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Understanding the Business Value: Towards a Taxonomy of Industrial Use Scenarios enabled by Cyber-Physical Systems in the Equipment Manufacturing Industry

Matthias M. Herterich
University of St.Gallen, Institute of Information Management, matthias.herterich@unisg.ch

Manuel Holler
University of St.Gallen, Institute of Information Management, manuel.holler@unisg.ch

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

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

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Matthias M. Herterich
University of St.Gallen, Institute of Information Management
matthias.herterich@unisg.ch

Manuel Holler
University of St.Gallen, Institute of Information Management
manuel.holler@unisg.ch

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

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

Abstract
The trend of digitalization provides new opportunities for industrial equipment manufactures as sensor technology and ubiquitous connectivity become part of the equipment. In particular, cyber-physical systems (CPSs) enable digital innovation for the industrial product and service business by improving operational efficiencies, facilitating innovative hybrid business models, and fuelling servitization in manufacturing. Despite the new opportunities, so far no research has been conducted to investigate and classify configurations and affordances of this new technology. To gain both a broad and in-depth understanding of use scenarios and added-value of CPSs for the service business in the equipment industry, a multi-method approach is chosen: a systematic literature review as well as case study research are conducted. Grounded in existing literature and based on empirical data of 45 use scenarios, we propose a taxonomy to classify use scenarios enabled by CPSs in the equipment industry. This work contributes to the theoretical body of knowledge by proposing a taxonomy of use scenarios enabled by CPSs. The taxonomy can be (1) leveraged to categorize use scenarios of CPSs in the equipment manufacturing industry and (2) used as a framework for further research. Practitioners can use the taxonomy to classify and compare use scenarios as well as identify business model archetypes.

Keywords
Information Systems, Service Science, Product-Service Systems, Cyber-Physical Systems, Case Study, Affordances, Manufacturing, Business Models, Classification, Taxonomy, Use Scenarios

1. Introduction
The manufacturing industry is subject to major structural changes. With the ongoing trend of servitization in manufacturing (Lightfoot, Baines, & Smart, 2013; Oliva & Kallenberg, 2003),

the operations phase in the lifecycle of industrial equipment (Blinn, Nüttgens, Schlicker, Thomas, & Walter, 2008; J. Y. Lee, Choi, Kim, & Noh, 2011) and service business models (Lay, Schroeter, & Biege, 2009; Peters, Kromat, & Leimeister, 2015; Zolnowski, Schmitt, & Böhmann, 2011) have gained in importance over the last decade. Equipment manufacturers now pivot selling products to offer services and equipment performance. In productive use, breakdowns of such machinery are expensive, as they result in downtimes, loss of earnings, and expensive and time-consuming repair work. However, a transformation is taking place: due to increasingly pervasive digital technologies (Yoo, Boland, Lyytinen, & Majchrzak, 2012) both consumer- and industrial products become cyber-physical systems (CPSs) comprising hardware, sensors, software, and connectivity. Particularly in an industrial context, where considerably higher requirements in respect of reliability, equipment utilization, and capabilities that cut across and transcend traditional product boundaries exist (Annunziata & Evans, 2012), new technological capabilities foster digital innovation (Fichman, Dos Santos, & Zheng, 2014; Yoo, Henfridsson, & Lyytinen, 2010) and herald innovative and unexpected affordances. Hence, manufacturers strive to leverage the emerging technological capabilities of industrial CPSs to engineer better products, increase efficiency of their technical customer service processes for maintenance, repair and overhaul (MRO) and come up with new added-value services. Organizations in the equipment industry aim for transparency on the benefits of equipping their products with sensors and connectivity to make more informed investment decisions. However, they often struggle to identify a clear strategy of what capabilities are relevant and how to leverage the emerging technical capabilities. Despite endless use scenarios and affordances of CPSs, such as predictive maintenance or supporting field service with operational machine data, existing scholarly literature lacks a common and validated understanding of characteristics and configurations of industrial CPSs service scenarios. Thus, a clear understanding and categorization of the affordances of those scenarios is missing. Both researchers focusing on digital innovation and the service science community call for design knowledge in this area (Böhmann, Leimeister, & Möslein, 2014; Yoo et al., 2010). Given the lack of research concerning industrial use scenarios and affordances of CPSs, this paper aims to answer the following research question:

What are the categories and corresponding affordances of cyber-physical systems (CPSs) in the equipment manufacturing industry?

To answer this research question, the remainder of this paper is structured as follows: in Section 2, the theoretical foundation is outlined and relevant concepts are defined. Section 3 presents the applied research methodology. Section 4 presents the taxonomy as a whole and provides an exemplary scenario for each characteristic. The paper ends with a conclusion and an outlook on future research in this context.

2. Theoretical foundation

Over the last decade, the equipment manufacturing industry has changed significantly. With ‘servitization in manufacturing’ (Lightfoot et al., 2013; Wilkinson, Dainty, & Neely, 2009), besides selling products, service business is gaining importance for manufacturing firms also. As a consequence of this development a Service-Dominant logic and Service Science have emerged (Vargo & Lusch, 2004, 2008). Academics start to investigate services as a distinct phenomenon (Spohrer & Kwan, 2009). Based on the rather universal conceptualization of a service system (P.

Maglio, Bailey, & Gruhl, 2007; P. P. Maglio & Spohrer, 2008), the term product-service system refers to combinations of products and services, realized in an extended value creation network (Aurich, Fuchs, & Wagenknecht, 2006). As those industrial product- service systems are permeated with pervasive digital technologies (Yoo et al., 2012), the term cyber-physical system is emerging (Mikusz, 2014).

The term cyber-physical systems (CPSs) initially appeared in the domain of computer science, to describe the integration of computation and physical processes (E. A. Lee, 2008). In his pivotal study, Lee (2008) conceptualizes CPSs as systems in which collaborating computational elements control physical devices by exploiting data gathered from different sensors and other devices, which operate in the devices' environment. In information systems (IS) literature, the concept of CPSs is likewise on the rise (Mikusz, 2014) – in particular its practical application is predominantly driven by initiatives like the 'Industrial Internet' (Annunziata & Evans, 2012) and the Industry 4.0 initiative of the German government (Böhmann et al., 2014; Matzner & Scholta, 2014; Soeldner, Roth, Danzinger, & Moeslein, 2013; Zdravković, Noran, & Trajanović, 2014). In this paper we follow the broadly accepted conceptualization of CPSs being 'systems with embedded software [...], which directly record physical data using sensors and affect physical processes using actuators; evaluate and save recorded data, and actively or reactively interact both with the physical and digital world; are connected […] via digital communication facilities (wireless and/or wired, local and/or global); use globally available data and services; have a series of dedicated, multimodal human-machine interfaces' (Acatech, 2011, p. 15). The taxonomy proposed in this contribution classifies product service systems that leverage CPSs in an industrial context. In a business to consumer (B2C) context, the phenomenon of equipping mechanical or electronic products with sensors and connectivity to generate added-value by exploiting operational product data is also referred to as 'smart products' (Heppelmann & Porter, 2014; Xu & Ilic, 2014). According to Kiritsis (2011), a smart product contains sensing, memory, data processing, reasoning and communication capabilities at various intelligence levels.

When investigating the business value and usage of IS or technology in organizations, the concept of affordances provides a valid theoretical lens (Markus & Silver, 2008). Technology affordance describes an action potential of what individuals or organizations can accomplish with a specific technology or an IS (Majchrzak & Markus, 2012). Understanding affordances generated by specific technology in a selected field can help to understand and predict how this technology might drive the business in the future. (Pozzi, Pigni, & Vitari, 2014). For building our proposed taxonomy, the theory of affordances is used as a meta-characteristic (R. C. Nickerson, Varshney, & Muntermann, 2013) and theoretical lens, since our taxonomy aims at characterizing affordances of CPSs' use scenarios for the industrial service business.

3. Methodology

Taxonomies bring order in complex areas of research and provide fundamental research foundations (R. Nickerson, Varshney, Muntermann, & Isaac, 2009). Due to the novelty of the topic, an explorative qualitative research design was chosen (Dubé & Paré, 2003; Yin, 2008).

Assuming effective implementation of industrial CPSs, the purpose of our taxonomy is to distinguish between relevant industrial application scenarios of CPSs. The meta-characteristic that derives from this purpose are IT effects and affordances of IS usage (Markus & Silver, 2008). Anchoring our taxonomy in theory (R. C. Nickerson et al., 2013), the *theory of* *affordances* is used to address the 'possibilities for goal-oriented actions' (Chemero, 2003; Gibson, 1986) in harnessing industrial CPSs. Although taxonomies are a common type of artifact in IS research, methods for building taxonomies in the domain of IS are highly dispersed. While in the IS discipline, taxonomies are often built *ad hoc* (R. C. Nickerson et al., 2013), some researchers use more structured approaches (Bapna, Goes, Gupta, & Jin, 2004; Larsen, 2003). For the sake of a rigorous research design, we adapt the methodology proposed by Nickerson et al. (2013; 2009). We follow an iterative methodology, combining a *conceptual-to-empirical* approach and an *empirical-to-conceptual* approach (R. C. Nickerson et al., 2013). Figure 1 provides a schematic representation of the research methodology used for taxonomy building (R. C. Nickerson et al., 2013).

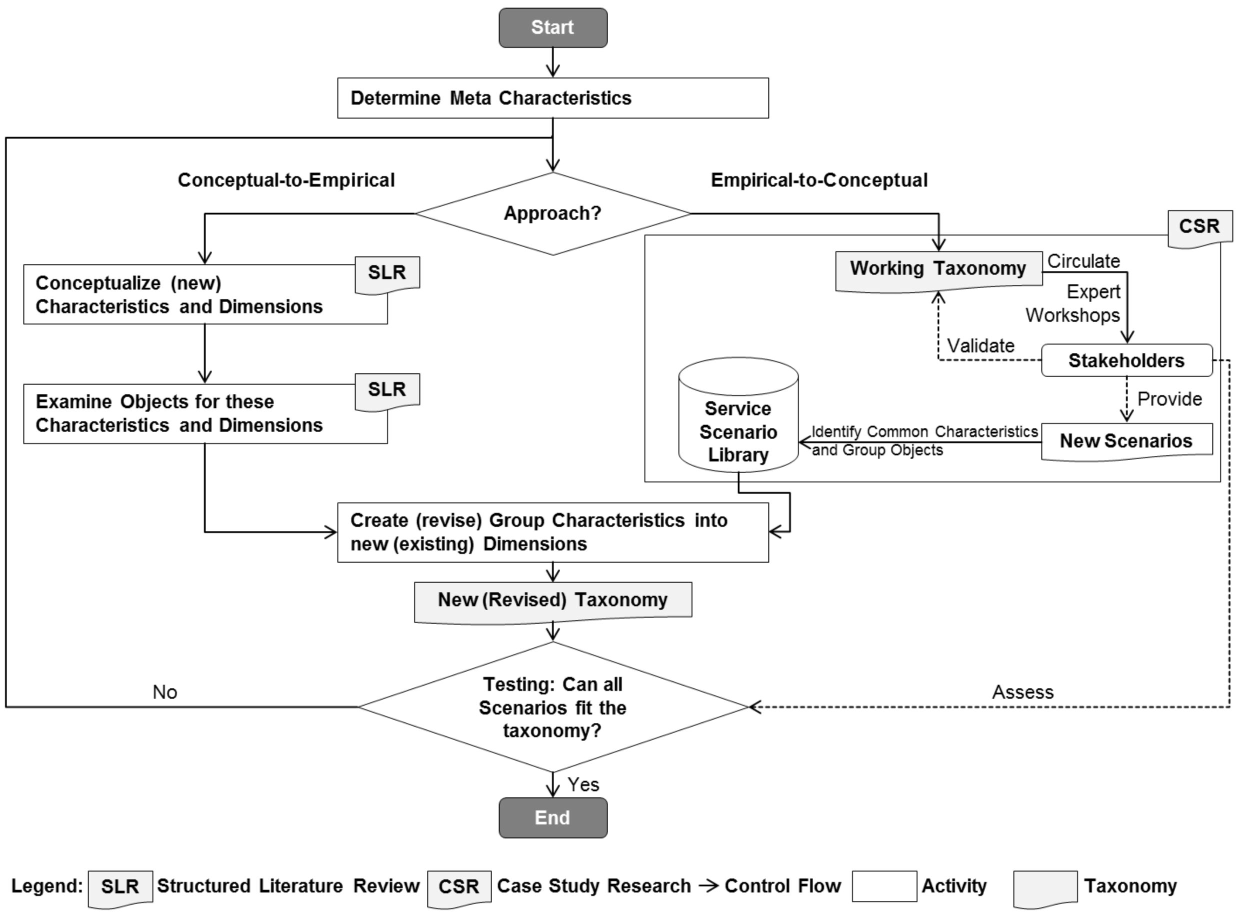

Figure 1: Schematic representation of adapted research methodology based on (Land, Smith, & Pang, 2013; R. C. Nickerson et al., 2013)

To build the taxonomy, a systematic literature review to identify existing work and potential dimensions of the taxonomy was conducted (conceptual-to-empirical). We started with the deductive approach to tie up with existing concepts. To obtain in-depth insights into practical application scenarios of CPSs, a 10-month soft case study (Braa & Vidgen, 1997) was carried out. Since qualitative research is often criticized for lacking in transparency (Eisenhardt, 1989; Yin, 2008), and the process of literature research is often not clearly outlined (Rowe, 2014), we followed a structured and transparent approach. Based on the insights, a service scenario library with 45 real-world use scenarios was set up as concrete instances (conceptual-to-empirical).

3.1 Literature review – conceptual-to-empirical

For the conceptual-to-empirical step, we conducted a systematic literature review based on the methodology suggested by vom Brocke et al. (2009) to (1) identify existing conceptualizations of potential dimensions and categories and (2) to obtain an overview of existing work. A keyword search was performed in the common databases for the IS domain. As the field of interest is very broad and cannot be captured solely by searching for permutations of the term *"cyber physical system"*, we iteratively refined the scope of the keyword search based on analyzing existing hits until we identified the following stable and comprehensive search term: *"cyber physical systems" OR "internet of things" OR "smart products" OR ("sensors" AND "connectivity") OR "embedded systems"*. We allowed peer-reviewed contributions in both journals and conferences and limited our search to title, abstract and keywords and a timeframe of the last 10 years (2006-2015) resulting in 1500 papers. Initially, title, abstract and keywords of the papers were read. Papers were included for further investigation when focusing on an industrial context and our understanding of CPSs (see Section 2). Papers that exclusively address technical topics (i.e., engineering, technical contributions on security and connectivity and technical understanding of embedded systems) or do not focus on industrial equipment were excluded. After applying inclusion and exclusion criteria, conducting forward/backward searches and eliminating duplicates, we obtained a set of 79 papers for in-depth investigation (see Table 1).

Database	Keyword search	Net hits after applying incl. & excl. criteria
AISeL	279	19
EBSCOhost	625	13
Emerald	369	16
ProQuest	91	13
ScienceDirect*	94	13
Web of Science*	42	2
Forward and backward search	-	3
Net hits	**1500**	**79**

*'AND "industrial"' was added for ScienceDirect (Web of Science) to further reduce the initial results from 1838 (6191) to 94 (42)

Table 1: Results of keyword search

3.2 Case study research – empirical-to-conceptual

The majority of IS taxonomies are based on case study research (Land et al., 2013). As the unit of analysis of this work is service scenarios leveraging CPSs in the equipment industry, we followed an interpretative case study approach. In IS research, the case study approach is a proven methodology for identifying use scenarios of emerging technology in a dedicated context (Braa & Vidgen, 1997; Kuschel & Dahlbom, 2007). Unlike the positivist paradigm, when following an interpretative approach, researchers try to 'understand the insiders' viewpoint, even going as far as becoming one of the insiders themselves' (Braa & Vidgen, 1999, p. 27). Interpretative case studies focus on generating a very deep understanding of a specific phenomenon rather than quantifying and confirming. Hence, we conducted an interpretative soft case study (Braa & Vidgen, 1999) in collaboration with one of the largest multinational conglomerate corporations in the manufacturing industry with a highly diversified product and service portfolio. The particular organization was chosen as they were about to equip their machinery in the field with sensor technology and connectivity mainly to increase internal efficiencies in the traditional MRO service business. The in-depth case study was conducted between March 2014 and December 2014. Besides the close collaboration in the strategic innovation project, we carried out two ethnographic field studies (Schultze, 2000) with service technicians, conducted expert sessions with product and service managers and had comprehensive access to documents of a strategic initiative on implementing CPSs. This allowed us to obtain a holistic picture of how the technological capabilities of CPSs are harnessed in different use contexts. Based on an in-depth understanding of the equipment industry, three focus group workshops with a total of 38 participants, and documents on a strategic initiative on implementing CPSs, were leveraged to identify and collect 45 concrete and practical CPSs service scenarios that were either discussed or implemented in the case organization. Focus group participants were characterized by high diversity – ranging from managerial, technical, and operative employees from different business areas to cover a broad range of application contexts. Scenarios were collected in a standardized format (scenario profile card) as suggested by Nickerson et al. (2013; 2009). Table 2 provides an example of a service scenario profile card. Each profile card consists of a descriptive title and a short textual description. A preliminary classification in our intermediate taxonomy results is provided as well as a unique identification number.

<table>
<tr><td>ID</td><td colspan="13">13</td></tr>
<tr><td>Title</td><td colspan="13">Leverage rotation sound sensor for predictive maintenance</td></tr>
<tr><td>Abstract</td><td colspan="13">Bloch and Geitner (1983) have noted that 99% of all machine failures are preceded by certain signs, conditions, or indications that a failure was going to occur. In many cases, first signs can be noticed already weeks or even months before a failure or breakdown. P-f curves describe the relationship of equipment performance depending on the time.
For instance, anomalies can be identified, based on ultra sound long before they can be recognized by human touch (thermography and vibration) or trained ears. In case of rotating assets/equipment such as wind turbines in onshore/offshore wind parks, based on the p-f curve, rotation and vibration sensors based on ultra sound as part of CPSs can be used to identify potential failures or breakdowns. Based on industry specific algorithms and historic data, predictive maintenance can be scheduled before the actual breakdown happens, resulting in equipment downtimes can be minimized.</td></tr>
<tr><td rowspan="4">Classification</td><td>Technical affordances of CPSs for realization of industrial use scenarios</td><td colspan="3">Monitor</td><td colspan="3">Control</td><td colspan="3">Optimize</td><td colspan="3">Automate</td></tr>
<tr><td>Service recipient</td><td colspan="6">SSP</td><td colspan="6">SSC</td></tr>
<tr><td>Addressed product/service lifecycle phase</td><td colspan="4">BOL</td><td colspan="4">MOL</td><td colspan="4">EOL</td></tr>
<tr><td>Ecosystem Perspective: Stakeholder groups benefiting from industrial CPSs service scenario</td><td colspan="3">Manufacturer</td><td colspan="3">Operator</td><td colspan="6">Service Organization</td></tr>
</table>

Table 2: Example of a service scenario profile card

Based on the scenario profile cards, the 45 scenarios were discussed and evaluated in expert interviews with six subject matter experts responsible for regional service subsidiaries of our case organization. Comments made by the subject matter experts were recorded and entered thoroughly in our scenario library shortly after the interviews took place.

4. Results

Net hits from the literature review were screened. To our best knowledge, no comprehensive research on taxonomies in the domain of interest could be identified. The following isolated constructs and frameworks could be identified due to the novelty of the topic: Maass and Varshney (2008) provide a framework for smart products with six general dimensions (situatedness, personalization, adaptiveness, proactivity, business-awareness, network capability). Nonetheless, the proposed framework is only valid in a consumer context. However, the following contributions were used to anchor the dimensions and categories of our proposed taxonomy in existing concepts identified in the literature: first, Heppelmann and Porter (2014) identify four capability levels of smart, connected products, namely *monitor*, *control*, *optimize*, and *automate*. Likewise, Kiritsis (2011) identifies four levels of intelligence in intelligent products. As they share the technical affordance perspective, we identified this as the first dimension of our taxonomy. Second, Mathieu (2001) sees that industrial services are becoming increasingly important and complex due to the servitization trend. To deal with the complexity, she provides a classification scheme for product services by distinguishing between s*ervices supporting the supplier's product (SSP)* and *services supporting the client's (operator's) actions (SSC).* This differentiation was also identified as helpful in focus group workshops. Third, Kiritsis (2011) as well as Aurich et al. (2006) distinguish between high-level lifecycle phases of industrial products, namely *beginning of life (BOL)*, *mid-life (MOL)* and *end of life (EOL)*. Case study results also indicate that CPS might impact on different lifecycle stages. However, most affordances could be identified in the operations phase for equipment operations and equipment service. Fourth, affordances targeting different stakeholders are generated based on the stakeholder ecosystem during the industrial equipment lifecycle.

According to Nickerson et al. (2013; 2009), the meta-characteristic of the taxonomy should be based on the purpose of the taxonomy and grounded in theory. By iteratively combining the findings from the conceptual-to-empirical step (SLR) and the in-depth insights generated from the case study research (CSR), an initial version of a taxonomy could be derived. Table 3 presents the dimensions and according characteristics. For each characteristic, a description as well as an example is given.

Dimension 1: Technical affordances of CPSs for realization of industrial use scenarios (Chen, Chiang, & Storey, 2012; Heppelmann & Porter, 2014; Kiritsis, 2011)		
Characteristic	Description	Industrial CPSs service scenario example
Monitor	CPSs enable the collection of data through sensors and external data sources. Collected data can serve to monitor the equipment operation and is valuable for various service scenarios. For instance, collected data enables alerts and notification of changes. Monitoring the condition and external environment of the equipment generates insights about the equipment's operation and usage.	Industrial cranes are constantly monitored by the manufacturer. In case of exceeding the maximum weight, no more warranty claims expire and the customer has to charge for service.
Control	Control capabilities build on the preceding monitoring capabilities. Based on a return path, (remote) service technicians can perform a remote diagnosis and actively control dedicated functionality of the equipment. For instance, a reset of the operating system could be performed. Dedicated features of the equipment can be customized, depending on the individual preferences of the operator.	With remote diagnosis, a malfunction could be identified at the doors of an elevator at level 23. As the malfunction has a mechanic reason, the level is disabled until a technician fixes the problem. Elevator displays make the fault visible to passengers.
Optimize	Having technical capabilities to monitor and control equipment, equipment operations can be optimized by using advanced industry-specific business intelligence and analytics (BI&A) capabilities (Chen et al., 2012). Asset operations can be optimized based on internal sensor data or external data sources. Thinking about MRO activities, predictive diagnostics, service and repair become possible. By performing statistical analysis of operational sensor data, maintenance activities can be optimized to maximize the uptime of the equipment by performing predictive diagnostics. Mobile workforce can be dispatched in an optimized way.	Based on equipment usage/condition, routes and schedules field service staff for maintenance, repair and overhaul (MRO) is optimized to increase operational service efficiency.
Automate	The combination of the previous three areas allows CPSs to achieve a new level of autonomy. Depending on the level of	At an airport, the in-facility transportation (i.e., elevators and escalators) of (transit)

	intelligence of the product, products can even learn about their environment, self-diagnose their own service need and adapt to the customer's preferences. The coordinated action of an autonomous product with other products or systems is also possible. As more and more products become connected, the value of this capability can grow exponentially.	passengers is optimized and automated based flight schedules.
Dimension 2: Service recipient (Mathieu, 2001)		
Characteristic	Description	Industrial CPSs service scenario example
SSP	SSPs are (industrial) services that support the supplier's product.	Sensor data is used to realize predictive maintenance for the passenger transportation equipment at an international airport. Product downtimes are minimized.
SSC	SSCs are (industrial) services that support the client's or operator's actions in relation to the supplier's products.	The operator of an airport leverages connected passenger transportation equipment (i.e. elevators and escalators) to control large people flows effectively (e.g. transit passengers are usually separated from domestic passengers). This is achieved by connecting the building- and flight control systems with the equipment control system.
Dimension 3: Addressed product/service lifecycle phase (Aurich et al., 2006; Becker et al., 2009; Becker, Beverungen, Knackstedt, Matzner, & Muller, 2011; Blinn et al., 2008; Kiritsis, 2011; Mathieu, 2001)		
Characteristic	Description	Industrial CPSs service scenario example
Planning Phase (BOL)	Beginning of life (BOL); conceptualization, definition and realization of equipment. Industrial service scenarios of CPSs primarily focus on engineering better assets based on data from operations in the field. Data collected by CPSs can be analyzed ex-post to identify weaknesses of equipment in operation.	Detailed analysis of failure statistics of forklifts can be used to engineer better equipment. Operational data helps to identify weak points. Analysis can be offered as a service for R&D and product engineering.
Operation Phase (MOL)	Mid-life (MOL); use, service and maintenance. For manufacturers of industrial equipment the service business is getting more and more important (Biege, Lay, & Buschak, 2012; Grönroos & Helle, 2010; Lightfoot et al., 2013; Oliva & Kallenberg, 2003; Ulaga & Reinartz, 2011; Wilkinson et al., 2009). Case study insights and concrete service scenarios suggest that most CPSs affordances are realized in the operation phase by increasing service efficiencies. Based on concrete industrial CPSs scenarios, the following sub-categories are identified: • Optimized equipment operations • Trigger field service activities • Support field service activities • Replace field service activities	Based on sensors, an elevator can adjust the levelling of its stops automatically. This results in replacement of field service activity. Another example for triggering field services is performing maintenance of elevators based on based on equipment utilization instead of static maintenance cycles (e.g. every 6 months).
Replacement Phase (EOL)	End of life (EOL); characterized by various scenarios such as: reuse of the product with refurbishing, reuse of components with disassembly and refurbishing, material reclamation without disassembly, material reclamation with disassembly and, finally, disposal with or without incineration.	Operational data can be used for usage analysis. Insights might help to decide on equipment characteristics of succeeding equipment.
Dimension 4: Ecosystem Perspective: Stakeholder groups benefiting from industrial CPSs service scenario (Ray, Muhanna, & Barney, 2005; Xu & Ilic, 2014)		
Characteristic	Description	Industrial CPSs service scenario example
Manufacturer	The manufacturer is responsible for engineering and production of the equipment.	Sensor data from CPSs can be fed back in the engineering process of the manufacturer to engineer better equipment.
Industrial Equipment Operator	Industrial equipment is used by the industrial equipment operator for its own value creation. The industrial equipment manufacturer is interested in a minimized downtime of the equipment, based on maintenance or repair activities and low operating costs.	Sensor data from CPSs can be made available via standardized interfaces and used to report and proof the performance that has been contractually specified. This would result in higher transparency and increases customer loyalty.

Service Organization	During the operations lifecycle phase, dedicated service organizations are responsible for proper and safe operations of the equipment. Often, manufacturers also run service organizations and sell the equipment, bundled with MRO services as hybrid offerings and PSS to exploit their market power and knowledge about the equipment.	Continuously analyzing operational equipment data can help to improve internal operational efficiency as competitive advantage.

Table 3: Taxonomy of industrial service scenarios of CPSs in the equipment manufacturing industry

5. Contribution, limitations, and outlook

Anchored in existing literature and based on 45 use scenarios identified in an in-depth case study, this paper presents an early version of a taxonomy for classifying service scenarios leveraging CPSs in the manufacturing equipment industry. For scholars the taxonomy serves as a guiding element for future research on the affordances of CPSs in an industrial context. The results of this analysis have shown that CPSs can be leveraged during the lifecycle of industrial equipment to engineer better equipment and can provide added value in many ways. Above all, CPSs can realize internal operational efficiencies in the service business. Besides, our investigation has shown that industrial CPSs might also serve as an enabler to exploit unexpected opportunities and create new (service) business models. To succeed in a cyber-physical environment, managers need to formulate clear business strategies, go-to-market strategies, and business models, as well as core operations to stay competitive and find a sustainable position in the fast-paced and highly volatile ecosystem. Practitioners might use this work as a framework to identify functional affordances as well as white spots of smart equipment operations. Finally, our contribution exhibits some limitations. First, due to the qualitative nature of this research, it cannot be ensured that the phenomenon at hand has been explored in an exhaustive way. To increase validity, future work should validate the results in a different industry. Second, we only had access to a single organizational entity for conducting the in-depth global case study. In the future, the presented taxonomy has to be validated in additional industries.

As industrial equipment is characterized by long life cycles (Blinn et al., 2008), it is difficult for manufacturing and service organizations to add sensors and connectivity to the variety of existing equipment classes. Manufacturing equipment that is already installed at the customers' facilities, results in high investment costs. Hence, implementation might take some time and resources until affordances can be realized.

Future research should focus on identifying archetypes of service scenarios based on the taxonomy. We plan to use the taxonomy for evaluating new (service) business models (Zolnowski et al., 2011) enabled by CPSs. Moreover, taking a technology perspective, the taxonomy might help as a structuring element to derive design principles for an adequate IS architecture supporting industrial CPSs.

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