high level of coordination, qualification and motivation of project team members [8,9], and formal development processes [10,11,12]. In terms of performance, process formalization has been found to directly and positively contribute to NSD speed, whereas using cross-functional (multidisciplinary) teams promotes creativity in NSD [13]. Key activities in organizing NSD can be seen concerning both structure and people, not only in terms of operational management, but also with regard to creating an innovative climate; a combination of creativity techniques and formal systems is seen as beneficial for successful NSD [14,15]. In this sense, NSD is not limited to an effectively and efficiently executed development process, but is completed with the introduction of new services into the market [10], which is closely related to the definition of an “innovation” [16]. With regard to formalization, manufacturing companies that exhibit optimized processes for developing their product-service systems strive to install formal roles or functions, project-based teams, roles explicitly dedicated to methodological aspects, advanced project management, and specified tools and methods. These companies involve selected customers as co-producers or co-designers, and they incorporate regular feedback for continuous improvement [17]. Finally, formalization of NSD processes should also enable learning from internal and external stakeholders as well as the integration of different skills and customer knowledge [18].

While the existence of a structured NSD process is one of several key elements for successful development, there are still issues to be dealt with. NSD processes seem to be less formalized in practice. Especially in fast-paced innovation areas (e.g. web-based services), companies seem to have a hard time applying them, showing a need for rapid development approaches. In addition, services tend to be rather intangible, and there are practical difficulties in creating a common understanding among development teams of what they are actually developing, which calls for adequate visualization methods [19].

As a conclusion, success in NSD can be defined as an effectively and efficiently conducted development process from idea management to market launch that promotes an innovative culture in a sustainable way by systematically managing not only the organizational structures and people within a company but also external stakeholders (e.g. customers and partners). Efficiency in more dynamic environments can be supported by rapid development techniques and visualization methods facilitating agile and flexible collaboration. The ideal approach thus seems to be both formal and flexible.

2.2. Applicability of existing NSD processes for developing service systems

As defined in the Capability Maturity Model Integrated for Development (CMMI-DEV), a “service system encompasses everything required for service delivery, including work products, processes, facilities, tools, consumables, and human resources,” and a “complex service system may be divisible into multiple distinct delivery and support systems or subsystems […]” [20], which matches the understanding of an ecosystem. These delivery and support systems or subsystems can be observed in some types of e-mobility services, e.g. charging, car sharing, mobile navigation. Regarding the large number of NSD processes that have been elaborated over recent decades, a critical question to consider is to what degree the models and techniques are applicable in today’s dynamic markets, while remembering that stage gate models might be outdated due to the need for more informal processes, faster NSD cycle times, less bureaucracy and norms of NSD [15,21]. What is true for single industries or international markets can also be applied to the field of e-mobility, which is, due to its ecosystem nature, characterized by dynamic and interdependent structures.

An analysis and comparison of process models for NSD has led to the conclusion that they typically consist of a stage gate process (see fig. 1) that prescribes phases and activities without distinguishing between different types of services; however, it could be shown based on a service typology that different service types require different development strategies in practice [22].

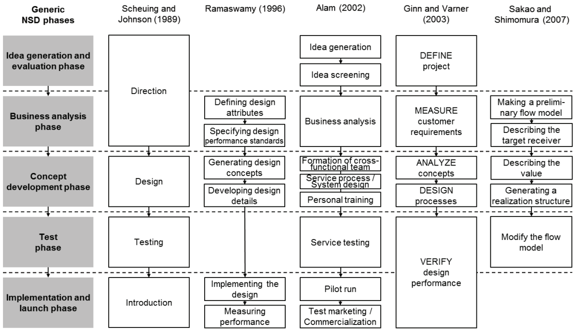

Fig. 1. Comparison of selected process models for new service development [22]

Also former studies indicate that NSD success depends on service types and that one service type cannot be treated the same way as other service types [23,24]. Furthermore, services and (physical) products are fundamentally different in nature – with respect not only to the objects of development but also to the structuring of innovation processes [25]. This makes it essential also to consider the differences in culture and habits between manufacturers, software companies and service providers, or even between different departments. As a conclusion, it can be summarized that the abovementioned characteristics of ideal NSD approaches, formalization and flexibility do not seem to be sufficiently covered by existing NSD models.

3. Agile reference model for developing e-mobility service systems

3.1. General considerations regarding the reference model

As stated above, the field of e-mobility exhibits a variety of service systems. The question is how to suitably support the successful development of these service systems. On the one hand, to serve the NSD research community and generate a reference model, it must be widely usable. On the other hand, the characteristics of the field of application, i.e. "e-mobility", must be taken into account to show that the reference model is applicable and thus useful.

3.2. Characteristics of e-mobility services and development specificities

The field of e-mobility services is broad and heterogeneous. By means of an exploratory survey, conducted from September to November 2016 among e-mobility providers in Germany, covering 98 usable questionnaires, a list of previously identified service fields could be sorted by their occurrence (see fig. 2).

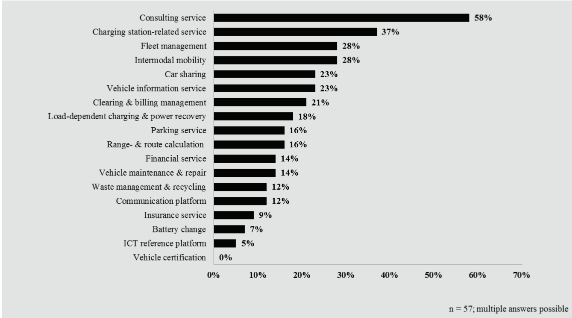

Fig. 2. E-mobility services and their distribution across German providers

At least ten service fields in this list have the character of a service system, e.g. services related to charging stations, fleet management, or intermodal mobility, to name a few from the top of the ranking. A cluster analysis (Ward's method) based on three key indicators, namely the development of profit, number of employees, and turnover, made it possible to separate a group of more successful companies participating in the survey from a group of less successful companies. Statistically significant differences between these two groups could be identified as regards the provision and development process of their e-mobility service: the more successful companies (1) prefer to cooperate with companies from other industries, and (2) prefer to involve customers in as many development phases as possible (see table 1).

Table 1. NSD in successful and less successful companies.

	SC	LC	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.
Clearly defined process steps	3.64	3.25	-.925	41	.360	-.386	.418
Clearly defined methods and tools	3.18	2.81	-.784	40	.438	-.375	.479
Internal standards and rules	3.64	3.56	-.177	41	.860	-.074	.417
Clear roles and responsibilities	2.91	3.28	.933	41	.356	.372	.399
Customer integration	3.70	2.73	-2.073	38	.045	-.967	.395
Efficient information flows	3.45	3.26	-.497	40	.622	-.196	.466
Cooperation with companies from other industries	4.20	2.93	-2.1893	38	.035	-1.267	.579

Notes: Comparison of means between successful companies (SC) and less successful companies (LC), means based on a scale from 1 (do not agree) to 5 (do agree).

An integration of customers into new service development as well as collaboration with companies from other industries can thus be interpreted as most significant success factors for companies that are active in the field of e-mobility. Interestingly, relevant aspects of formalization such as clearly defined process steps, methods and tools as well as internal standards and rules could not be identified as distinctive features, although they tend to be more common with successful companies (but not significant).

Four case studies in Europe – in Finland, Estonia, Denmark and Norway – meant it was possible to extract and discuss additional success factors concerning NSD in the field of e-mobility that also suit an agile approach well. In particular, living labs and pilot projects promoted stronger customer involvement, as did feedback systems, data loggers, and visualization techniques (e.g. heat maps). Playful methods and training, marketing and educational concepts were found to be effective ways to enable and motivate the development team and customers to participate [26].

3.3. Agile development approaches

Since the promotion of "Extreme Programming" (XP) in the late '90s of the 20th century [27] and the emergence of the "Manifesto for Agile Software Development" in 2001 [28], agile development practices have increasingly been drawing attention from disciplines other than software development.

Scrum is the most popular and most widely used agile methodology, promoting agile project management and challenging traditional management culture [29]. Thus, this article uses it as the reference agile approach. The Scrum development process is an enhancement of the iterative and incremental approach and is based on the assumption that initially planned variables relevant for a (software) development project are prone to change during the project. These variables are: customer requirements (how the current system needs enhancing), time pressure (what time frame is required to gain a competitive advantage), competition (what is the competition up to and what is required to best them), quality (what is the required quality, given the above variables), vision (what changes are required at this stage to realize the system vision), and resources (what staff and funding are available). The main difference between the more conventional waterfall (stage gate), spiral or iterative methodology and Scrum is that the Scrum approach assumes that the analysis, design and development processes in the Sprint phase (where the actual production happens) are unpredictable ("black box"), but a control mechanism is used to manage the unpredictability and control the risk [30].

3.4. Agile NSD

As mentioned above, there is obviously no evidence of any NSD approach dedicated to the need for more flexibility and dedicated to the characteristics of different types of services or service systems. Generally, research efforts and publications in NSD-related literature that consider agile approaches seem to be scarce to non-existent. Nevertheless, there are similar research streams that need to be considered, including service prototyping and lean service development. The service design discipline, design thinking and the business-model innovation domain offer many methods and tools that provide practical support for prototyping and visualization [31], as well as customer co-design and collaborative development in a multidisciplinary context.

One approach combining business model innovation with lean business development and service-dominant logic is based on an iterative and cyclical process, with each loop aimed at leading to a more developed level. The principle of continuous improvement from an initial idea to the final service is accompanied by deep customer understanding and co-design, testing and experimenting with users and other stakeholders, and by a rapid testing and learning loop [32].

Not surprisingly, approaches explicitly claiming to be "agile" come from the realm of computer science, thus rather focusing on the ICT-related service landscape [33]. Still, a dedicated NSD model that implements agile principles in a comprehensive and self-contained way, including process models and service-specific roles, does not exist. Most existing approaches are limited to a discipline other than NSD (e.g. business model development) or one that is part of NSD, or they focus on specific service types or industries (e.g. ICT-based services).

Although there is evidence that NSD can benefit from agile principles, the question of adaptability remains: agile approaches have their origin in software development, and thus their applicability to other disciplines such as NSD has to be questioned critically – especially when it comes to more "traditional industries" [34]. Here, there is obviously a need for more research related to different aspects such as structure or culture.

3.5. Conceptual considerations for an agile NSD reference model

In light of the previous statements, a suitable approach to organizing service-systems development must reflect a two-fold view: (1) an engineering model supporting the development process in an appropriate way, including artifacts such as methods, techniques and tools; (2) a project management model supporting the proper application of the engineering model, including artifacts such as roles, responsibilities, rules and communication standards. These two perspectives can be complemented by a third one that serves as a link between (1) and (2): (3) an information model supporting both the visualization of information flows and their efficient controlling and timing. The figures 3, 4, and 5 show a first conceptualization of the reference model, based on theoretical considerations. The current status will be further developed in the next step after collecting company requirements.

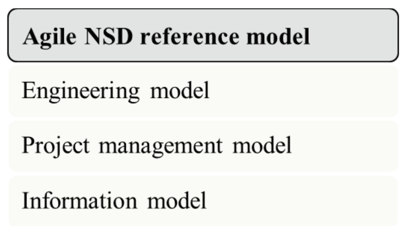

Fig. 3. First overall concept of an agile NSD reference model

The proposed engineering model is like the Scrum framework presented in [30] a combination of formal development-process components and a "black box" where the actual creation of the service system happens (see fig. 4). The phase "planning of the service system" includes the definition of modules, i.e. components of physical products, software or services which are self-contained functional entities, but have to be considered as interdependent within the service system. The "black box" is characterized by design and test iterations, performed in sprints and producing module and service system prototypes that are created and refined incrementally. Risk management and progress control for development activities in the "black box" are defined in the project management model.

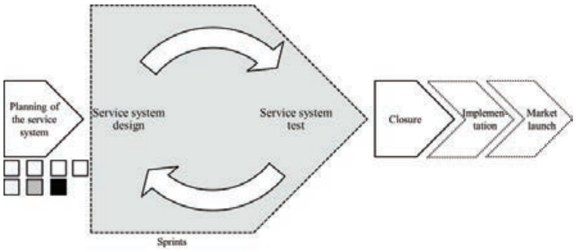

Fig. 4. First concept of the engineering model

Information- and communication flows are an integral part of development projects and are emphasized in agile practices such as Scrum. While bringing together the concept of development processes (engineering model) and project management, information entities and flows could be identified as common elements: both between development entities like activities or results, and project management entities like roles or documents, an exchange of information and transformational processes due to information happen. Here, still more research work has to be done, in order to clearly distinguish between information types, carriers, flows, effects etc. that are relevant for NSD. Figure 5 roughly shows the idea of information flows in development processes between modules and single development activities. The next step will be to elaborate a full information model for agile NSD.

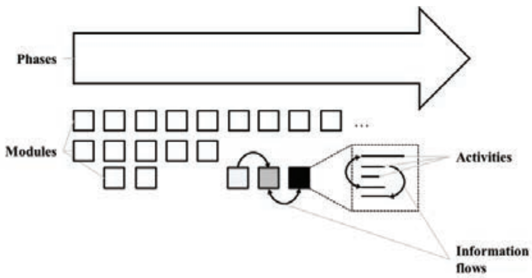

Fig. 5. First concept of the information model

4. Discussion and conclusions

The literature review showed that agile development has not been transferred and adapted to NSD yet, although there are advantages with regard to the requirements of service-system development in dynamic contexts such as e-mobility. Agile approaches like Scrum, which address both the development processes and the accompanying project management, are likely to offer a useful framework that lies between formalization and flexibility. Generally, agile approaches are geared to multidisciplinary collaboration and customer involvement because they are people-oriented, leaving the "black box" to trust in the development team's ability to self-organize. However, existing agile approaches do not further specify cross-company collaboration, i.e. more complex eco-system settings. Furthermore, they have not yet incorporated the service-specific knowledge and features that can be found in several decades of NSD research.

The description of the field of e-mobility and its characterization as a dynamic field of application for service-system research and development serves as fundamentals for further professionalization of e-mobility from the point of view of NSD. Furthermore, the field is a contemporary revitalizer for change and the adaptation of existing NSD models to reflect new requirements.

The conceptual considerations for an agile NSD reference model aim to combine the structured and detailed nature of engineering approaches without over-formalizing the NSD process.

5. Limitations and contributions

Currently, the presented approach is rather generic. In order to further elaborate the concept, more specific requirements particularly with regard to agile project management and information flows have to be collected. Moreover, the agile NSD reference model has to be implemented prototypically in different e-mobility companies to test and optimize it.

As stated above, the request for an agile NSD approach could be found in combining survey results in the field of e-mobility, which exhibits a large proportion of (complex) service systems, with the limitations of existing NSD models in literature. Although the findings were gained through research in the field of e-mobility, the results might be applicable to other areas as well. The developed reference model should be tested not only in this application area; to strengthen the conclusions and the explanatory power of the approach, more research and validation activities have to be done in other industries.

The presented agile NSD approach is an innovative first step to enhance more traditional models so that they can be adapted in more complex service system fields. It is aimed at supporting dynamic collaboration environments such as (electric) mobility, but can be adapted to other application fields as well.

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