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Information Systems in the Industrial Service Business: Analyzing Unaddressed Requirements in a Multiple Case Study

Alexander A. Neff
University of St.Gallen, alexander.neff@unisg.ch

Florian Hamel
University of St.Gallen, florian.hamel@unisg.ch

Falk Uebernickel
University of St.Gallen, falk.uebernickel@unisg.ch

Walter Brenner
University of St.Gallen, walter.brenner@unisg.ch

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falk.uebernickel@unisg.ch

Walter Brenner
University of St.Gallen
walter.brenner@unisg.ch

Abstract
The manufacturing industry is subject to structural economic change reflected in the constantly rising fraction of industrial services. Being confronted with the strategic challenge to reduce operating costs while at the same time meeting ever-increasing industrial service demands, manufacturing firms struggle to find the appropriate information technology (IT) solution for planning and execution. Despite the existence of a parsimonious set of standardization efforts addressing product-related services, manufacturing firms have not reached a common understanding of the product-service system and the corresponding business processes and IT systems. This paper addresses this need by exploring key requirements for information systems (IS) support of product-service systems based on a multiple case study approach. For a critical reflection we confronted those requirements with scientific and managerial frameworks which are derived from a structured literature review. We contribute to the theoretical body of knowledge by outlining six highly relevant requirements for the under-researched field of back stage service systems. Based on the explored requirements, managerial practitioners are able to draw a preliminary roadmap that prioritizes their investments according to firm specific needs.

Keywords
Service Science, Information Systems, Product-Service Systems, Manufacturing Industry, Multiple-Case Study.

1. Introduction
The manufacturing industry is subject to structural economic change (Vargo & Lusch, 2004; Wölfl, 2005). The fraction of industrial services is constantly rising (Stille, 2003), resulting in a need to support product-service systems with the appropriate IT solution. Being confronted with the strategic challenge to reduce operating costs while at the same time meeting ever-increasing manufacturing-related service demands, manufacturing firms struggle to find the

appropriate IT solution for planning and execution (Dietrich, 2006). For the service component expensive proprietary systems and highly customized standard solutions must be maintained (Thomas, Walter, Loos, Nüttgens, & Schlicker, 2007) while legacy systems need to be replaced. In particular, firms encounter problems in supporting managerial accounting and the maintenance function of product-service systems (Dietrich, 2006; Thomas et al., 2007). Beyond these strategic challenges, one of the major difficulties lies in the detail and accuracy of status information in the service execution process needed on different firm levels.

Traditionally, service research has focused on the front stage of service delivery, studying phenomena such as provider–client relationships, co-creation of value, service quality, service encounters, and service experiences (Glushko & Tabas, 2009). In contrast, a lack of studies investigating the back stage of service systems can be observed (Becker, Beverungen, Knackstedt, Matzner, & Müller, 2011; Glushko & Tabas, 2009). In order to cope with the wide array of business to IT and technology-related challenges, a comprehensive view on design and transformation is essential. A concept that is able to provide an integrated vertical view is the business engineering framework with its dimensions structure, process and system (Österle 2010). Our objective is to explore unaddressed requirements of product-service systems and the corresponding IT implementations. Hence we address the following research questions (RQ):

RQ1: what are the unaddressed requirements for the IS support of product-service systems?

RQ2: how are these requirements covered in existing theoretical and managerial frameworks?

The remainder of this paper is divided into four parts. The first part lays the foundation with regard to central terms and the research gap applied in this paper. The second part describes the selected research approach. The third part answers RQ1 by exploring unaddressed requirements based on a multiple case study approach and analyzes the coverage of these requirements in existing theoretical and managerial frameworks (RQ2). Finally, we conclude with the major contribution of this paper, supplemented with a critical reflection and an outlook on future research endeavors.

2. Theoretical foundation

Over the last 30 years academics as well as practitioners have begun to investigate services as a distinct phenomenon with its own body of knowledge and rules of practice (Spohrer & Kwan, 2009). Their approaches are revitalized under the emergent discipline of service science, management, and engineering (SSME). Requirements for planning, operating and disposing of customer solutions are discussed in several academic disciplines such as SSME, IS, marketing and operations management (Bardhan, Demirkan, Kannan, Kauffman, & Sougstad, 2010; Rai & Sambamurthy, 2006). Recently, the notion of the "service system" has been put forward as the basic abstraction of service science (Maglio, Vargo, Caswell, & Spohrer, 2009). In view of the broad conception of a service system, extant literature in operations management tends to combine products and industrial services in terms of bundles (Oliva & Kallenberg, 2003), solutions (Davies, Brady, & Hobday, 2006; Tuli, Kohli, & Bharadwaj, 2007) and systems. We apply the definition of product-service systems, since it achieves most hits in a literature search (among the three terms: *bundles*, *solutions* and *systems*) and fits best with the manufacturing focus by adding the life cycle aspect. The definition refers to the "customer life cycle oriented combinations of products and services, realized in an extended value creation network" (Aurich, Fuchs, & Wagenknecht, 2006).

Current research in SSME tends to focus on customer value, such as value creation in service economies, service marketing issues or value co-creation with customers (Clarke & Nilsson, 2008). However, little insight into business processes (Glushko & Tabas, 2009) and enterprise systems that are required to integrate manufacturing and service processes in service systems has yet been provided. Although exchanging information is accepted as one of the key challenges in SSME (Chesbrough & Spohrer, 2006), the literature substantially lacks in outlining how IT artifacts have to be designed to make the appropriate information accessible (Becker et al., 2011). In this light, there is an obvious need for an integrated solution with selected information exchange. We focus on the requirements of product-service systems and the corresponding IS/IT implementations.

3. Research methodology

In order to identify unaddressed requirements (RQ1) as well as to elaborate their coverage in existing theoretical and managerial frameworks (RQ2), we select a qualitative research design based on a multiple case study approach (Eisenhardt, 1989). Since qualitative research is often criticized for lagging in transparency and literature scholars seldom expose their research process, we follow a structured and stringent process (cf. Figure 1) to guide our research endeavor. In this light our approach starts with the *problem identification* (step 1). We specified the research problem, provided practical relevance, and derived appropriate research questions. The second step, *derivation of theoretical foundation* (2), builds on the first step and explains the research paradigm, provides definitions and helps in the identification of the research gap. As part of this step, we conducted a structured literature review in accordance with vom Brocke et al. (2009). We analyzed the existing literature that seemed promising for addressing the discussed requirements. We present below (Table 1) the results of the *keyword search* in which, using relevant keywords from literature reviews (Bardhan et al., 2010; Berkovich, Leimeister, & Krcmar, 2011; Spohrer & Kwan, 2009), we performed searches of certain databases (EBSCOhost, ProQuest [ABI/INFORM], Emerald, ScienceDirect, Web of Science, and AISeL). We limited our search to title, abstract, and keywords, and it resulted in 14 matches for in-depth analysis. Then we continued the literature search with a *forward/backward search* that yielded 13 articles; hence 27 articles in total were derived for analysis. During the third step, *determination of research approach* (3), we defined the research approach as outlined in this section.

Since the boundaries between service and manufacturing processes are not clearly evident, case study research is well suited to guide our research (Yin, 2009). For the fourth step, *derivation of the requirements* (4), we conducted seven exploratory case studies at global leading manufacturing firms from April 2012 until May 2012. Based in the high-wage countries of Germany and Switzerland, the manufacturing firms heavily rely on innovation and customer service for achieving efficiency synergies.

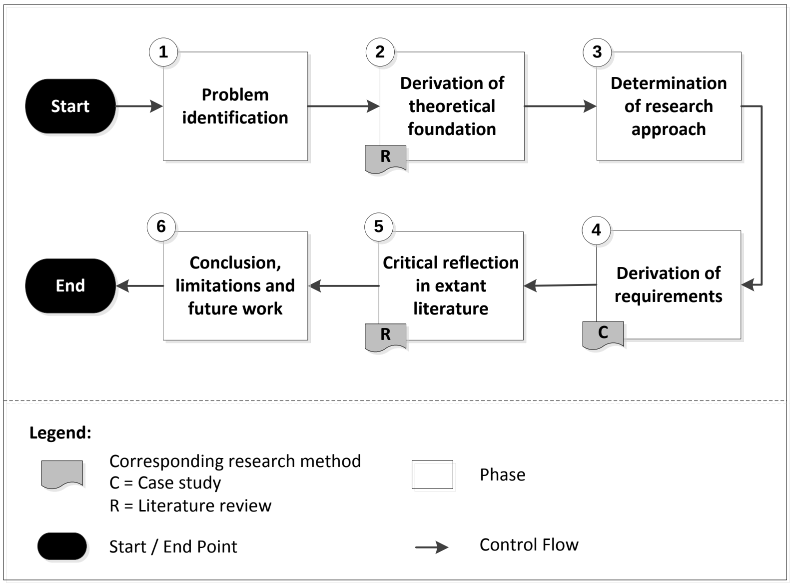

Figure 1: Research approach

Semi-structured interviews were our primary method of data collection. Eisenhardt (1989) emphasizes the benefits of the multiple case study approach in terms of enhanced validity. We employed a "specified population" to strengthen the external validity, while the following comparison to extant literature satisfies the internal validity needs (Eisenhardt, 1989). A high-level interview guideline is provided in the appendix. The interviews took an average of 2.25 hours and were conducted by two researchers in person. After writing down the interview transcripts, we complemented interview-based data collection by further analyzing corporate documents. For reliability purposes, the final results were documented and triangulated in a case study report which consecutively was approved by the industry partner (Yin, 2009). Based on this reviewed documentation we used the qualitative content analysis of Mayring (2008) to identify unaddressed requirements, since it is a well-suited method for analyzing similarity in the coding process, e.g. as applied by Lacity and Janson (1994). The coding was conducted by two researchers independently to reduce the bias in the qualitative data analysis. Further, we discussed the intermediate results with two IT practitioners and two senior IS scientists to outline the status-quo more precisely and summarize unaddressed requirements in a list of six most important topics. Finally, we concluded with the major contribution supplemented with a *critical reflection* (5) and an outlook on *future work* (6).

Database	AND	"Requirement" OR "concern" OR "challenge"				
		"Information technology" OR "information systems"				
		"Service science"	"Product service bundle"	"Product service system"	"Product service solution"	**Net hits***
EBSCOhost		1 (24)	0 (2)	1 (3)	0 (2)	**2**
ProQuest		1 (32)	1 (5)	1 (2)	0 (6)	**3**
Emerald		0 (5)	0 (0)	0 (5)	0 (2)	**0**
ScienceDirect		2 (41)	0 (3)	3 (16)	1 (7)	**6**
Web of Science		5 (193)	0 (0)	2 (9)	0 (0)	**7**
AISeL		0 (2)	0 (1)	2 (7)	0 (0)	**2**
Net hits*						**14**
Legend: **)Double counts are removed manually*						

Table 1: Results of the keyword search

4. Requirements derivation

The intensive interviews with experts from different manufacturing corporations outlined the fact that there is neither a common definition nor a standardized business model classification on the product-service systems available. Rather, those firms have developed their firm-specific terminology including classification approaches for business models. We conducted interviews with IT executives such as the Chief Information Officer (CIO) and managers from the service division (see Table 2).

Case company	Industry sector	Employees > 10,000	Turnover 2010 > €10 Billion	Interview partner	Number of interviews
ALPHA	Industrial	✓	✓	Process Automation Division IS Manager	2
BETA	Industrial	✓	-	Vice President Service Division	2
GAMMA	Construction	-	-	CIO	2
DELTA	Industrial	✓	-	CIO	1
EPSILON	Industrial	✓	-	Head IT Strategy & Transformation	1
ZETA	Utility	✓	✓	CIO	2
ETA	Industrial	✓	✓	Head of Corporate Solutions & Technologies	1

Table 2: Profile of case study participants

4.1 Cross-case analysis

During the interviews we were confronted with a large number of specific challenges and requirements for product-service systems. After analyzing all of the data extensively, we aggregated and consolidated the aforementioned requirements and discussed them in a focus group. This process resulted in the derivation of a list of six highly relevant requirements:

(1) Business model

The business model influences the service portfolio and hence the business processes. However, all case study participants acknowledge that keeping capital equipment goods operating at the customer site is essential to succeed in the service business. The IS manager of ALPHA stated that "the ALPHA group distinguishes three business model stereotypes: spare parts, life cycle service and full service. Each of them requires different service processes for realization."

(2) Service quality

Since the value of industrial services arises when the business customer applies it, the service quality has to be ensured along the entire value chain, including external vendors. For that reason, the following methods have been applied: roll-out global service processes, establishing audits, and certifications and performance indicators. The CIO of DELTA outlined that "we rolled out standardized service processes worldwide. Once a year, the service locations are checked in an audit program."

(3) Installed base management

Managing the installed base is salient as it presents valuable customer knowledge and creates critical insights about the machines in operation. The following elements characterize this requirement: collecting and updating historic data after repair and maintenance events, usage of condition monitoring for preventive maintenance, and optimizing the customer processes including equipment investment goods from competitors. As stated by the manager of BETA "the application of emerging technologies such as remote setup, repair, and maintenance can help to keep up the operation condition with efficient resources."

(4) Mobile solutions

There is a clear need for supporting service technicians during the customer visit. The main purpose is to provide master data, historical data, service catalogs, access to the knowledge base, and to trigger the billing and accounting processes. The manager at EPSILON reported "on a mobile solution that guides the service technicians during repair and maintenance activities. However, expensive proprietary systems serve as a technical basis for the mobile support of our service technicians."

(5) Enterprise integration

Larger production entities, smaller service entities and local subcontractors form a comprehensive service network that requires appropriate architectural solutions. The resulting complexity provides additional challenges to the IT architecture. As specified by the manager of ALPHA, "locations with production and service hubs require substantially more IS support than smaller locations with less budget. Cloud-based IS present a contemporary approach for such small entities." The manager of GAMMA refers to expensive customization projects for adapting enterprise systems to the service-specific needs.

(6) Data quality & integration

Ensuring high efficiency in the service processes requires substantial investment in corporate data quality to establish standards. Five case study participants clearly indicated that the applied IS for product and service business were separated. As a result, product and service components are covered by distinct data models. However, an efficient contract management requires an integrated view of product and service objects. The manager of BETA mentioned that "the service level is specified as long text in the product object."

4.2 Literature analysis

In order to identify appropriate frameworks for a critical reflection, we analyzed 27 articles (total result of keyword and forward/backward search), assessing whether they addressed the exploratory derived requirements (see Table 3). Amongst the results of the *forward/backward search*, we found four German Standard Specifications (from now on referred as DIN PAS). Being an accepted scale in extant IS literature, e.g. as used by Alavi (1984), each article was ranked on a five point Likert scale for every requirement according to the degree of coverage from 1 (*very low*) to 5 (*very high*). In line with Österle (2010), we structured the requirements along with the dimensions strategy, process, and system:

Strategy

[R1] Business model: the strategic debate about the appropriate business model in the "servizitation" (Neely, 2008) of the manufacturing industry receives most attention in the literature, resulting in 14 articles for analysis. After dealing with transaction-based services, manufacturing organizations shift their focus to relationship-based activities such as sophisticated maintenance and professional services (Oliva & Kallenberg, 2003; Tuli et al., 2007). Although particular publications achieve a relatively high coverage of R1, the average resides on a low to medium level.

[R2] Service quality: The need for monitoring and controlling the service quality is outlined in a few articles (eight articles). Scholarly literature understands the importance of customer involvement for delivering high-quality services (Nägele & Vossen, 2006; Spath & Demuß, 2006) and the identification of the product and service parameters in early design stages development (Geng, Chu, Xue, & Zhang, 2011). However, the performance indicators remain on a very generic level (time, quality, and costs), as outlined in DIN PAS 1091. The same applies to audit processes and certifications. Hence the requirement is only sparsely addressed in the extant literature.

Process

[R3] Installed base management: Oliva and Kallenberg (2003) consider installed base management as key capability for transforming the manufacturer's business model. Although the literature (six articles) recognizes the need to conduct activities such as collecting machine data, condition monitoring and maintenance for competing brands, the implementation remains completely unclear (Spath & Demuß, 2006; Zhang & Chu, 2010). Additionally, business processes and IT systems for preventive maintenance services based on remote access are not further specified (Paluch & Blut, 2011; Zolnowski, Schmitt, & Böhmann, 2011). Hence we conclude with a low coverage of this subject.

[R4] Mobile solution: The IS requirements specified by DIN PAS 1090 are based on a particular case study analysis and, hence, lack in validity (Thomas et al., 2007). Further, the document does not incorporate latest technological shifts such as cloud computing, refers to custom-built software for the service technicians of the construction industry and does not address billing transactions. We conclude with a partial coverage of the mobile solution requirement addressed in these three articles.

System

[R5] Enterprise integration: Seven articles consider the IT architecture that provides the necessary systems integration (Davies et al., 2006), but neglect the software and infrastructure implementation. For example, scholarly literature proposes that a service-oriented architecture presents a suitable approach to support service processes (Bardhan et al., 2010). However, the architecture for supporting smaller entities with scalable cloud-based solutions is not addressed. Hence, we conclude that there is only a low coverage of this subject.

[R6] Data quality & integration: Literature scholars clearly report the need for high-quality customer data to support industrial service processes (Becker, Beverungen, & Knackstedt, 2010), but neglect the implementation in terms of quality assurance processes and data integration approaches. For that reason, we decide to classify the coverage of this subject in literature to be low (average 1.4).

Literature source	Search type		Strategy		Process		System	
	Keyword	*Forward / backward*	*R1*	*R2*	*R3*	*R4*	*R5*	*R6*
Bardhan et al. (2010)	✓		1	1	1	1	3	1
Baxter, Roy, Doultsinou, Gao, & Kalta (2009)	✓		1	3	1	1	1	1
Becker et al. (2010)	✓		2	1	1	1	1	3
Becker et al. (2011)		✓	1	1	1	1	3	1
Biege, Lay, & Buschak (2012)	✓		3	1	1	1	1	1
Davies et al. (2006)		✓	3	1	1	1	1	1
DIN PAS 1082 (2008)		✓	3	1	1	2	2	3
DIN PAS 1090 (2009a)		✓	1	1	1	4	4	1
DIN PAS 1091 (2010)		✓	3	3	1	1	1	3
DIN PAS 1094 (2009b)		✓	4	3	3	1	1	2
Dominguez-Péry, Ageron, & Neubert (2011)	✓		3	1	1	1	1	1
Geng, Chu, & Zhang (2011)	✓		1	3	1	1	1	1
Goh & McMahon (2009)	✓		1	1	1	1	1	1
Hildenbrand, Gebauer, & Fleisch (2006)		✓	4	3	1	1	3	1
Kim, Kishore, & Sanders (2005)	✓		1	1	1	1	1	1
Kindström (2010)	✓		3	1	1	1	1	1
Nägele and Vossen (2006)		✓	4	3	1	1	1	1
Neely (2008)		✓	3	1	1	1	1	1
Oliva & Kallenberg (2003)	✓		5	1	4	1	2	1
Paluch & Blut (2011)		✓	1	1	3	1	1	1
Schrödl & Turowski (2011)	✓		3	1	1	1	4	1
Spath & Demuß (2006)		✓	4	3	3	1	1	1
Thomas et al. (2007)		✓	1	1	1	4	1	1
Väyrynen (2010)		✓	1	1	1	1	1	4
Windahl & Lakemond (2006)	✓		3	1	1	1	1	1
Zhang & Chu (2010)	✓		1	3	3	1	1	1
Zolnowski et al. (2011)	✓		3	1	3	1	1	1
Average			**2.4**	**1.6**	**1.5**	**1.3**	**1.5**	**1.4**
Legend: *Degree of coverage: 1 very low; 2 low; 3 medium; 4 high, 5 very high*								

Table 3: Model fit assessment

5. Contribution, limitations, and outlook

This paper aims to analyze key requirements for the IS support of industrial product-related services from the provider perspective that are characterized as highly relevant by managerial practitioners. Hence we conducted a multiple case study. To provide a rigorous theoretical foundation, a structured literature review in line with a well-accepted literature review framework was conducted. While literature analysis provides the relevant definitions for conceptualization and an overview of existing theoretical and managerial frameworks, the multiple case study approach was selected to derive relevant requirements. We analyzed seven case studies on industrial product-related services in the manufacturing industry. The findings are reflected with publicly available standardization specifications and existing scientific frameworks that are the result of a structured literature review. RQ1 has been answered by analyzing the case study results, while RQ2 was approached through a critical reflection with standardization efforts in this field of research. We contribute to the theoretical body of knowledge by outlining six unaddressed requirements for the under-researched field of back stage service systems. While the business model requirement is partially covered by the extant literature, service quality, installed base management, mobile solution, enterprise integration and data quality and integration are not adequately addressed in academic literature. Managerial practitioners, in turn, are able to prioritize their investments into the appropriate capabilities for fulfilling the requirements and thereby optimizing the product-service systems within their organization.

The case selection presents a possible limitation of the presented study. A generalization of the results could be improved by examining more cases and more industries. However, seven case companies represent a manageable complexity to explore unaddressed requirements. The utilization of further research methodologies such as surveys might help to validate the findings. Another limitation is the focus on German and Swiss companies. However, this limitation fits to the focus on large scale manufacturing enterprises that heavily invest into their service business. Exploring and reflecting on unaddressed requirements presents an important step for understanding why manufacturing firms struggle with the IS implementation of product-service systems. In this line of argumentation, in conclusion we posit the development of a maturity model that allows the comparison and classification of the IS support of product-service systems.

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Appendix

Interview guideline

1. Introduction
   1.1. Please describe yourself, your company and your role within the company.

2. Service strategy
   2.1. How significant is the service business?
   2.2. Which are the most important services in your portfolio?
   2.3. How do you classify your most important service products?
   2.4. What is the organizational structure of your service business?
   2.5. How is the interaction between the service and the product business organized?
   2.6. What are innovative business models in your company?

3. Service processes
   3.1. Which are the processes enabling the business models?
   3.2. Do you develop service processes according to a structured procedure? If yes, which?
   3.3. Do you apply specific norms and standards for your service processes?
   3.4. How do you define service quality and how is it ensured?
   3.5. What performance indicators are in place to control service processes?
   3.6. Please describe any additional requirements for the industrial service business.

4. Supporting IT systems

4.1. Which IT systems are involved in the support of service processes? Thereof, which are standard systems, proprietary systems and legacy systems?
4.2. How do you manage the integration of the involved systems?
4.3. What data do you need for which application?
4.4. How do you address data quality assurance?