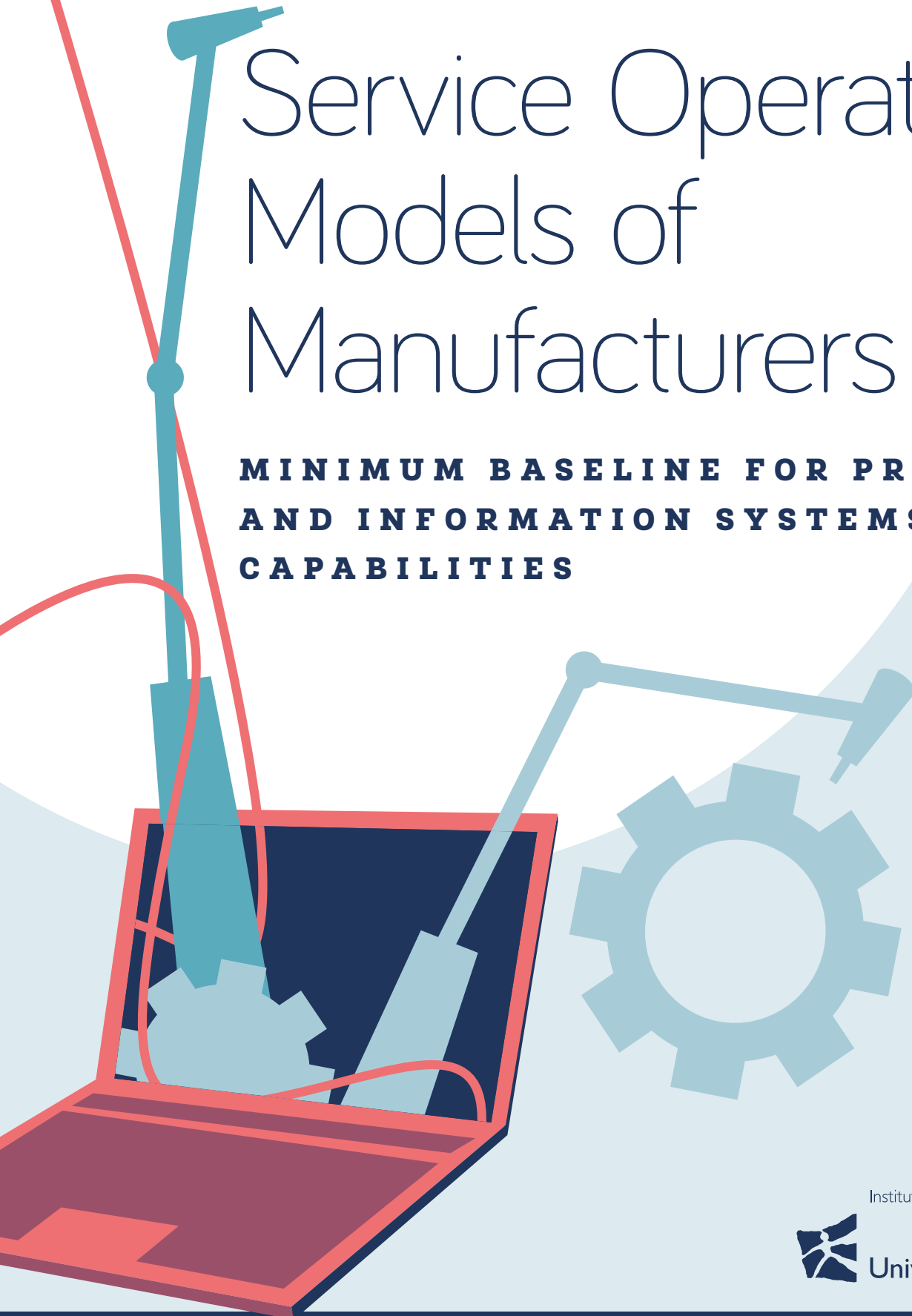


Alexander A. Neff, Falk Uebernickel, Walter Brenner

Service Operation Models of Manufacturers

**MINIMUM BASELINE FOR PROCESS
AND INFORMATION SYSTEMS
CAPABILITIES**



Institute of Information Management



University of St. Gallen

Why we wrote this report

Services are continuously gaining importance for value generation of manufacturing firms. Those services can lead to higher and more profitable growth—particular in times of crises—has been widely accepted. Manufacturers with a larger service operation in their business have a competitive advantage over their peers. To enter the service business, firms need to integrate their service offering into the new equipment-oriented business model. Customer organizations demand a high service quality and put this into contractual agreements for their investment decisions. Subsequently the manufacturer's service operation units are confronted with physical resource limits to roll out service models globally, e.g. well educated service workforce in developing countries.

Information technology seems promising to overcome these shortcomings by providing information to the relevant process stakeholders in the service operation units and thereby making service processes more efficient. However, existing information systems (IS) applications in manufacturing firms are often ill-suited to provide the needed support. For instance, they do not adequately cover the customer interaction process or lack the required detail for technical descriptions on installed equipment.

Leading manufacturers have translated their unique service business knowledge into very specific processes and information technology (IT) requirements. Confronted with the shortcomings of standard applications (such as linking technical description with contract data, computer aided

design drawings, processing of sensor data and service history) they projected large scale proprietary. To enable efficient service processes custom-built IT systems are enriched with remote technology and mobile computing. Those leading manufacturers succeeded in merging and processing customer descriptions, serialized asset data, product lifecycle data with sensor information for service planning, execution and analytics. However those solutions have become legacy systems, while falling short in scalability, collaboration and consistency.

Being a holistic and business-to-IT related challenge, we address both managers from the service division and IT executives by developing a maturity model in this study. This model can serve as a management instrument to analyze the current set-up to determine the key levers for improvement. It is not our ambition to develop a comprehensive model that addresses all heterogeneous service issues. Rather the model aims to give indication for investment decisions as minimum baseline for process and IT capabilities for service operation models in the manufacturing industry. We do hope to inspire thought about the role of IT as a nimble and valuable partner on the route to a digitized service business.

Please note that parts of this study have been previously published as contributions to the academic body of literature (e.g. [10]).

I would like to express my gratitude to all contributing European manufacturing organizations for their insights and dedication.

Prof. Dr. Falk Uebernickel

Institute of Information Management
University of St.Gallen

Abstract

In the last few years, services are continuously gaining importance for value generation of manufacturing firms. That services can lead to higher and more profitable growth—especially in times of crises—has been widely accepted. Manufacturers with a larger service operation in their business have a competitive advantage over their peers. However, a lot of money is still left on the table: service potential remains unrealized and many companies conceive services only in terms of providing spare parts. The road to becoming a service champion—a firm that provides a wide variety of services and manages the customer's operations—is stony. To enter the service business, firms often need to adjust their whole business model and are confronted with physical resource limits. In addition to business challenges, a major obstacle lies in finding the appropriate IS support of the newly established service system. Existing IS applications in manufacturing firms are often ill-suited to provide the needed support. For instance, they do not adequately cover the customer interaction process or lack the required detail for technical descriptions on installed equipment. This paper aims at closing this gap by presenting a maturity model that includes five different service business models as well as the respective design of the IT landscape. The model is structured along the “integration of service offering into the business

model,” from providing spare parts to managing the customer's operations, and clearly defines the necessary IT capabilities to implement a particular service model.

In a detailed fashion, the model describes how the integration of services into the manufacturer's business model requires adaptations of the strategy, the organization, and its interaction with customers as well as investments in IT artifacts. Key elements of the model are performance measurement of industrial services, installed base management, mobile support for the service workforce, integration of service and product data, and data quality assurance. The configurations of these elements vary along the five maturity levels of including services in the business model. The model allows practitioners to better self-assess their performance in the service business and can function as a basis for necessary investment decisions in order to expand and improve the service offering. In addition to presenting the maturity model, the paper provides input for reflection on how to achieve a successful transformation from product-centered to service-minded firms.

KEYWORDS service business, manufacturing firms, transformation process, IT support

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List of Abbreviations

CAD	Computer Aided Design
CIO	Chief Information Officer
CRM	Customer Relationship Management
CRUD	Create Read Update Delete
ERP	Enterprise Resource Planning
IS	Information Systems
IT	Information Technology
IWI	Institute of Information Management
KPI	Key Performance Indicator
M2M	Machine to Machine
OECD	Organisation for Economic Growth Cooperation and Development
OEM	Original Equipment Manufacturer

Digitalization, automation, and servitization call manufacturing firms to rethink their business models



1.1

Industrial services: From pure manufacturing to service excellence

An era comes to an end: Nowadays the industrial goods industry can no longer afford to focus only on product improvement and large scale deals with industrial clients. Pure product sales have already made way for holistic product solutions, including industrial services. According to a recent study by the consultancy Bain & Company, services can become the cash cow of tomorrow for manufacturing companies. Currently, services account for about 20% of revenues for many European industrial goods manufacturers. The return on sales is above average as these 20% of business generate about half of the sector's profit. Further, the service business is growing steadily at 5% per year [14].

However, while this growth is truly impressive, the service business of most original equipment manufacturers (OEMs) is still underdeveloped. The service potential of their installed base is huge, but currently companies exploit only a small fraction. Most firms realize from 10% to 25% of potential revenue from services. Often, even the ability to estimate the full service potential is missing in many OEMs. The transition from pure manufacturing to service champions is in full swing, and the financial crisis and respective slower growth in product sales has led to a change in thinking. Executives now understand an efficient service business as a road to growth, value creation, greater predictability, and resilience to economic cycles [14].

Service opportunities are manifold. Many industrial goods manufacturers assess services only in terms of providing spare parts. However, others, so called service champions, are aware of the fact that they can supply a wide variety of services to their clients, such as installation, maintenance, upgrades, or training—all of which allow for value creation and profit. A recent Boston Consulting Group study differentiates between three types of services opportunities: traditional technical services, extended technical services (lifecycle based), and business services. While traditional technical services cover only basic installation and training, enhanced technical services include retrofits and upgrades. Service champions, however, not only provide all kinds of technical services, they also engage in business services such as consulting, financial services, and outsourcing. They have understood the opportunity at hand and aim at turning their service business into a competitive advantage by reaching a high level of service excellence [9].

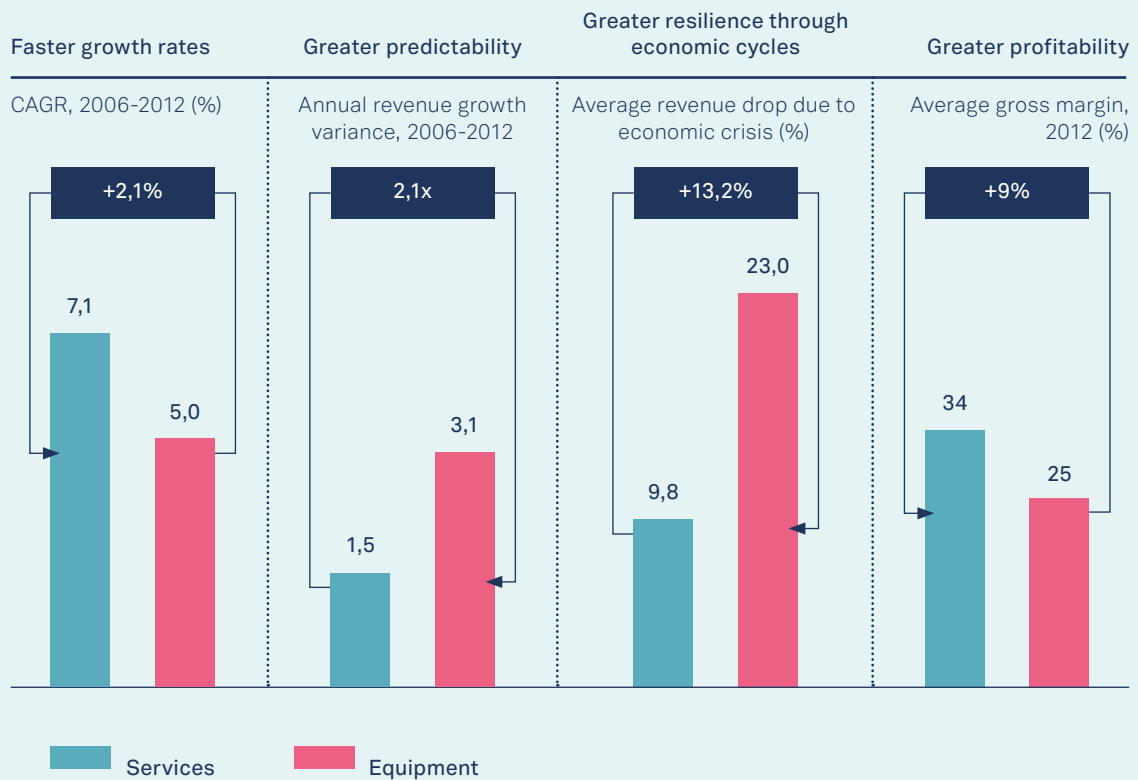


FIGURE 1: Service sales outperform equipment sales in growth and profitability [5]

Interconnected with the boom of industrial services of manufacturing firms is the fourth industrial upheaval that is driven by automation of the production processes. This new industrial era is commonly referred to as “Industry 4.0.” Industry 4.0 is understood as the computerization of traditional industries such as manufacturing, which ultimately leads to a smart factory—a factory characterized by adaptability, resource efficiency, and ergonomics as well as the integration of customers and business partners. Besides a stronger automation, the Industry 4.0 initiative fosters the development of smart monitoring and autonomous decision making processes that allow for realtime control and for optimization of enterprises and value networks. In other words, the digital refinement of production plants, industrial equipment, radio sensors, embedded actuators, and smart software systems bridges and synchronizes the virtual world (digital model) and objects in physical reality [7]. Thus, Industry 4.0 not only allows for process optimization but also enables new industrial services.

Connected in the Internet of Things, smart products enable smart services as they are able to automatically trigger service tasks and allow for new ways of service collaboration. More precisely, new service opportunities emerge due to new, more detailed data about the operation and performance of the installed base (smart data). IS permanently collect, provide, and analyze data about the environment, deployment, operation and use of equipment, tools, and the behavior of users. This in turn results in vast amounts of data. “Big data” generates new knowledge by using algorithms, pattern recognition, and data fusion. This knowledge does not only allow for proactive behavior, but it also considerably accelerates the innovation processes. Companies receive better and more immediate information on how to improve products, processes, and services and how the layout of warehouse, distribution centers, and manufacturing plants can be optimized.

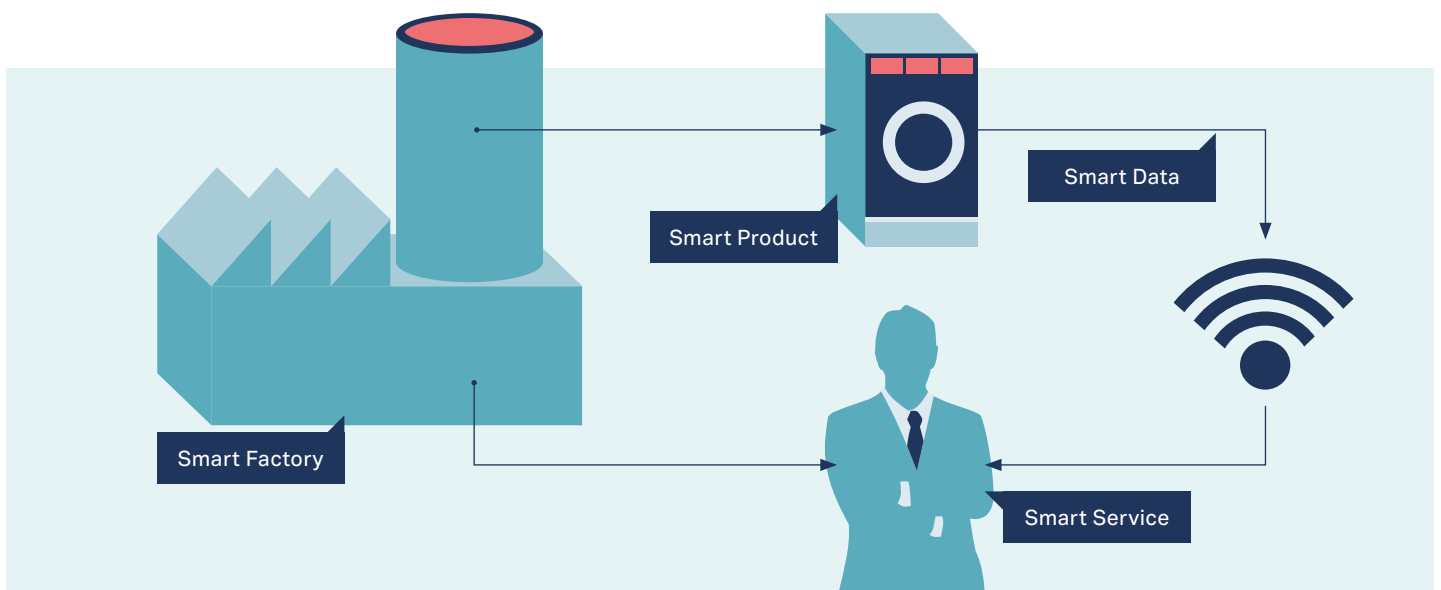


FIGURE 2: Four characterizing concepts of Industry 4.0

The collection and analysis of data, of course, also happens when the smart products have left the factory and are installed at the customer's side. This knowledge can serve as a basis for new knowledge-based services (smart services) or even new internet-based business models. It is possible to develop advanced added value potential because smart products become platforms for new knowledge-based services.

1.2

Industry 4.0: Roadblocks on the way to service excellence

As the market environment for manufacturing firms is constantly changing and the importance of an efficient service business for revenue, growth, and profit is increasing, OEMs not only need to respectively adapt their business model, but they are also challenged by possessing the necessary physical resources. To be competitive, companies permanently add new service businesses to their product portfolio. Thereby, a transformation process is triggered that requires both changing strategy and structure as well as changing business processes [16]. While this transformation process can be observed in most manufacturing firms, it is especially incisive with manufacturers offering long-living and highly productive products. Consequently, services such as maintenance repair and change operations are particularly important capabilities in order to achieve and maintain a high return on sales.

More precisely, the change process from pure manufacturing to a business combining products and respective services means that manufacturing firms have to overcome their pure business focus on engineering and production by complementing their business model with a completely different service component. An example of a metal-forming company illustrates this need. The firm has been very successful in building a large equipment base. However, it did not meet the after-sales needs of its customers, which lead to 80% of its service potential being exploited by competitors. In order to capture the service needs, the company had to adopt a new business model including broader geographic coverage, an expanded service product portfolio, a new management team, and more proactive customer management [14].

Several factors complicate a successful transition. Numerous companies underestimate the effort needed to turn a product-focused company into a company offering service systems. A major roadblock on the way to service excellence includes physical resource limits. In many cases, the available resources are insufficient for successive integration of services into the business model. For instance, human resources lack sufficient qualified staff to provide the newly offered services. Call centre employees, for example, are often insufficiently trained to deliver requested technical remote services for the installed base. Further, they often lack access to the necessary information for handling the service demand (e.g. information on the installed base, sensor data, etc.). In addition to physical resource limits, the firm's culture needs to undergo drastic change as well. To achieve a mindset shift in the organization toward service, not only the management needs to fully commit to the service business but also significant investments in people and capabilities are required. In addition to business challenges, IS challenges, which will be discussed in the following chapter, must be overcome as well.



The CIO needs to
fulfill the increased
service requirements
with the technical
capabilities



2.1

Proprietary systems: Service excellence cannot be reached with existing IS applications

IT artifacts have an enabling effect on the transformation process from product-centered to service-minded firms. Technological capabilities are able to reshape the service processes in an improved way. Specific technical competences such as mobile computing, remote machine control, and data management allow more efficient performance of service processes such as service quality controlling, knowledge management, mobile workforce, call center processing, and predictive analytics.

However, similar to the above-mentioned business challenges, limited physical resources also hamper the development of these technical capabilities. For instance, customers are physically unable to maintain operational condition on machinery in production facilities at 99% availability. This has the effect that the customer demands extended service offerings based on a prediction-based model instead of service reactions triggered by call centers. This example illustrates that the service division of manufacturing firms needs more precise and accurate information about the equipment installed at the customer's location.

Only with precise and accurate information it is possible to establish professional monitoring and prediction and thus offer efficient services. Precision refers to serialized data on sold assets and deep technical information (e.g. bills of material). Accuracy means that all information on past service activities performed on the equipment (e.g. maintenance, repair, and overhaul) is available. Thus, in order to successfully manage the transformation process, as the BCG study highlights, firms should also improve technical competences—especially information and communication technology—necessary to service their sold equipment [5].

However, existing IS applications in manufacturing firms are often ill-suited to appropriately support service systems [3, 4]. Enterprise resource planning (ERP) applications [6, 11] lack in the customer interaction processes, while customer relationship management (CRM) applications [12] are limited in the required detail for technical descriptions on installed equipment. Many manufacturing companies solved these deficiencies of standard applications by designing and building individual proprietary IS solutions. These applications are often more capable of collecting, processing, and evaluating machine statuses and mobile workforce information [2, 8, 15]. However, this workaround is flawed, too. On the one hand, this leads to redundancies: Different enterprise applications on corporate, plant, and shop floor layer [13] run in parallel. On the other hand, this situation hinders standardization efforts: Integration projects are hampered and costs increase.

2.2

Service requirements: Achieving process and technology fit is king

Information technology needs to be aligned with the new business model towards service systems. Several key requirements for transforming the IS support of service systems to offer service-oriented business need to be fulfilled. These key requirements (referred to as R) have been identified in cooperation with seven leading manufacturing firms (see company profiles in Appendix A).

(R1) Integration of a service offering into the business model

According to all interviewed manufacturing firms, it is essential that the equipment installed at the customer's location is constantly operating. This is the basis for success in the service business. Beyond that, the business model influences the service portfolio and the business processes. According to the IS manager of ALPHA, different configurations of the service business and thus different business models are conceivable: spare parts, life cycle service, and full service. "Each of them requires different business processes for realization."

(R2) Service quality

Only when the business customer applies the offered services as an integral part of his manufacturing planning and execution, the service division generates value. To achieve value generation, a high level of service quality along the entire value chain, including external vendors, needs to be ensured. This can be reached by establishing the following methods and tools: roll-out global service processes, establishing audits and certifications, and performance indicators. The CIO of DELTA states, "We rolled out standardized service processes worldwide. Once a year, the service locations are checked in a comprehensive audit program."

(R3) Installed base management

When managing the installed base, the manufacturer gains valuable customer knowledge and critical insights about the equipment in operation. This requirement is characterized by the following elements: collecting and updating historic data after repair and maintenance events, the use of condition monitoring for preventive maintenance, and optimizing the customer processes, including equipment investment goods from competitors. The manager of BETA asserts, "The application of emerging technologies such as remote setup, repair, and maintenance can help to keep up the operational condition with efficient resources."

(R4) Mobile support for the service workforce

The manager at EPSILON reported, "On a mobile solution that guides the service technicians during repair and maintenance activities. However, expensive proprietary applications serve as a technical basis for the mobile support of our service technicians." This quote illustrates the clear need to provide IS support for service technicians during the customer visit. Based on mobile support, the technician can gain access to master data, historical data, service catalogues, and to the knowledge base that helps to perform services in an efficient way. Further, after the service performance the technician can trigger the billing and accounting processes.

(R5) Enterprise integration

While the production of most of the case companies is located in their European home market, local entities perform sales and service activities. Thus, an appropriate architecture is needed for the firm's network comprised of larger production entities, smaller service entities, and local subcontractors. This structure leads to an increased complexity providing additional challenges to the IT architecture. As highlighted by the manager of ALPHA, "Locations with production and service hubs require substantially more information systems support than smaller locations with a smaller budget. Cloud-based information systems present a contemporary approach for such small entities." The manager of GAMMA refers to expensive customization projects for adapting enterprise applications to the service-specific needs.

(R6) Data quality & integration

Efficient service processes and contract management are in great need of reliable master data and an integrated view of product and service objects. To build such a base substantial investments in corporate data quality and integration are often required. However, many case study participants indicated that in reality service and product businesses are separated from an organizational perspective. This separation is illustrated by a detachment of the respective information systems. As a result, distinct data models cover product and service components. The manager of BETA stated, "The service level is specified as long text in the product object."

Integration of service offering into the business model: from spare parts sales to service champions



3.1

The maturity model at a glance

The revealed requirements in the previous chapter serve as a basis for a maturity model* that describes, accompanies, and facilitates the transformation process from traditional manufacturing companies to those embracing service systems. A discussion with practitioners high-lighted that the requirement (R1), integration of a service offering into the business model, should be given a more prominent position in the model than being a dedicated element, i.e. the level descriptions should indicate how the transformation evolves. In this light, the model is structured along the “integration of service offering into the business model,” from providing spare parts to managing the customer’s operations. The model at hand (Table 1) presents a minimum baseline of a manufacturer’s ability to implement a particular service model and reveals which basic prerequisites need to be fulfilled for each business model. Accordingly, the term “maturity” is understood as the difficulty in achieving a particular capability. For instance, the implementation of a performance contracting service model requires more investment than a service model purely based on spare parts.

The transition in service operations presents a holistic business-to-IT related issue and hence the affected capabilities in the model are quite heterogeneous. We classify the affected capabilities, thus the five elements of the maturity model, in three different dimensions: strategy, environment and organization, and IT artifact. The dimension strategy covers crucial aspects of the IT strategy and its interconnection with and influence on business strategy considerations. This part of the model includes the performance measurement of industrial services [A.1]. As the management of service performance is narrowly connected to strategic management decisions, such as the selection of service models for product and service bundles, [A.1] is classified as an element of the first dimension. For each maturity level, the performance is measured by KPIs closely related to the respective service model. Thus, the implemented KPIs for each model both reflect the firm’s position in the transformation process as well as measure the success of the chosen service system.

* Please find the academic version of this study online published as: [10] Neff, A. A., Hamel, F., Herz, T. Ph., Uebernickel, F., Brenner, W., vom Brocke, J., “Developing a Maturity Model for Service Systems in Heavy Equipment Manufacturing Enterprises”, Information & Management (I&M) (2014), DOI: 10.1016/j.im.2014.05.001.

The second dimension of the maturity model, environment and organization, deals with the impact of IT on the organization itself as well as on the client's organizations. The respective element in the model is installed base management [B.1]. The goal is to measure how automated the firm receives data about the operation and performance of equipment at the customer's location and how valuable and detailed this data is. Thus, this element affects both the organization as well as interaction with the customer. Therefore we classified the installed base management as part of both dimensions. More precisely, installed base management is understood as a service operations process that provides knowledge on the functioning of equipment in use. With the collected data, the organization is able to manage repair, overhaul, and maintenance operations on the customer equipment. Based on remote technology such as sensors, these operations can be launched automatically. By applying IT, the service process can be altered and improved as it becomes possible to supply output-based service contracts at high service level.

The IT artifact, the third dimension, deals with the technical aspect of IS, i.e. with the concrete technical tools. This dimension frames three elements of the maturity model: mobile support for service workforce [C.1], integration of service and product data [C.2], and data quality assurance [C.3]. Mobile support for service workforce [C.1] refers to mobile computing and backstage enterprise applications that facilitate the tasks of service technicians. Integration of service and product data [C.2] and data quality assurance [C.3] cover the form of data collection and data validation. Thus, they are a means to manage data resources necessary to perform service operations.

	Rudimentary spare parts service model	Reactive maintenance service model	Predictive maintenance service model	Performance contracting service model	Managing the customer's operations model
[A] Strategy	[A.1.1] No service specific KPIs are in place, but logistic KPIs, e.g. order fulfill rate, average turnaround rate	[A.1.2] Focus on financial KPIs (efficiency driven for service processes, travelled route, answering time, working capital)	[A.1.3] In addition to A.1.2, non-financial KPIs are added (e.g. remaining product lifetime, equipment and machine failure rate)	[A.1.4] In addition to A.1.3, financial and non-financial KPIs are balanced (alignment of business model KPIs, e.g. quality maximization, equipment reliability)	[A.1.5] In addition to A.1.4, KPIs are adjusted regularly to customer needs (extension towards competing machines)
[B] Environment & Organization	[B.1.1] No coordinated interaction	[B.1.2] Basic electronic reports are manually released and exchanged	[B.1.3] In addition to B.1.2, remote calls on machines are supported with access to real-time state and sensor reports	[B.1.4] In addition to B.1.3, continuous monitoring is established and coordinated in the service center	[B.1.5] In addition to B.1.4, remote and continuous monitoring service processes are performed on competing machines
[C] IT Artifact	[C.1.1] No mobile support necessary	[C.1.2] Access to customer data and installed equipment data is provided	[C.1.3] In addition to C.1.2, access to knowledge database (best practices, blueprints and service history) is provided	[C.1.4] In addition to C.1.3, transactions of billing are provided (digital signature, confirmation billing and service execution)	[C.1.5] In addition to C.1.4, full integration of mobile device is given
	[C.2.1] Data is collected on an ad-hoc basis without an integrated approach (equipment to machine mapping)	[C.2.2] Data collection is done manually with basic integration applications (combination as-is built bill of material and customer data)	[C.2.3] In addition to C.2.2, data collection (as-is maintained list) is partially automated with partial data integration (e.g. intranet-based Web tool)	[C.2.4] In addition to C.2.3, data collection is fully automated, data integration with major business entities (e.g. MIS) and access to consistent customer, contract, sensor, spatial data	[C.2.5] Data integration is fully automated and optimized as real-time integration to globally provide access to customer, contract, sensor data from competing installed equipment for the whole enterprise[
	[C.3.1] No data quality assurance in place	[C.3.2] Rudimentary quality assurance (plausibility checks)	[C.3.3] In addition to C.3.2, quality assurance includes horizontal integration (e.g. between product and service division)	[C.3.4] In addition to C.3.3, quality assurance involves vertical integration (e.g. between operative & analytical systems)	[C.3.5] In addition to C.3.4, data quality is part of a continuous improvement process

TABLE 1: Minimum baseline for process and information systems capabilities [10]

3.2

Maturity levels in detail

3.2.1 Rudimentary spare parts service model

Rudimentary spare parts services, service systems prepared (level 1), means that manufacturing firms mostly concentrate on product development and sales and only provide rudimentary services on their equipment, such as the sale of spare parts. That the service business is underdeveloped can be seen along all elements of the maturity level. The manufacturer has not implemented any service-specific key performance indicators (KPIs) and only applies KPIs from the logistics department, such as order fulfill rate or average turnaround rate [A.1.1]. The equipment sold is not equipped with sensors. As a result, the organization does not automatically receive any data on the operation and performance of the installed equipment in order to perform a professional installed base management [B.1.1]. As the firm does not employ any on-site service technicians, mobile workforce support [C.1.1] is redundant at this service level. Any data needed for an analysis of business processes is collected manually and on an ad-hoc basis [C.2.1]. However, basic data on spare part sales—which spare parts have been sold for which machinery—is available. The quality of data remains unchecked [C.3.1].

3.2.2 Reactive maintenance service model

With the reactive maintenance service model, service systems engaged (level 2), the manufacturing firm has begun to include service operations in its business model beyond spare parts sales. At this level, the company reacts to customers' need of maintenance services and tries to maximize the efficiency of its own operations. The implemented KPIs reflect these goals as they exclusively cover financial aspects, such as answering time and working capital ratios [A.1.2].

An installed base management is in place, however in a very basic form: The customer manually provides electronic reports on the operation of the installed equipment to the manufacturer. The service center of the manufacturer then uses these reports to clarify maintenance demands and to prepare for on-site maintenance work [B.1.2]. A mobile support system allows the service technician to retrieve customer data and some information on the installed bases such as the bill of material [C.1.2]. The data is still entered manually, however data integration is performed by basic applications [C.2.2], and the data gets regularly checked for plausibility [C.3.2].

3.2.3 Predictive maintenance service model

When advancing to predictive maintenance service model, service systems established (level 3), the manufacturer performs maintenance services that have been triggered automatically. The necessary capabilities for this intermediate service level include non-financial KPIs, particularly remaining machinery lifetime, equipment and machine failure rate, which can ensure a professional performance measurement [A.1.3]. In order to perform predictive maintenance services, the manufacturer needs more accurate and up-to-date data on the installed equipment. The service center at the manufacturer's site calls up real-time information on the machinery state (failure code, software release, etc.) and sensor reports (temperature, humidity, oil state, etc.). Thus, the organization obtains very precise data on the installed bases and a deep understanding of the machinery use of its customers. Only with this information, the organization is able to meet the advanced service requirements of its customers (e.g. short reaction times, prevention of machinery breakdown, high machine availability) [B.1.3]. With the information obtained, the manufacturing firm can derive best practices and crossselling opportunities. Further, all data collected is stored in a knowledge database which can be accessed by the service technician via the mobile support systems [C.1.3]. Thus, before performing the service operation, the technician knows about best practices and previously carried out services. After completing the maintenance service, the service workforce uses the mobile device to enter the service transaction. Thereby the as-is maintained list in the backstage enterprise application gets updated automatically.

This service model requires that the manufacturer is able to analyze the customer and installed base data in detail (e.g. to calculate remaining lifetime). In order to facilitate these analyses, an automated data collection process and data integration are needed. At this intermediate level, an intranet-based web tool partially integrates the data [C.2.3]. Further, the partially automatically collected data undergoes extended quality checks and is horizontally integrated between different business units [C.3.3]. Thus, the product and service division access and use the same data sources.

3.2.4 Performance contracting service model

Companies that decide to offer performance contracting service models, service system managed (level 4), need to transform their business model in a way that aligns it with the customers' business model. The goal is no longer to organize interaction with customers efficiently and maximize it. Rather, the advanced service system is characterized by the minimization of service transactions and increased reliability of the installed equipment. The customer's needs are center stage. This paradigm guides the needed capabilities for this level of service systems. KPIs cover quality maximization, equipment reliability measures, and production up times. Both financial and non-financial KPIs are in place in order to reflect the increased customer focus [A.1.4]. A performance contracting service model further requires an improved use of remote technology in the installed base management. To fulfill the service level agreement and to ensure that the machinery at the customer's location is constantly running, the service center needs to permanently monitor the condition of the installed equipment [B.1.4].

Maintenance, repair, and overhaul transactions are triggered in a two-step process. First, the machine automatically communicates an incident that is then, secondly, confirmed by the backstage service center. In addition to accessing technical specifications, customer data, and service history, the service technician can use the mobile device for billing and contracting transactions with the customer. Electronic copies of signed bills and contracts are automatically sent to the customer and processed internally for accounting activities [C.1.4]. Further, spatial data can guide the service technician through the customer's facilities and help locate where service operations are necessary. Installed base management as well as mobile support function at the described level only when sophisticated data is available, integrated, and of high quality. Data of all types (customer, contract, sensor, and spatial data) should be collected automatically and integrated across all business units [C.2.4]. Automatic data quality assurance allows for both horizontal and vertical integration (for different enterprise application systems, e.g. operative and analytical systems) [C.3.4].

3.2.5 Managing the customer's operations model

Managing the customer's operations, service system optimized (level 5), reflects the most advanced service system. The service business is fully integrated into the manufacturer's business model. The manufacturer not only fulfills service level agreements on the self-constructed machines, it also completely manages the customer's operations. More precisely, this means that the agreement between manufacturer and customer is expanded to competitor-constructed equipment. The KPIs in place are adjusted to the customer needs and adapted when the customer's operations change [A.1.5]. Similar to the performance contracting service model in level 4, enhanced remote technology is used for professionally installed base management. The permanent, real-time monitoring and control of the customer's production process based on sensors, embedded software, and the customer's manufacturing execution system is extended to all machinery the customer uses, self- and foreign-built [B.1.5].

Service technicians can rely on fully integrated mobile devices to access, perform, update, and delete operations for the installed base. Further, they are able to trigger billing transactions and access the knowledge database with all necessary data on customers, machinery, best practices, etc. [C.1.5]. To reach this service level, the company needs to invest in its application portfolio and its infrastructure to allow for seamless, real-time integration of production and service data across all business divisions [C.2.5]. Another prerequisite of an effective and efficient service system is high data quality. At this level consistent, constantly improved data quality (e.g. master data, operational data, transaction data, and knowledge base data), including vertical and horizontal reconciliation, is of great importance [C.3.5].

3.3 A guideline to assess your organization

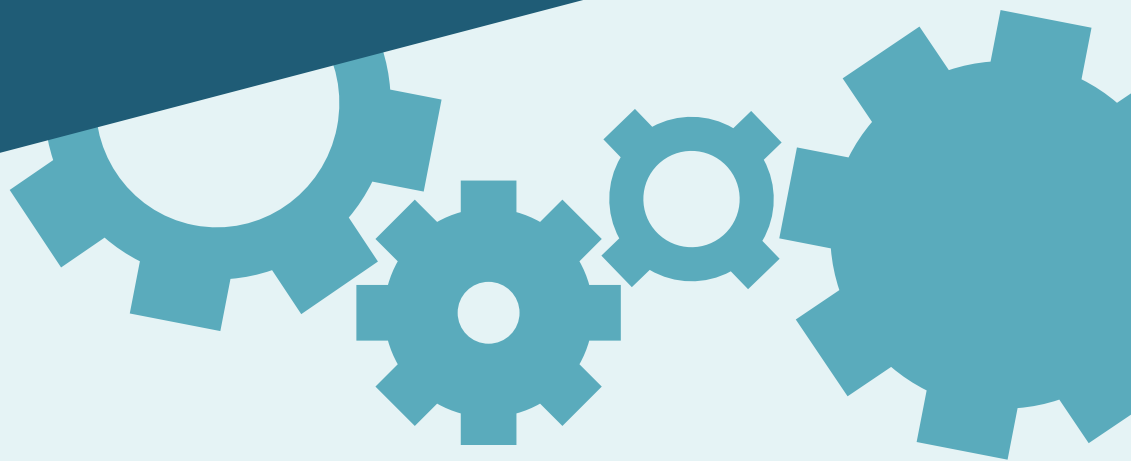
The application of the model has especially two major benefits for practitioners: On the one hand it serves as a management instrument to assess the actual state of the manufacturer's service business and on the other hand it builds a basis for investments in the IT support of service systems. Further, the model provides the ability for organizations to compare their maturity level with other organizations or other parts of their own organization. By deploying the maturity model, the organization gains the opportunity to better understand the current position and the actual service model. The model describes the status quo along the different dimensions and elements.

Shortcomings in necessary resources and capabilities will be revealed. Based on this analysis, the firm can then make carefully thought out decisions (e.g. investment decisions) for improving the service capabilities in order to climb the service ladder. However, it is in the nature of the model to be focused on assessment and evaluation: Concrete change measures (on how to get from one maturity level to another via the various capability areas) need to be related to the individual context of the manufacturing firm and are thus not directly included in the model. While the model can inform change measures, the tangible action plan can be developed only by the management and service workforce of the respective firm since measures need to be highly individualized and require firm-specific technical and managerial know-how.

Several internal and external factors have an influence on a firm's development from one maturity level to the next higher one. Common factors are, for example, regulatory requirements—regulation in a certain market prohibits data integration of service and product systems—or a works council request to limit the digital trackability of the mobile workforce. Further, the firm's position in the supply chain indicates its ability to improve its maturity level. A component manufacturer often does not have access to sensor data because the machine manufacturer usually installs the embedded software in the equipment.

For deploying the maturity model, it is also important to know that the lowest level in one dimension determines the overall maturity level of the firm. Thus, an overall high maturity level is hard to reach and extremely low levels in specific elements are the primary adjusting screw for improving service capabilities. However, a managerial expert in a practitioner's workshop mentioned that he classified his company overall at level 4 even though some elements were below the advanced level. He justified this assessment in the following way: "Today, we are able to remotely monitor the installed base at the customers' plants. Our solution continuously analyses the sensory data and informs the service staff when problems occur. By doing so, we are not only able to ensure an immediate replacement of the correct defect product (one assembly line can be driven by dozens of heavy equipment goods), but also provide accurate predictions on the remaining lifetime. The customer value lies in the reduced downtimes of production facilities. As a consequence, our sales went up while the company saved money by streamlining and accelerating the service processes." Thus, not only the concrete measures for change are contextual but sometimes also the self-assessment of a firm's maturity level.

Transformation: How to make it happen



4.1

Grasping how the 5 service models can support the process

The spare parts service model presents the first initiative to enter the service business by servicing products. All analyzed manufacturing enterprises confirm the importance of this model for mainly two reasons: It has a particularly high margin potential and fosters customer loyalty. After determining this after-sales strategy, executives push efficiency-driven performance indicators to master the cost challenge. A web shop is rolled out for efficient spare parts sales processing. The necessary equipment is forecasted and provided by inventory management. Further, contracts with parts suppliers open up optimization potential by renegotiating existing contracts. The IT organization fosters data management initiatives to integrate supply chain and web shop applications. Customer master data and spare parts equipment data are gathered and consolidated to enable the order processes and improve supply chain management.

In the reactive service model, it becomes essential to build up service-specific organizational structures and processes. The management board decides to extend the service model and pushes customer relationship management, service organization formation, and performance benchmarking projects. Being part of the rising service organization, new roles find their way into corporate structure, such as service technicians, service schedulers, call center agents, backstage service support, and service managers. Embedded as part of a strategic customer relationship management initiative, the manufacturer needs to learn about customer needs as service consumers and not as new installation business. Performance indicators are primarily aligned with internal efficiency-raising projects for the own operations. The call center has been introduced as a customer touch point for maintenance, repair, and overhaul requests. Audit and certification programs ensure a globally comparable educational level of the service workforce. A professionally installed base management is projected to collect and centrally store information about the installations including bill of material, customer master data, and customer-released failure reports. This operational process serves as the central point of truth and provides call center and service field technicians with the required customer and machine information. For frontstage applications, call center automation and mobile applications for the service workforce are rolled out to fulfill operative information needs. As backstage enterprise applications, CRM Customer Service and ERP Service Management are deployed.

Standard data types are adapted to service-specific needs, e.g. combining structures (bill of material) with customer master data and failure reports. Plausibility checks are performed to give the required data quality assurance.

The predictive maintenance service model builds on the service specific organizational structures and processes that became necessary on the previous level. The focus of this service model, in contrast to level 2, is no longer the internal efficiency of the service operations but the quality of the services at the customer's location. Thus, the firm's management establishes a quality management in order to balance efficiency and quality standards. In order to include quality claims in the interaction with the customers, service level agreements with reaction times are agreed on. Further, services performed are no longer independent of each other; instead bundled services are offered. A professional remote service management is established to remotely monitor, access, and repair products in use at customer sites. As customers are globally distributed, the installed base gets consolidated. Again, new roles and responsibilities with regard to expert and knowledge management and a knowledge base storing best practices are introduced. To fulfill service level agreements and reach high quality standards, the manufacturer needs better and more detailed information about the installed equipment and thus installs sensors allowing for real-time machine data. Further, the firm integrates production and service planning and establishes one database containing all information on customer equipment.

The performance contracting service model continues the focus on service quality management of the predictive maintenance model. In addition to the previous level, the manufacturer's service business is completely output oriented and aligned with the customer. The customer's needs are the basis for the service level agreements. The manufacturing firm provides all services around the installed equipment operations and is responsible for reliable machine performance. The management of the manufacturer manages its service business by both applying financial and non-financial KPIs. Remote services are further extended. Machine to machine (M2M) communication is deployed to allow for automated data transmission and measurement among the installed equipment and between the manufacturer and the installed base. To optimize the service business, the service center of the organization is able to perform extensive analytics based on spatial, performance contract, customer, and sensor data.

The managing the customer's operations service model is the optimization of the service business of a manufacturing firm. Services are no longer limited to self-manufactured equipment. The manufacturer manages the customer's operations and entirely aligns its service offering with the operation and production of the customer. To perform this service model, the manufacturer gains knowledge on competing equipment in order to be the contact person for service needs of externally produced machinery. Thus, knowledge management and knowledge base are extended. The installed base management and respective technology, such as sensors, are expanded beyond own equipment. Also, the interface for accessing machines for real-time state and sensor reports needs to be adapted, too. Further, the manufacturer starts service network initiatives and tests subcontracting with third party service providers in order to manage the customer's operations globally, at all times and beyond own expertise.

	Rudimentary spare parts service model	Reactive maintenance service model	Predictive maintenance service model	Performance contracting service model	Managing the customer's operations model
[A] Strategy	» After-sales service strategy	» Customer relationship management » Formation of service organization » Performance benchmarking	» Establish quality management and balance efficiency and quality programs » Design service level agreements with reaction times and bundles services	» Establish total quality management with output orientation » Service level agreement management with customer alignment » Service controlling for balancing financial and non-financial KPIs	» Establish customer operations management and extended alignment
[B] Environment & Organization	» Spare parts web shops » Inventory management optimization » Logistic contract renegotiation	» Call center implementation » Audit and certification program for service workforce » Installed base management	» Remote service management » Installed base consolidation (globally distributed customers, etc.) » Expert and knowledge network with multiple organizational roles	» Remote service extension	» Knowledge management for competing equipment » Installed base for competing equipment » Service network initiatives with subcontracting, service providers etc.
[C] IT Artifact	» Customer master data consolidation » Equipment to machine mapping	» Call center automation » Mobile workforce roll-out » Data structuring for service process » Rudimentary data quality assurance	» Interface implementation to access machines for real-time state and sensor reports » Data integration bring together production and service planning (as-is maintained list) » Database consolidation: one version of the truth for customer equipment	» M2M communication » Extensive analytics based on spatial, performance contract, customer and sensor data	» Interface specification for accessing competing equipment at the customer site

TABLE 2: Jointly conducted practices of the service operations models

4.2

Insights from industry practices

Transformation comprises a bunch of jointly conducted practices (as summarized in Table 2) that are typical in the manufacturing industry. We want to elaborate on concrete scenarios (i.e. customer retention for renewal customers, centralized service access point, mobile workforce support in the U.S. and remote service management) since this allows a more accurate view on industry practices of four companies, which we have intensively studied.

4.2.1 Customer retention for renewal customers

ALPHA is an international manufacturing enterprise in the construction and equipment industry. They offer equipment for mining, plant, and large scale transportation. ALPHA is a well-known brand that enjoys a high reputation among its customers. The organizational setting consists of a few production facilities and over 200 local sales and service entities. After selling the product, customers enjoy a 5-year warranty. The first customer usually deploys the product for 6 years and then re-sells it to a service provider. The service provider overhauls the product, conducts retrofit measures, and offers it on the renewal market. In that position, the service provider takes over the maintenance and repair service business, which after 6 years becomes relevant. Since ALPHA only holds the data of the first customer, retention for the renewal customer becomes very expensive or even impossible. However, economically it is the renewal customer that is relevant for the service business.

For that reason, ALPHA launched a customer retention program to keep the machinery equipment as customer independent from the machine operator. Management has decided to extend the warranty for two years when the retrofit is done by ALPHA or sublicensed contractors. Technical information (machine status reports, service history, and spare parts description) were used to give transparency (e.g. qualified value assessment, genealogy, and traceability) in the recently deployed trading platform for remarketed equipment.

4.2.2 Centralized service access point

The equipment of OEM DELTA involves a high complexity due to the number of variants, installed components, and significant retrofit. Inefficiency in the DELTA's service operations results in the need for a technical clarification instrument. This need emerged when the company expanded in the Asian markets with the service offering and was not able to build up the necessary workforce.

DELTA projected a corporate service platform that allows technical clarification based on PLM, CAX, and ERP service management information. Further unstructured data for service documentation are accessible from the service platform. In this light, the platform serves as central access point for technicians, engineers, and operators to acquire information on the equipment and its components. The functionalities incorporate:

- » Document based research with full-text-search, including language and document type filtering
- » Service parts catalogues in 2D or 3D based on the CAD format
- » Machine based material and bill of material search
- » Alternative parts search based on SAP spare part chain and bill of material
- » Integration into SAP Service Management with automatic updates of the used service parts within the as-maintained machine specific bill of material
- » Machine related retrofit management (as-maintained documentation)



4.2.3 Mobile workforce support in the U.S.

In 2000, LAMBDA's sales and service team in the U.S. developed the idea of mobile devices supporting the service technician at the customer site. The project objective was to provide the service technician with the knowledge about the history of the customer's machines, the actual failure report, and further customer data listed in the CRM system. The technician is informed about the reported defect and can therefore take the necessary spare parts. Moreover, when the technician reports about the customer's need or interest in additional products or services of the firm, the information is updated in the CRM system, and the local sales representative will be automatically informed. This solution is associated with numerous benefits, such as coherent and integrated customer information (one version of the truth) and more efficient services, which in the end ensures lower costs and higher customer satisfaction.

The local IT application development unit implemented a prototype based on Microsoft mobile. The prototype was tested and rolled out in the U.S. subsidiary. After recognizing the potential, the other service entities show strong interest in adopting the mobile solution as well.

4.2.4 Remote service management

BETA's sales growth (new equipment business) in China and Brazil becomes a critical success factor but, in their role as producers, customers also request integrated service components in the sales contracts. Service operation capabilities were limited because it was almost impossible to find educated service technicians and engineers in those markets. Once available, they were driven beyond their physical resource limits; i.e. human resources lacked sufficient qualifications and technical expertise. Performance contracting models further make the OEM commit to customer's production availability, i.e. production downtimes often make the service model unprofitable.

In 2005, the organization launched a remote machine control project to develop an integrated remote service management solution. The intention was to compensate the increased costs (in comparison the Asian OEMs) with the efficiency gains, which can achieve automation and centralization. Moreover, the machine software includes built-in remote functionality that enables several services to be performed on BETA's equipment via the internet. The back office service center can access the machine to provide live assistance, analyze log files, run diagnostics, or even correct a fault.

- » Diagnosis incorporates troubleshooting of problems on machines, remote advice on applications and machine operation, parallel consultation with an expert from the knowledge network, and send-in machine report to prepare a later service visit.
- » Call back sends simultaneously, in case of problem identification, an automatic notification to the control station and BETA's service center. Notification, data transfer, and smart pre-diagnosis are performed in less than one minute.
- » Monitoring continuously analyses and communicates the measurement points on the installed equipment to the service center. Once irregularities (i.e. derivations from the norm or exceeding limit values) are detected, the service center operation staff evaluates the data and summarizes it in a list of tasks for remote diagnosis or a service visit.

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APPENDIX A:

Case study and focus group research involving 11 organizations reveals what service model stereotypes can look like**

Since design science research refers to a problem-oriented approach, the development of the model is usually initiated either by a “need and require” intention or by opportunity-based innovation. The procedure applied in our research consists of five steps, and we describe each of them in Figure 3 according to the tasks performed, the techniques used, and the output achieved in complementing our research. The second step, a comparison of existing models (2), builds on the problem identification (1) and the identification of shortcomings or lack of transferability in the analysis of existing maturity models. As part of this step, we conducted a structured literature review to identify existing maturity models devoted to the same or similar domains.

Subsequently, we analyzed the models according to their domains and functionalities as well as their capability to address the research problems we outlined. During the iterative model development (step 3), we used model adoption mechanisms (i.e. configuration, instantiation, aggregation, and specialization analogy) in the rigorous creation of a maturity model (structure and content). The first iteration included the conceptualization of a maturity model with the relevant elements and maturity levels using model adoption techniques and content analysis of the case study reports. After the elements and concepts of the model had been designed, we evaluated the model with selected interview partners from the case company to create the maturity level descriptions for each dimension. The second iteration included a focus group workshop to adapt and balance the maturity levels across the dimensions to maximize the practical use of the model. Then we structured the elements along the maturity concept that serves as a sensitizing device. For the next step, model evaluation (step 4), we combined the conception of transfer and evaluation, the implementation of transfer media and the evaluation into one step [1]. As final step [step 5] the findings were discussed on their implications for research and practice.

** Please note that this section has already been published, such as in [10] Neff, A. A., Hamel, F., Herz, T. Ph., Uebernickel, F., Brenner, W., vom Brocke, J., “Developing a Maturity Model for Service Systems in Heavy Equipment Manufacturing Enterprises”, Information & Management (I&M) (2014), DOI: 10.1016/j.im.2014.05.001.

	Step	Activities Performed	Techniques Used
Motivation & Problem Statement	Problem Identification	» Identification of the scientific shortcoming » No appropriate design of information systems for service operations in heavy equipment manufacturing firms)	» Seven exploratory case studies » Initial literature review
Background	Comparison of existing models	» Identification of service requirements in the HEM Industry » Evaluation of existing enterprise applications for service planning and execution	» Seven exploratory case studies » In-depth literature review
Reference Model Design	Iterative model development	» Iteration 1: Conceptualization of service functions and definition of structural elements » Iteration 2: Model refinement	» Iteration 1: In-depth analysis of case study reports and industrial standards » Iteration 2: Expert interviews and refinement workshop
Model Evaluation	Evaluation	» Multi-perspective approach » Multiple evaluation rounds » Reflection on evaluation results	» Focus group workshop with four additional manufacturing enterprises » Self-positioning of manufacturing enterprises
Discussion, Summary & Outlook	End of Model development	» Summary of findings » Discussion on implications for research and practice » Limitations and future research	» Reflection of study findings and extant body of literature » Reflection of study findings and industry standards



Phase of corresponding research approach in [10]

FIGURE 3: Five step research approach

Data Sampling: The case selection was based on a theoretical sampling approach applying the criteria of “company size” (defined by turnover and number of employees) and “industry.” For each criterion, companies with different characteristics were included (small, medium-sized, and large companies as well as companies from different industries) to ensure a sample that is representational of the heavy equipment manufacturing industry in Germany, Austria, and Switzerland. The inclusion of companies from different industries should assure a holistic requirement evaluation and replication and mitigate the possibility of missing important potential requirements. The individual cases of this multiple case study are the analytical unit for the course of the research.

Data Collection and Analysis: Over a period of three months, from April 2012 to June 2012, a team of two researchers conducted seven exploratory case studies at worldwide leading heavy equipment manufacturing firms. For model evaluation, a confirmatory focus group involved four organizations. The interview partners were carefully selected to balance both the business view and the IS view of the company with the aim of avoiding a respondent bias in either of the views (Table 3). The ambiguity of the position descriptions in the participating companies called for multiple interviews to ensure an equal representation of both views.

Case company [Industry]	Employees > 10k	Turnover € > 5 Billion	Interview partner	Number of interviews
ALPHA [Industrial]	✓	✓	Process Automation; IS Manager	2
BETA [Industrial]	✓	✗	Vice President Service Division	2
GAMMA [Construction]	✗	✗	CIO; Head of Processes	2
DELTA [Industrial]	✓	✗	CIO	1
EPSILON [Industrial]	✓	✗	Head of IT Strategy & Transformation	1
ZETA [Utility]	✓	✓	CIO; Head of IT Strategy	2
ETA [Industrial]	✓	✓	Head of Corporate Solutions & Technology	1
THETA [Industrial]	✓	✗	Head of IT Services for Sales; Head of Customer Service	2
IOTA [Industrial]	✗	✗	Director of ERP Systems	1
KAPPA [Industrial]	✓	✓	CIO	1
LAMBDA [Industrial]	✓	✗	Head of Service Transformation	1

TABLE 3: Company profiles of the study participants

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Institute of Information Management
Chair of Prof. Dr. Walter Brenner
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www.iwi.unisg.ch

Graphic Design & Layout

Paul Grabowski
www.paulgrabowski.de

Authors

Alexander A. Neff is Research Associate at University of St. Gallen. You may contact him via phone at +41 71 224 3807 or by e-mail at alexander.neff@unisg.ch.

Prof. Dr. Falk Uebernickel is Assistant Professor for Information Management at University of St. Gallen. You may contact him via phone at +41 71 224 3774 or by e-mail at falk.uebernickel@unisg.ch.

Prof. Dr. Walter Brenner is Full Professor for Information Management at University of St. Gallen. You may contact him via phone at +41 71 224 2409 or by e-mail at walter.brenner@unisg.ch.

Contact

Institute of Information Management
Müller-Friedberg-Strasse 8, CH-9000 St. Gallen,
Switzerland
Tel.: +41 71 224 3807
Fax: +41 71 224 3296

