# Value oriented and integrated development of smart services with systems engineering - a practical methodology


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**Structured Abstract**


The integrated view of smart services is a young approach in systems engineering, through which a reduction of the overall resource consumption, better service consistency, maintenance, higher quality performances, and, in result, higher sustainability can be achieved. Still, development methodologies need to adapt to practical challenges. Firstly, regarding the collaborative integration of important stakeholders, industrial project sometimes face limited resources and need a streamlined methodology for systems engineering. Secondly, considering the synthesis from requirements to system functions and to the physical structure, current methodologies lack in guidance for defining the level of abstraction on which system elements are defined. Thirdly, new approaches are needed to integrate available resources and perceived qualities in context with sourcing options of smart services, as there is a new, complex challenge of designing product-service-systems. This research presents a streamlined, collaborative methodology for designing smart services that is validated in an industrial use case of digitalizing a value stream in a company for jewellery production.





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# 1 Introduction

## 1.1 Relevance of Smart Services

The digital transformation of economies and societies is one of the currently ongoing megatrends worldwide. The advancing equipment of machines and products with sensors and connectivity as well as their intelligent interconnection among each other leads to a mergence between physical and virtual worlds. (Herterich et al., 2016) This development is not limited to smart production systems in terms of an “Industry 4.0” only, but affects nearly all relevant application fields (e.g. mobility, health or energy). (Neuhüttler, 2015) Vast amounts of data collected in the “Internet of Things” hold substantial potentials for developing innovative service systems. (Schüritz et al., 2017) In this context, “Smart Services” describe data-based, individually configurable bundles of services, digital applications as well as products, which are usually organized and performed on integrated service platforms. (Bullinger et al., 2017) The concept addresses the intelligent analysis and combination of collected data and the transformation into user-centered service offers that lead to an added value for both, service providers as well as customers. One central component of Smart Services are integrated service platforms, on which unstructured data is turned into structured data and physically delivered services, digital services and physical elements are combined to solutions. Based on contextualized customer information, the combination is conducted rather customer- than provider-oriented. In advanced Smart Service Systems, solution elements and resources are even combined across company boarders. Therefore, significant changes of operational processes, business models and even whole value creation systems are required. (Bullinger et al., 2017)

The disruptive potential of smart services highly depends on the digital maturity level of branches as well as characteristics of targeted solutions. In many areas, data is already used in order to improve existing service offers and to exploit quality and productivity potentials. One example can be seen in remote services, such as “Predictive Maintenance”, where machine data is used for optimizing the maintenance processes of service technicians and to ensure a continuous availability. Based on the continuous collection and analysis of physical machine data for conspicuous patterns, manufacturers can plan maintenance intervals demand-oriented as well as identify potential failures in advance and thus prevent breakdowns of their plants and machines. As a result, the usage of data leads to benefits for providers and customers. However, smart services are also linked to a number of challenges, such as the definition of algorithms for analysing data patterns or the provision of real-time data for service technicians. Especially small and medium-sized companies (SME) often do not possess competences to cope with these new challenges and thus are depending on external partners, such as software providers or data specialists. Consequently, the companies´ value creation system is expanding. (Jernigan et al., 2016) However, the concept of Smart Services comprises more than a digital improvement of existing services. The collection and combination of data from different sources (e.g. devices, sensors or machines) holds vast potentials for developing completely new service systems. Popular scenarios are indicating that integrated service platforms could thereby play the role of fully automated market places, where products, services, production capacities or data is traded between suppliers and consumers across



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company borders. The required modularization of traded elements is expected to lead to a higher flexibility of solutions as well as a higher degree of capacity utilization and shorter response times. Operators of these integrated service platforms take the role of orchestrators of resources and thus occupy the customer interface. (Scheer, 2016) This also leads to a massive transformation of existing value creation systems and forces participating companies to adapt their business models to more collaborative value creation.

## *1.2 Challenges and Requirements*

Although both stated examples of Smart Service offers represent a different level of data deployment and digitization, they have one main implication for companies in common: the need for additional competences and external data leads to a highly collaborative value creation in complex service ecosystems. (Wieland et al., 2012) Consequently, companies are forced to develop new smart services collaboratively and to integrate and synchronize solution components (e.g. services, data analysis or infrastructure) of different ecosystem stakeholders. (Neuhüttler et al., 2018) Moreover, the development needs to take the specific Smart Service characteristics into account and allow an integrated view on all internal and external solution components: Physical Product, Smart Technologies as well as digital and personally delivered services. So far, scientific literature has not delivered respective approaches and methods to support such a collaborative process. (Wuenderlich et al., 2015) Provided approaches and methods from service engineering literature, for example, are not suitable, because they do not sufficiently consider the physical and digital elements and their specifics. In reverse, product and software engineering approaches neglect elements and characteristics of personally delivered services. Therefore, new approaches that allow an integrated development of Smart Services are required.

Another major challenge in developing smart services is seen in developing concepts that transform data potentials into a substantial added-value for customers (Lim et al., 2018). From the customers´ point of view, smart services are not only linked to potentials but also to a number of risks, such as data security and privacy or a perceived loss of control (Paluch and Wünderlich, 2016). Consequently, companies have to design their data-based concepts in a way that the perceived value exceeds existing risks and concerns. Therefore, manufacturers have to develop smart services in a way that the perceived value is exceeding the perceived risks and uncertainties of potential customers. However, academic literature with regard to industrial smart services is still in its infancy and provides only little knowledge about customer expectations or appropriate methods for designing smart service successfully. (Wuenderlich et al., 2015) In this context, understanding how customers perceive and evaluate quality of smart services is a highly relevant research issue (Maglio and Lim, 2016) that supports companies to develop and design smart services that meet the needs of their customers in a better way. Although quality perceptions of individual smart service elements (e.g. digital or personal services) are well analyzed, little is known regarding the perceptions of their data-based combination into integrated smart service solutions. (Neuhuettler et al., 2017)

### 1.3 *Quality Perceptions for a value-oriented development of Smart Services*

For simple products, objective criteria, such as durability or resource consumption, are appropriate for quality evaluation. For predominantly intangible and highly complex solutions it is more difficult to define objective criteria, since customers cannot touch them or might lack the necessary expertise to evaluate them objectively. Therefore, quality in the realm of smart services needs to be regarded as a subjective construct, relying on the comparison between expected and perceived fulfillment of relevant needs and requirements. (Zeithaml, 1988) For this reason Neuhüttler et al. 2019 presented a quality framework that outlines relevant categories and aspects of quality perceptions. The framework (see Fig. 01) consists of 12 fields to describe Smart Service concepts. It is structured by the four relevant elements of Smart Service concepts “Technology and Data”, “Digital Services”, “Personal Services”, “Integration” and the three dimensions “Resource”, “Process” and “Outcome”. For each of the resulting 12 fields, relevant quality categories were assigned from existing quality models in respective literature streams as well as they were complemented by new and more specific ones. The „resource“ dimension addresses quality aspects of the Smart Service prerequisites. Besides traditional quality dimensions (e.g. appearance and structure of digital applications, competences and equipment of employees or physical characteristics of technology), following new dimensions become important (selection):

- Data privacy issues (e.g. the perceived connection between collected data and their necessity for providing promised value)
- Perceived embeddedness of sensor technologies in the working environment of users, e.g. in regard of perceived surveillance
- Collaboration possibilities with other Smart Service platforms (e.g. by providing relevant API and data formats).
- Projected size of installed product base and additional data sources for providing intelligent solutions.

The process dimension addresses personal and digital activities for providing the Smart Service. This considers the integration of intelligent products like human-to-human, human-to-machine as well as machine-to-machine interactions. Exemplary new aspects that influence perceived quality are:

- The integration of physical, digital and personally delivered activities
- Automatic adaption of processes to the context and situation of customers
- New forms of collaboration between customer and provider and the depth of integration into customer processes
- Perceived control options for intangible activities and automated decisions

•	Empathy of systems and contextualized information provision

•	Transparency, comprehensibility and ethics of algorithms

The outcome dimension addresses the value provided by each of the Smart Service elements as well as its contribution to the overall Smart Service value. In many cases, the outcome of the sensing technology (e.g. perceived data consistency) builds the basis for the outcome of the digital (e.g. information visualization) or personal (e.g. solving a machine failure) service. The integration of the different outcomes is also of high importance as well as the individual adaption to the customer situation. Moreover, new result categories (e.g. emotional value or the joy of using an adaptable solution) are mentioned in the provided framework. Stated quality categories provide a good overview about the relevant aspect of customer quality perceptions and thus work as indicators to evaluate and address perceived value in a systematic and structured way.

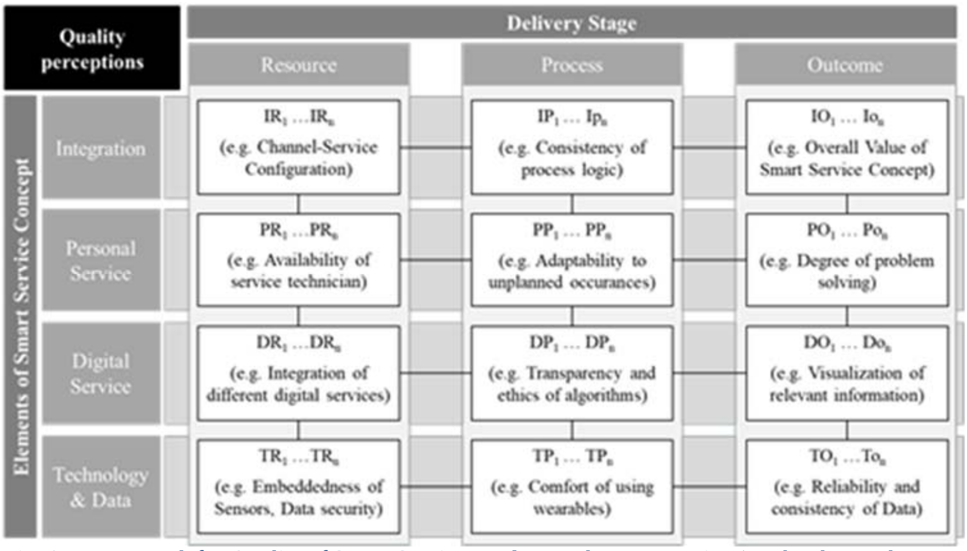

*Fig. 01 Framework for Quality of Smart Services and exemplary categories (Neuhüttler et al., 2018)*

## *1.4 Smart Services in Systems Engineering*

Model Based Systems Engineering is the standard paradigm of integrated development of product-service-systems such as smart services or cyber physical systems. (Eigner et al., 2017) It deals with the rising complexity of products developed and needed integration of multidisciplinary teams in the engineering design. It not only supports the development process, but also gives a holistic view on the system lifecycle. (Eigner et al., 2016) Recent research dealt with the integrated development of product-service systems with the systems modelling language (SysML). (Friedenthal, 2014) Some approaches included physical products or systems combined with services under a sustainability viewpoint. (Apostolov et al., 2018) The integrated view of smart services is a young approach in systems engineering, through which a reduction of the overall resource consumption, better service consistency, maintenance, higher quality performances, and, in result, higher sustainability can be achieved (Apostolov et al., 2018; Hara et al., 2017; Neuhüttler et al., 2019). In the following the layers of the model framework for systems engineering is described based on the frameworks developed for cybertronic systems (Eigner et al., 2016) and for product-service-systems (Apostolov et al., 2018).

1. The first layer represents the context of the system to be developed. At this stage, the system is seen as a black box. It includes elements that provide constraints or interests regarding the system, such as business requirements, required machines, customer groups, or employees that work with the system. Therefore, each context element results in a bundle of requirements on other elements on each of the following layers. However, the requirements as well as the validation measures are seen as spaces that span across all the mentioned layers of systems engineering. Other important elements of the system context are the use cases, which are further defined in activity diagrams.

2. The second layer represents the system functions, which aim to describe the system independently from technical solutions to be used. Functional elements enable the expected behaviour at context level and ought to be described non-redundantly and hierarchically. However, the functional layer includes the first decision whether to implement a part of a product-service-system as a product or as a service.

3. The third layer describes the logical blocks or principle solutions of technical means that realize the intended functions. It is an important method in systems engineering to generate options for principle solutions based on e.g. life performance or costs. In a product-service-system, the previously defined activities are detailed in concrete operations or product components. This layer also includes the definition of the general information flow model.

4. The fourth layer constitutes the technical solutions which are the most concrete but still abstract elements in the system model. A characteristic of these elements is that they are explicitly assigned without overlapping with organizational units that are responsible for them. In this dimension, the transfer from systems engineering to discipline-specific development is defined and collaboration of experts becomes necessary. In a product-service-system this layer includes the documentation, e.g. for conducting activities in services or IT-specifications.

### *1.5 Application in the »Business Innovation Engineering Center BIEC«*

The presented research is carried as part of the »Business Innovation Engineering Center BIEC«, which is funded by the Ministry of Economic Affairs, Labour and Housing Baden-Württemberg. The main task of BIEC is to support small and medium-sized enterprises in increasing their digital transformation and innovation capabilities. BIEC provides different transfer services to SME in six relevant application fields of digital transformation: Smart Products and Services, AI and Data-driven Business, New digital Technologies, Collaborative Value Creation, Business Model Innovation as well as Organization and Leadership. Within the topic “Smart Products and Services”, one of the



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transfer measures are coachings, in which SME are taught relevant methods and instruments to develop smart services within their companies with the help of research associates. One of the participants of the BIEC program was the Friedrich Binder GmbH & Co. KG: the market leader for jewellery chain production in Germany. One of the key success factors for this leadership is a continuous development and automatization of the machinery and work processes. The jewellery is produced with full vertical range of manufacturing, closely integrated supplier management and high automatization. Important production assets are turning and milling technologies in which Friedrich Binder is pioneering. The company participated with the vision to digitalize one of their value streams in an older division. The project was initiated with a team consisting of innovatively thinking members of different functional units such as head of department with operative authority, production control and middle management. One of the goals for designing the system was to clear up the vision and the goal, the required system functions and to discuss the implementation options. However, since the initiative was not yet supported with budget, the resources were limited. Furthermore, the different involved stakeholders challenged to find a collaborative approach in systems engineering.

## 2 Challenges in systems engineering for the application case

### *2.1 Limited resources for development*

In research literature, little guidance was found on a streamlined procedure to generate reliable outcomes and first drafts of the system to be designed. Especially when involving important stakeholders such as customers, works council or upper management, the available time for sitting and working together is limited. However, an involvement in the development process is crucial. One solution approach is to involve the stakeholders in a collaborative manner like in a one-day workshop or with the focus group methodology, which is a more structured combination of a workshop and interview method. Another approach can be to generate quick results and drafts of a system model and communicate it to the relevant groups.

### *2.2 Synthesis from requirements to function to physical structure*

One of the main challenges in systems engineering is the synthesis from function to physical structure. (Ueda et al., 2017) Ueda, Takenaka, and Nishino explain that the basic principle in engineering is to collect, select, configure and structure knowledge and design an entire structure from partial knowledge. This results in an asymmetric process in extracting knowledge or configuring systems. Hehenberger explicitly states that one of the most frequent challenges of functional models is to define the functions. Even when using the same systematic approach, a different representation of a system’s functionalities will occur. (Hehenberger, 2014) Various literature sources approach to analyse the problem of abstraction. However, too few sources gives guidance which level of detail to consider and how to derive the functional or logical layer in systems engineering. (Hehenberger, 2014) Generally, the procedure of systems engineering frameworks is to work from system context down to the level of single components and results in the concretization of technical solutions. (Anderl and Nattermann, 2012; Apostolov et al., 2018; Eigner et al., 2016) The methodology for the modelling language

SyML suggests a zigzag-pattern. (Weilkiens et al., 2015) It describes a relation between the requirements layer and the different architectural descriptions of the product. It suggests to further detail the requirements after new architectural modules such as functions have been defined. The single layers in system engineering frameworks cannot be processed one after each other. Especially in a collaborative approach, people need systematic guidance for the work with different levels of fidelity, i.e. levels of abstraction. The freedom of defining functional or logical blocks in different levels of abstraction leads to difficulties in matching the different layers of the systems engineering model such as matching between applications (in SysML represented in the context and functional layer) and technologies (in SysML represented in the logical and physical layer). This task requires a great technical expertise and knowledge of e.g. inner available resources, company strategies and company external, available provider and sources. A better-structured, guided deduction from one level to the other or a matching procedure between applications and technologies, especially for the use in workshops, is needed.

### *2.3 Consideration of values and qualities not only as requirements*

Considering non-technical aspects, such as value or quality, perception by customers or stakeholders in the development of product-service-systems with SysML is a very young research field. Eigner et al. developed a method for considering sustainability aspects in systems development. (Eigner et al., 2017) Their approach is to ensure the traceability of the key drivers for a value, such as the motor of a vehicle is the key driver for CO2-emission, and calculate according use cases provided by the system models. Neuhüttler et al. developed a framework for “customer quality perception” of smart services. (Neuhuettler et al., 2017) However, no approach was found to support a systematic, streamlined methodology for considering the different perceived values of smart services during the development phase.

## 3 Research Design

Systems engineering is seen as a well-developed methodology in industry. However, facing the above-mentioned challenges only little guidance was found in literature. The overarching research goal is to develop a streamlined methodology for designing the interface between the functional and the physical layer of a smart service system under the consideration of values such as perceived quality, and the interdependence with sourcing options. Furthermore, the method should be practically used in projects with limited resources, like in one-day workshops. Based on these challenges, existing methodologies and approaches in systems engineering have been adapted to create a resource efficient and targeted process considering the digitalization of a value stream part. The chosen approach for the methodology to be developed is a practical usability for workshops. Workshops in this context are facilitated group collaborations where outcomes are visualized on post-its, flipcharts, whiteboards, and other workshop materials.

The basic logic of the workshop procedure is to discuss and elaborate system models in a cause-effect context. Requirements are elaborated when they are needed; the environmental context is detailed when it is necessary. In this way, the stakeholder to be involved can participate just in parts of the workshop and does not need to be present the whole time. Another advantage is to develop closely the systems modalities along given conditions. Guided, streamlined decisions of modality options are rarely supported by literature. Moreover, elaborating the system elements in their context supports a far better understanding. This approach differs from the SysMOD zigzag-pattern which describes the occurrence of new requirements based on identifying more detailed system elements that are not thought about before. The approach in this work separates the requirements in categories that are elaborated at different phases. Furthermore, the approach in this work is to introduce the concept of smart service modalities in the logical layer instead of in the functional layer. The general steps are shown in Fig. 02 and explained in the following.

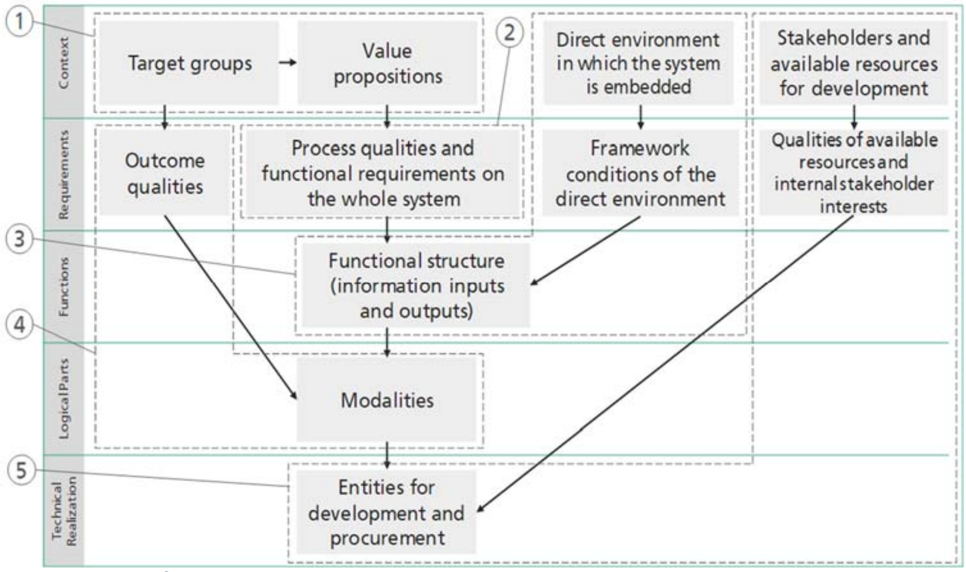


*Fig. 2 Practical five step procedure to develop collaboratively smart service systems*

For the consolidation of the method hypothesis, the developed systems models are discussed in their entirety regarding feasibility and completeness after the conducted workshop. The subsequent steps include a preparation of the results and finally the company internal communication in management, development department, procurement, and other initially identified stakeholders. The goal is to gain financial and moral support and verify the feasibility of the concept. For validation of the developed workshop format and success evaluation of the outcomes, both workshop participants and facilitator are asked for feedback on the procedure and comprehensibility.

### *3.1 Step 0: Preparation phase*

The operative goal of the workshop for system development was to structure the available knowledge. One measure to assure the availability of knowledge is to gather internal knowledge carriers of the company, such as engineers that are familiar with the internal development processes, members of the IT support team, participants of the works council, or sales persons. Another measure is to organize preliminary workshops and homework for the companies in which the prerequisites for the system development workshop could be prepared, such as the development of future scenarios or design thinking workshops. These tasks were conducted within the BIEC program.

### *3.2 Step 1: Development of the basic context*

Systems engineering uses the context layer for defining the borders of the system while the system itself remains as a black box in this stage. Important components of the system context are human and machine actors that set up the basic functional requirements, frame conditions, or use the system. This step is especially important for setting up the scope and focus of the system to be designed. At first, the target groups and value propositions are listed. Since workshop participants include a variety of stakeholders and potential users of the system, a structuring is needed that distinguishes between different subsystems. The collected groups and values are clustered by the connection among them. The goal is to create consistent clusters so that each cluster has a minimum of "target group-value proposition-pairs" but no cross-link of a target groups to value propositions of other clusters. For example: a controller as well as a project manager have an interest in traceability of the production costs. A machine worker is interested in an ergonomic work place. The controller, however, has no direct interest in the workers work place and the worker has no interest in production control. The identified clusters are subsystems that can be developed separately or after each other which is crucial in a bigger context of e.g. digitalizing a factory. The subsystems can be chosen strategically.

### *3.3 Step 2: Core functional requirements*

The identification of relevant requirements in systems engineering is often achieved through methods such as interviews or creativity methods. (Daniel Angermeier, 2006) The SysML methodology provides the derivation from use cases. (Weilkiens et al., 2015) For the methodology in this research the requirements are categorized by the SysML context elements and therefore in the order of usage. The categories are "basic functional requirements", "framework conditions of the direct environment", "outcome qualities", and "qualities of available resources and internal stakeholder interests". These categories are not elaborated in one step but one after each other at the time when they become relevant. In this second step, process qualities and functional requirements on the whole system are defined. Functions describe an input-output-logic where a transformation of energy, substance or signals takes place. (Feldhusen et al., 2013) The leading question is which functions are necessary to generate the initially stated value propositions. It especially includes the personal and digital activities for providing the smart service. (Neuhüttler et al., 2019) As a result, a set of core functions is identified that directly generate the value propositions, by which the developed system can be validated.

### *3.4 Step 3: System functions for closing the gap between detailed environment and functional requirements*

The context elements defined in step one represent the direct environment in which the smart service is placed. At first, this step defines the context elements in detail. Usually, companies do not start to build on undeveloped IT landscapes but on given conditions. Furthermore, especially small and medium enterprises cannot afford to build systems from scratch but evolve incrementally. Not considering the given and planned IT landscapes and machineries can lead to a chaotic integration. To avoid this, a member of the company's IT support team or a PLM professional should be participating the workshop. The purposes of this step are to identify relevant circumstances, considered interfaces be, and available resources to exploit. The procedure is generally to close the gap between given resources and the required core functions approaching from both sides. Firstly, it is defined which functions are needed to fulfil the core requirements and secondly, it is discussed which resources are able to provide these functions. Functionalities that cannot be derived from given resources or the environment are marked as new input factors that need to be provided. As explained above, functions are input-output-transformations of signals, substances or energies. It is important to keep them neutrally described in terms of implementations. The technologies for implementation is to be discussed later. The level of abstraction of functional descriptions should be as high as possible but as low as needed to visualize the value stream.

### *3.5 Step 4: Modality options in the logical layer*

The relevant inputs for this step are the stakeholders that need to work with the system and the perceived qualities that the systems delivers to them. Before discussing the logical layer of the system, the stakeholders including customers are listed and their requirements on the qualities of outcome are collected. The essential procedure in this step is a discussion of modalities based on the synthesis of functionalities. Basic modalities are physical technologies and local data processing, provision of digital or personal services, or the integration of services, data, or infrastructure. (Neuhüttler et al., 2019) For example, integration mechanisms can be physical or software interfaces. In practical use cases, many variations of these categories and maybe even new categories occur. In brainstorming sessions and open discussions the before defined functionalities of the system are clustered in logical blocks that represent a modality, e.g. machine data processing in a wearable device, that provides the function. This step generates various possibilities of modalities, which afterwards can be collaboratively evaluated by the stakeholder requirements identified in advance. In the workshop, this clustering can take place directly in the functional diagram.

### *3.6 Step 5: Segmentation into development and procurements blocks*

The system to be developed has to be closely aligned to production resources, capabilities and existing partner networks. The purpose of this step is to provide a basis for the creation of development or procurement options. Each of the previously defined logical elements are divided in objects that represent a physical outcome of internal mechanical or software development activities or physical components that can be procured from suppliers or partner. This procedure also enables the assignment for responsibilities or ownerships. The general rule for choosing the level of abstraction in this step is to detail the logical block so far that it can be assigned to a responsibility or ownership, or until further detailing and structuring become the task of an engineering discipline, such as mechanical construction or network designer. The context of the system is completed by adding available development and production resources in detail. Additional requirements derive from the providing actors or the technical environment in which the system is embedded. The base for identifying and discussing the physical elements of this step are the resulting qualities of resources or pre-requisites.

## 4 Research Outcomes

The conducted project resulted in a system model for the digitalization of one value stream. It is used for communication, further investigation of stakeholders and detailed development and implementation. The system model was developed in a one-day project.

The first part of the workshop generated the system context, simplified shown in Fig. 03, with internal as well as external stakeholder. During the workshop, it became clear that the project vision was separable into two sub-systems: firstly, tracking of time and cost of single production units and, secondly, tracking of waste and production errors. Each one would imply different, relevant stakeholders and different projected investments. A discussion of resources showed that the system "tracking of time and cost of single production units" is seen as a gain with low effort and thus was elaborated in the following steps. A list of functions was identified that would be needed to generate the intended value propositions, such as "information about machine utilization" or "information about stocks of materials".

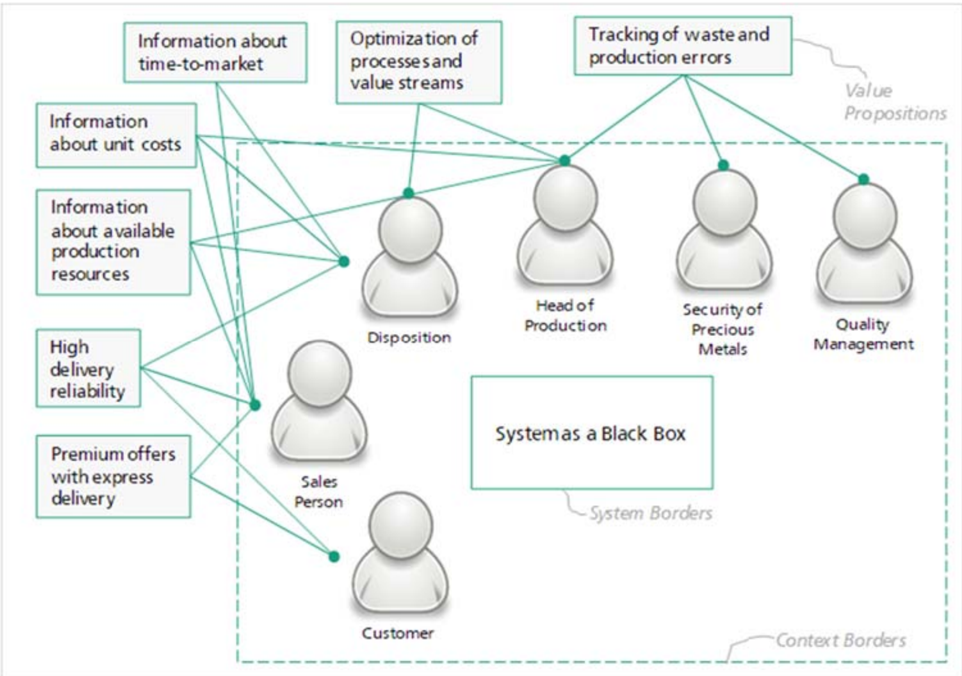


*Fig. 3 Schematic workshop documentation of the system context after step 1*

In the second part of the workshop, the steps 3 to 5 from the methodology were conducted. For simplicity reasons, papers have been prepared that represent elements of the current value stream. On the wall, the part of the value stream was visualized that should be digitalized and the IT-landscape was outlined. Each of these elements was described as a functional element with inputs and outputs. On the bottom of the workshop wall, the goal function “provision of information about available production resources” is stated, which is abbreviated with “available resources”. The functional structure was developed, originating from these two sides. In the next part of the workshop, the functions were aggregated to logical modules that could be implemented with a certain smart service modality. “Available machines” and “volume of orders” are two functional elements, more specifically information that comes out from the enterprise resource planning system (ERP). Therefore, the modality that combines these functions is an interface to the ERP system that would provide data to a core platform of the system to be developed. Fig. 04 displays the schematic workshops on the room wall.

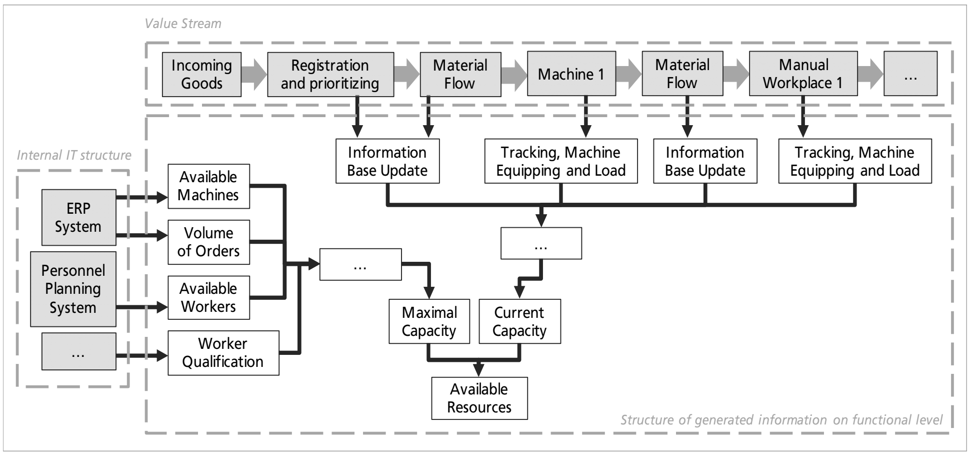


*Fig. 04 Schematic workshop documentation of generated information structure on functional level within given system conditions*

In the last part of the workshop, the physical implementation options of the modalities, such as software programs, IT interfaces, machine interfaces, and digitalization technologies were discussed. This took place in close alignment to internally available software resources and familiar machine equipment providers.

## 5 Conclusion and outlook

Based on the developed methodology in this research, the Fraunhofer IAO and the industrial company Friedrich Binder developed in a collaborative approach a concept for a digitalized value stream with the opportunity of new services in the jewellery market. This was conducted in accordance to the requirements that come along with the development of smart services, the limited resources in the project and the support of all necessary stakeholders in the value creation. Due to these circumstances, the approach of developing product-service-systems had to be adapted. Furthermore, an integration of quality oriented development and testing was necessary. A desktop research on current methodologies in secondary sources and the exchange with the best practice experience of



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Fraunhofer experts provided valuable input to the development of the methodology. Primary research was conducted within the industrial application case. The feedback of the workshop participants and the practical experience of the facilitator validated the developed methodology. In the subsequent steps of the project in the industrial case, the resulting concept is discussed with the management and communicated within the company. Finally, it was used for detailed planning and roadmapping of the development and implementation steps.

In the context of the work presented, potentials for additional research unveiled in the following areas: - Agreeing on standardized, methodological approaches to develop smart services in a value oriented and streamlined manner. - Further developing methodologies to better support the decision of make or buy within the system development process. A new method requires a close alignment of the requirements and conditions, which is e.g. the possible implementation solutions with given resources and competencies, external technological trends or future scenarios that describe economical, legal or societal trends. In addition, there are other methodological interfaces for the development of development and production roadmaps.

## 6 Acknowledgements

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