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A simplified service engineering approach used by an industrial service solutions provider

Jörgen Sandin*, Christian Berggren

Department of Management and Engineering, Linköping University, SE-581 83, Linköping, Sweden

* Corresponding author. Tel.: +46-13-282539; fax: +46-13-149403. E-mail address: jorgen.sandin@liu.se

Abstract

This paper shows how a provider of complex hardware with long operation times makes use of a structured methods approach to develop maintenance, repair and overhaul services and improve its service solutions. Service engineering is a methodical approach for the design of service offerings, and can be described by using the dimensions outcome, structure, process and management. So far, little is known about how firms implement such approaches. On the basis of a longitudinal case study within a large, product-based, high-technology business corporation, the paper shows that the use of a simplified service engineering model may be effective in supporting both the development and the maintenance of a comprehensive service business. More specifically, the case suggests the following factors to be important for success: A systematically applied engineering method, the presence of dedicated service champions, an ability to articulate and formalize new service roles, and deep technical knowledge of the involved hardware.

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Keywords: Service engineering; industrial service solutions; work breakdown structure; long product life-cycles; longitudinal case study; aircraft industry

1. Introduction

Research on product and business development tends to focus on the early phases of the life-cycle, i.e. product design and market launch. However, also the later operational phases of a product’s life-cycle are important, and particularly in capital goods industries aftermarket services involve a huge potential for many firms, since the installed product base often exceeds the annual flow of new products by 10 to 100 times [1]. Moreover, if the installed base is large, and technical complexity and/or regulatory requirements imply a need for frequent services, the maintenance, repair and overhaul business (MRO) may become very significant for the product provider.

Few empirical studies have analyzed the development process regarding services in this type of product-based firms [2,3]. Thus there is a need to identify where and how firms generate, evaluate, and realize various service offerings, and relate them to the need to balance efficiency and customized processes with customization and flexibility [3]. There is also a need for research regarding how to structure services, by means of e.g. service engineering [4], and how to integrate specific services in product-service system solutions late in product life-cycles.

The aviation industry constitutes a fertile field to study these issues. A few decades ago, all major airlines had their own in-house MRO operations, but after the deregulations in the 1970s, new independent suppliers have gradually emerged to offer lower cost services. Established airlines have responded either by outsourcing MRO, or by offering their services also to other airlines. In this highly competitive environment, product providers, i.e. aircraft manufacturing companies have started to offer product-service system solutions which mean that they integrate forward and take over activities previously conducted by their customers [5]. By optimizing hardware and services, such solutions may reduce 30-40% of the total product life-cycle cost for a customer, according to some estimates [3].
In this paper we will concentrate on services to products late in their lifecycle, i.e. services to already existing fleets. Hence, providing solutions imply a focus on services to products designed many years ago instead of a joint optimization. Therefore we use the term service solutions to denote such service packages.

This paper studies the development and delivery of aircraft services, mainly MRO, as an example of industrial service solutions in a capital goods industry with long product lifecycles. This context implies that the hardware is fixed and that operations are strictly regulated for safety reasons. Many providers aspire to expand their offerings. A key question in the paper is to understand how an aircraft maker may build on its engineering capabilities to develop a comprehensive approach to service solutions in this context.

Service Engineering (SE) is a technical-methodical approach to structure complex service offerings. So far, little is known about how firms implement these approaches. This paper aims to fill some of this gap by studying how an aircraft maker, an instructive example of firms providing complex hardware with long operation times, makes use of such an approach to develop maintenance, repair and overhaul services and improve its service solutions. This is specified in three research questions:

RQ1: What parts of the suggested SE approaches are particularly useful for a product-based service provider when developing a service solution for products late in their lifecycle?

RQ2: How is the SE approach used to structure and formalize the new service business?

RQ3: Is SE used as a one-off event, or can it be used also for continuous improvement of the results?

2. Theoretical framework

A strong trend among product providers is to grow beyond their core product business by developing ancillary service offerings [6]. By doing so providers may exploit untapped markets, become strategic partners to their customers, and even out the cyclicality of revenues [1,7,8]. The benefits offered to the customer could be reduced maintenance costs and increased availability, and the ability to focus on their core operations, creating more value for their own customers [7].

2.1. Generating service solutions

A strategy to move towards service solutions affects several parts of a company. The strategy needs to be linked to structure, processes, business models and competence development [9]. They also have to increase their knowledge of customer operations and change their business models. Compared with conventional cost plus services, the provider now has to generate revenues by delivering services more efficiently than customers are doing themselves. To achieve this, the service solutions provider’s processes need to be structured, repeatable and team based rather than based on ad hoc responses from single individuals.

During development of service solutions several functions within the provider need to be involved. Also customers and users are often involved throughout the entire process. Hence, the work needs to be both inter-functional and inter-organizational. It is common that lead users are involved to a particularly high degree, which tends to result in highly customized service offerings [10].

The implementation and delivery of services differ substantially from the delivery of physical products. Services are created in connection with the customer, an infrastructure needs to be in place, the operation is people intensive and customer satisfaction is strongly related to relational quality [10]. This implies that a profound understanding of the customer process is crucial for success. At the same time it is important to develop processes which are easy to standardize and implement at several sites in order to increase transparency and reduce costs. This calls for some structured design approach. In this paper we will focus on one such engineering-based approach for the development, implementation and the delivery of services. Before we present the empirical findings, we will describe this approach, service engineering, in more detail.

2.2. Engineering service solutions

Development of services is generally treated as market-oriented and customer-driven subject. Service Engineering on the other side is a technical-methodical approach that aims at structuring service development and operations [4,11,12]. SE has been a research area since the early 2000s [12] and aims at intensifying, improving, and automating the creation, delivery, and consumptions of services [11]. The SE structure contains models, methods, and tools but may also include general R&D management practices [4].

Bullinger et al. [4] describe service development by using the dimensions outcome, structure and process. The first dimension outcome concerns the service product, i.e. what the service produces. This can be modeled in different ways to analyze the impact on the customer: as a product model, a view model, an intentional service model, and a scenario model. The product model specifies the outcome on the customer [4]. The view model is a tool to help designers to customize value by changing realization structures [11,13]. The model expresses mutual relationships among parameters connected to functions [11]. The scenario model is used to understand a customer’s needs and their behaviors in receiving the service [11]. The intentional service model describes a service from an intentional perspective, rather than from the functionally it performs [14]. This model accentuates the intention to be achieved but does not describe the method to achieve it. The intentions are broken down to the lowest possible level, and are then implemented in software. Major aspects to consider in the analysis of outcomes include customization and configuration of service structures and modules.

The second dimension, resources (structure according to Bullinger et al. [4]), is connected to human, material as well as immaterial resources in a resource model [4]. Sakao and Shimomura [11] describe a flow model to facilitate for designers to consider which resources - organizations and agents - to allocate to a particular service [11].

The third dimension process can be described in model of all the activities, from the initial provider to the final receiver [4]. The objectives are to establish transparency from the concept phase, ensure efficiency and remove unnecessary
In this analysis, the receiver state parameters play a great role. They are classified into value or cost depending on how customers appreciate them. "In SE, value is defined as a change of a receiver’s state that he/she prefers, so that function is just a realization method to provide the value in SE" [11] (p 592). In a further step, Sakao and Shimomura [11] and Sakao et al. [15] have implemented the models in a software tool, the Service Explorer.

Bullinger et al. [4] also discuss management although it is not labeled a dimension. Organizational design and human resource management in service development is discussed in general terms, concerning roles, for example.

Figure 1 summarizes the dimensions discussed above, and the connected service models.

4. Findings

4.1. Developing the new service solution offering

The studied provider’s development of the new service concept coincided with negotiations concerning a new service business with an existing military customer. Hence, the development of a generic service solution concept and the ‘pre-sales’ activities of the specific military service solution were executed more or less in parallel. The new concept and its business model were partially based on a similar concept which had been successfully implemented for two customers with civilian aircrafts in another part of the corporation. This application was reused in the new extensive business, and the actual development became a process of elaborating and structuring the previously used concept.

In the parallel pre-sales activities with the military customer, the provider mapped the flow of aircrafts, sub-parts, spares, technicians and more. However, in the beginning the customer and the provider had vastly different opinions regarding the real cost of the preferred availability level.

In the parallel development of a more generic service concept, the provider relied on a structured approach, embodied in a six armed Work Breakdown Structure (WBS). This WBS was developed for the new generic service business, but was to a large extent based on the former two business cases. The interviewed service champions all emphasized that this WBS had a great importance throughout all the phases from the development to the operation of the service solutions. This generic structure could be applied to a specific business by activating or inactivating various cells in

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Figure 1: Overview of the theoretical framework with its four dimensions in SE and service models connected.

It could be being argued that ‘structure’ is an important part of SE. Bullinger et al. [4] describe a structure dimension as follows: “the structure determines the ability and willingness to deliver the service in question” (p 277). In this paper we will focus on service structure as supporting or enabling the processes, resources, outcome and management. This means that structure is closely related to SE and important for its impact. Important structural aspects concern configuration [16,17], modularization [3] and customization [18]. Modularization is related to the challenge to design a service system for reproducibility and sufficient flexibility to be adaptable to differences in regulations, legal systems and customer needs [19].
the WBS, where each cell is connected to descriptions of work, organization, and cost calculations.

The application of this structured concept relies on access to detailed data for each type of operation. As mentioned above this constituted a great challenge in the business negotiations, where access to the relevant data from the customer, analysis of this data and the reaching of an agreement with the customer on how to interpret data turned out to be complicated issues. The required data included detailed cost data on maintenance, repair, and overhaul as well as data for the follow-up of regulations and certificates.

When finally all information was available, the WBS could describe each specific cell to a relevant chapter in the program plan, and the responsible person/unit would add information regarding roles, costs, quality, etc. The service solutions structure was also complemented with a simulation tool to create and test different business scenarios.

4.3 Continuous improvements

During the development and the implementation phases the ways of working were described to a level of ‘good enough’. Later on, in the delivery phase, the ways of working and their descriptions were further improved, and this process has continued when the provider has expanded its service business to new customers. The evaluation and continuous improvement of the service operations focus on three parameters: availability, costs and maintenance of the certificates. Some processes are judged as generic and are described as such in the operations management system. According to the interviewees, however, a complete service solution could and should not be described as a generic process. Each service solution is customized, and to support a specific configuration the provider relies on the service WBS.

When revisiting the case approximately five years after the WBS was first used in the military service solution described above, a visualized version of the WBS had become available. The new version was used as marketing material and contained links to detailed information behind each main part. According to the interviewees the basic design of the WBS had not changed since its inception. Hence, the original WBS structure was used as a basis in all the providers’ service solution deals, (seven, at that time of study). During this five years the provider had also developed its way of combining and reusing modules. Civilian and military activities are related to different set of regulations and are described in specific handbooks. So are also aircrafts versus helicopters. After securing the fifth service solution, the provider had experiences from all the possible combinations. Hence, the sixth and the seventh solutions could be seen as more or less reusing experiences than was the case during the previous service solutions.

The implementation of the enterprise resource planning system had faced several problems, but after almost five years, most of the problems seemed to be solved, even if some interviewees still complained about the system. Now, with seven service solutions in operation, the challenges tended to be oriented to organizational structure and process. Further, some interviewees mentioned the need for improved ‘immediate fleet management data’ to provide the customers and also internal resources with real-time information regarding each individual aircraft on the different product platforms.

5. Discussion: The value of a simplified approach

The theoretical framework contained a presentation of Service Engineering as a fine-grained model, based on three plus one dimensions, with a number of specific models related to each dimension. The empirical study has shown the operation of a simplified version of such a SE approach, where each of the dimensions are clearly relevant, but several of the specific sub-models are not. Thus the study shows the value of this type of approach for the development, implementation and delivering of service solutions targeting capital goods in late operational phases.

5.1 Simplifying the SE-dimensions for the development of industrial service solutions

The first dimension in the SE framework, outcome [4], refers to intentions, realization and customization. In the studied case, a major simplifying device was the development of a consistent WBS-structure, which was used for configuration of the service modules offered to the customer. This has some similarities with both the product model and the intentional service model where service is captured at the business level. The WBS highlights the services intention to be achieved but does not describe the method to achieve it. In the studied case the service champions activate or in-activate different cells in the WBS. This way of working corresponds, in a simplified way, to the theoretical view model which supports customization by changing realization structures to
create value for the customer. The studied outcome could be summarized as the content of the service solution structured via a WBS, see Figure 2. The scenario model suggested in the literature should be used to understand customer’s needs and wants. In the studied case, availability was in focus. The term impact generalizes this aspect of the outcome dimension, and covers other possible aspects, for example improved customer operations. In the studied case, the impact on operations and on provider was elaborated through mapping and simulating the flow of aircrafts, sub-parts, spares, technicians and more. The results were visualized both in flow paths and in text and numbers. This leads to another outcome aspect: predictability and trustworthiness. In the studied case, negotiations with the first, lead customer, involved a lot of time spent on discussing the realism with the customer, where the tools used were not sufficient to convince the customer. This elucidates that trustworthiness for the customer is crucial for a service solution provider.

The second dimension resources, involves according to the literature participating organizations and other needed resources. On an overarching level, resources can be described in a flow model, which specifies the organizations planned to participate in the service delivery. On a more detailed level, they can be described in a resource model where humans, material and immaterial resources are specified. In the studied case, the program manager requires the responsible actor for each individual work package in the WBS to describe what resources s/he will use. This is compiled in the program plan. Hence, the program plan can be perceived as a concretization of the resource model. Further, the studied case also elucidates the importance of clarifying certificate holders, which can be seen as an immaterial resource. In addition, historical data regarding operations and fleet management were crucial. Hence, the resources used can be divided into human, physical and immaterial resources structured via organizational arrangements, the program plan and to some extent also the WBS.

Concerning the third dimension process [4], change of state, interfaces and efficiency are in focus. Here the span of providers and receivers are specified with the purpose to make the service effective, establish transparency and remove unnecessary interfaces. In the studied case, the process was characterized by a duality of developing a generic simplified approach and developing a specific solution for a lead customer. When the new business was first developed, the WBS was customized through selecting work packages and adding specific information. This information was compiled into a program plan connected to the cells in the structure, and also included predicted customer operational plans, maintenance plans, roles, human resources, financial calculations, relevant handbooks and processes. Hence, the use of a program plan aggregated important information and was a way to achieve transparency. Further, an enterprise resource planning system was supposed to support the flow of material, but many problems occurred. The process dimension in the studied case can be viewed as selection and activation of options based on a common platform with a focus on seamless operations and efficiency.

The theoretical framework only provides some minor information regarding the fourth dimension management of SE, but the case is quite rich on such information. The Business Model (BM) and infrastructure are naturally important parts of this, as is the simulation tool, developed to complement the WBS. In the case, some parts of the program plan also described how the service solution will be managed. The overall level of efficiency and seamlessness in operations relies much on the responsible program manager, and his/her way to steer and control operations. To be cost efficient the provider focused on optimizing the system and individual aircrafts’ life-cycles. Each aircraft has its own plan for maintenance and similar activities. This is in line with Shimomura et al. [12] who emphasize the importance of complementing human processes with physical processes. Describing the flow of material are quite straightforward and the actual provider had detailed knowledge regarding the value chain and various processes. The challenge was to access and agree on detailed data regarding operation, MRO, and follow-up on regulations and certificates, rather than modeling it.

A challenge in the aviation industry, which is not discussed in the theoretical framework, is the importance of updating procedures according to changing government regulations, and to acquire relevant certificates for maintenance, systems, aviation, etc. The studied case might be rather extreme regarding the importance of such regulations and certificates, but similar issues are likely to be found by other service solution providers. In the studied case, the operations management system describes the relevant activities and responsibilities, for example by using process descriptions. The interviewed service champions differentiate between handbooks and process descriptions. Handbooks are judged as important tools for guidance and control, whereas formal process descriptions are experienced by many as something to obligate, but not really supporting the daily operations. Summarized, it can be concluded that management covers a broad spectrum from legal requirements, to availability, costs and optimization. The structure to support this might contain modules, operations management system and infrastructure.

5.2. Improved engineering and way of working

When revisiting the case five years after the original development phase, the provider had developed its way of
combining modules of regulations and knowledge, for example linking aircrafts with operations supporting military platforms. The most important tool, throughout all the phases, was still the generic work breakdown structure (WBS) and the way of working developed in connection to this. The tool had been further developed, but the basis was still the same. By this tool, a foundation for automating was available.

For the existing service solutions much focuses was on evaluating and improving the operations. This was mainly executed though controlling three parameters; availability, costs and the maintenance of certificates.

The enterprise resource planning system had finally been implemented, but could still not fulfill the role it was aimed to play, and even after five years, the interviewees experienced little support from this system. At the same time, new needs originally fitted to hardware development now refined, partly based on previous service solutions, and used as a foundation for developing the new offerings as a system of modules. The studied case shows that the use of a simplified service engineering model supports the development, implementation and maintenance of a comprehensive service business for long-lived complex products. More specifically, the case indicates the importance of the following key factors: A systematic engineering method, a systematic way of controlling human and physical processes, an ability to articulation of new roles, dedicated service champions, and deep technical knowledge of involved hardware.

We have built on and further explored previous research regarding service engineering, as for example Bullinger et al. [4]. This has been summarized with the four dimensions outcome, resources, process and management. In addition we have exemplified the structure aspect with a generic engineering management tool; a work breakdown structure originally fitted to hardware development now refined, partly based on previous service solutions, and used as a foundation for developing the new offerings as a system of modules. This structure also included program and maintenance plans, certificates, OMS and handbooks, modules, BM and a simulation tool, organizational arrangements and infrastructure. The case shows that such a structured method can be a very important means for a firm’s transition to a provider of comprehensive service solutions. The study further indicates that the approach suggested by Shimomura et al. [12] where human processes are complemented with detailed physical processes might also be useful. The structuring of materials flow via e.g. an enterprise resource planning system seems both important and difficult, but not infeasible. Another important factor in developing the new service solutions consisted of role articulation. This process of formalization related safety responsibilities and formal permissions has a special importance in the studied industry, but has not been articulated in previous studies.

In driving the entire process, a set of dedicated service champions played a great role during the entire process, from development to the implementation and operation of the new service solution. In addition, it may be argued that the provider’s intimate knowledge of the involved hardware was a basic condition for its development of reliable and trustworthy service solutions.

Comparative studies evaluating the importance of these elements: a deep technical knowledge of involved hardware, a systematic development of an engineering methodology, the successful formalization of new service-related roles, and the impact of designated “champions” in different industrial contexts, would be a valuable contribution.

6. Conclusions

The studied case shows that the use of a simplified service engineering model supports the development, implementation and maintenance of a comprehensive service business for long-lived complex products. More specifically, the case indicates the importance of the following key factors: A systematic engineering method, a systematic way of controlling human and physical processes, an ability to articulation of new roles, dedicated service champions, and deep technical knowledge of involved hardware.

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