

The 9th CIRP IPSS Conference: Circular Perspectives on Product/Service-Systems

## Maturity model and action recommendation: a PSS capability self-assessment tool for companies

Konrad Exner<sup>a,b\*</sup>, Raphael Zimpfer<sup>a</sup>, Rainer Stark<sup>a,b</sup>

<sup>a</sup>Technische Universität Berlin, Pascalstraße 8-9, 10587 Berlin, Germany

<sup>b</sup>Fraunhofer Institute for Production Systems and Design Technology, Pascalstraße 8-9, 10587 Berlin, Germany

\* Corresponding author. Tel.: +49-30-39006247; fax: +49-30-39006246. E-mail address: [konrad.exner@tu-berlin.de](mailto:konrad.exner@tu-berlin.de)

### Abstract

The main idea in Product-Service Systems (PSS) research is to provide solutions instead of products or services. Nevertheless, PSS comprise a broad variety of characteristics from product-oriented services, to use-oriented services and result-oriented services [1]. In industrial practice all of these dimension as well as intermediate stages are evidently realized. Additionally, trending topics like smart services, which can be described as the exploitation strategy from Industrie 4.0 [2], also known as cyber-physical systems and Internet of Things, accelerate the interest in PSS. However, many companies' in particular small and medium-sized enterprises just started realizing the potential and necessity to establish service thinking in order to stay competitive. These companies face considerable challenges regarding the transformation from an Original Equipment Manufacturer (OEM) towards an Original Solution Provider (OSP) [3]. In a first step, companies need to assess their current situation and develop a strategy based on the desired target situation. For this reason, the authors developed a model combined with a self-assessment method which enables a basic analysis of the companies' situation including action recommendations. The research results as well as the evaluation with a company are presented in this paper.

© 2017 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Peer-review under responsibility of the scientific committee of the 9th CIRP IPSS Conference: Circular Perspectives on Product/Service-Systems.

**Keywords:** Product-Service Systems; maturity model; self-assessment

### 1. Introduction

Mont described PSS as a trend with a high sustainable potential. Besides effects on sustainability PSS also account for innovation, customer integration and competitive capacity. [4] Since then, PSS researchers created method and tools to support the development of integrated products and services and transferred them into industrial practice. Nevertheless, without research driven projects many companies tend to focus classical product-centered development approaches and add additional services [5, 6]. In this perspective, it has to be stated that the full potential of PSS can only be utilized by integrated approaches, thus profound changes for the company have to be considered [3]. These changes result in several challenges which need to be addressed. Foremost, the company's culture and organizational structure have to be reconsidered in order to

strengthen the voice of the customer and increase the skills and importance of service development [3]. Additionally, several specific challenges will occur due to change in in the revenue structure and the integrated development, such as pricing, ownership, risk, responsibility, longevity, reimbursement, knowledge, experience, costing [7, 8]. However, discussions with industrial partners in projects, seminars and conferences indicated another need of several companies. Many managers are interested in initializing PSS projects or pilots, but do not have the knowledge to start an analysis of the as-is and to-be situation as well as the first roadmap. Existing research approaches (cf. chapter 3) seem to be too generic or not applicable without a consultant. For this reason, the authors developed an elaborated maturity model in combination with an easy to apply questionnaire in order to enable a self-assessment of the company. Additionally, generic guidelines have been developed,

which provide basic instruction regarding the transformation from one stage to another. In this paper, the research results including the evaluation with an industrial partner will be discussed. In a first step the authors describe the research approach and the research questions (cf. chapter 2). Afterwards the authors give a short overview of the state of the art in the research field in chapter 3. In the following chapter 4 the method including the maturity model, the questionnaire and the guideline will be illustrated before the findings of the evaluation are described in chapter 5. Finally, the authors give a short conclusion and an overview for future research needs regarding the addressed topic in chapter 6.

**2. Research approach and research questions**

The research approach is based on the Design Research Methodology (DRM) [9] including an iterative development with two prescriptive and two descriptive studies (cf. Figure 1). The scope of this contribution comprises the first three steps of the research approach, marked green in Figure 1. The last two steps, marked blue in Figure 1, are not part of this contribution and will be discussed in chapter 6.

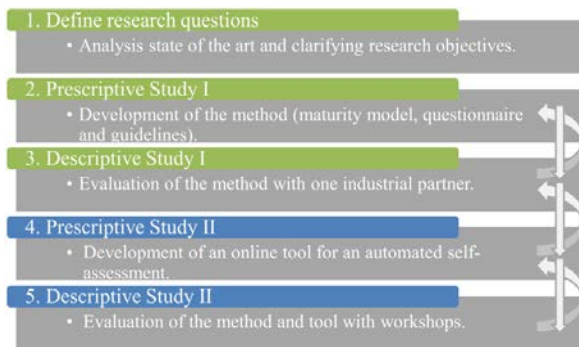


Fig. 1. Research approach.

In a first step the research questions (RQ) have to be defined in order to clarify the research objectives.

- [RQ1] Which specific maturity levels and criteria can be described regarding PSS?
- [RQ2] How can these maturity levels be determined?
- [RQ3] Which instructions can be formulated to support the transformation from one level to another?

Complementary, the state of the art in relevant research fields have been analyzed (cf. chapter 3). Based on these results a method has been developed (cf. chapter 4) and evaluated (cf. chapter 5). Therefore, the research question will be answered in the following chapters.

**3. State of the art**

Maturity models have been developed in the 1970s in order to describe leadership categories [10]. Since then, these models evolved to describe typologies in various disciplines in order to define certain degrees of maturity. For instance, in development

processes the degree of maturity comprises the “increasing concretization” from e.g. laboratory specimen to a pilot-run product [11]. In PSS research maturity models mostly describe the existing manifestation of PSS between completely product centered and pure service oriented solutions. The following Table 1 introduces a section of existing models which have been analyzed and utilized regarding the development of the model (cf. chapter 4).

Table 1. Overview of PSS maturity models.

Model	Dimension	Description
The model of <i>Tukker</i> [1] describes various customer needs, which are based on different combinations of tangible products and intangible services	Three main maturity levels, which consist of eight specific PSS types	Intangibility of the performance result, product-oriented, use-oriented, result-oriented
The model of <i>Berkovich</i> [12] comprises PSS embedded in the interaction with customers during the planning progress as well as the intangibility of the performance results	Four different maturity levels, which restrict the PSS in his definition.	Interaction with the customers during the planning progress, intangibility of the performance result
The model of <i>Burianek et al.</i> [13] describes seven characteristics, which define the complexity of the PSS and the coherent performance result	Every combination of the seven characteristics creates a new maturity level	Customer benefit, range of services, heterogeneity, Technical integration, individualization, temporal dynamics, integration in the value creation of the customer
Model of <i>Beyer</i> [14] and <i>Becker</i> [15] shows the gradual integration of intangible services from added services to a combined system of tangible products and intangible services	Three main maturity levels, which consist of five specific PSS types	Product-oriented, use-oriented, result-oriented, interaction with the customer, intangibility of the performance result
Model of <i>Gaiardelli et al.</i> [16] combines Tukkers main levels with the inherent interaction of customer and provider as well as the holistic process	30 different maturity levels	Product-oriented, use-oriented, result-oriented, focus on the product or process, transaction-based versus relationship-based
Model of <i>Rapaccini et al.</i> [17] defines five maturity levels from initial stage to an optimized new service development (NSD)	Four dimensions with 9 elements	The models is based on a NSD process and focuses organizational, resources, stakeholders and management aspects
Model of <i>Karni and Kaner</i> [18] defines a PSS maturity model based on general maturity levels	Three dimensions with 38 factors	The model focusses customer-facing, life cycle and offer

*Tukker* [1] classified three main groups in his model, which are further divided into eight sub categories. The model is widely known and accepted and demonstrates the importance of new revenue models. Nevertheless, the interaction with the customer is missing. The model of *Berkovich* [12] introduces a new characterization, which defines PSS in a different way. It involves the interaction with the customer during the planning progress. Likewise, it emphasizes the intangibility of the performance results. These two dimensions create four different maturity levels, which are known as mass-market product,

mass-market service, customized product and customized service. The PSS is embedded between these four limitations. Additionally, a smooth transition between these different groups is described. The model of *Burianek* [13] introduces further characterizations, which can define a PSS. Every factor has two possibilities to choose from. According to the selection of the seven characterizations, different PSS types can be defined. These factors are known as customer benefit, range of services, heterogeneity, technical integration, individualization, temporal dynamics and integration in the value creation of the customer. The model of *Becker* [15] and *Beyer* [14] shows the gradual integration of an intangible service. The more intangible services are included, the more interaction occurs between customers and companies. The role of the customer is focused as a key factor in this model. The model of *Gaiardelli et al.* [16] evolves the model of *Tukker* regarding the relationship between customer and provider. The characteristics of the 30 maturity levels comprise inter alia: level of customization, relationship-intensity, risk, product owner, product user and product decision maker. The model of *Rapaccini et al.* [17] emphasizes roles, skills and methods as well as different management perspectives. The criteria are elaborated in detail, however a guided assessment is crucial for a successful implementation of the model. Model of *Karni and Kaner* [18] describes in detail the importance of the customer view and the customer specific offer as well as a processual lifecycle perspective. However, a practical implementation and other stakeholder are not integrated. In each model diverse important characteristics have been provided. The level of intangibility is an important factor. Furthermore, the interaction between customer and provider can be highlighted is the core aspect in defining a PSS. This aspect covers more than the intensity of the interaction, thus including the integration of the customer in the companies' lifecycle. An important commonality is the missing application de-

scription and guidelines. A new model which includes the results of this analysis is introduced in chapter 4, which is designated as Product-Service-Change.

#### 4. Product-Service-Change

The Product-Service-Change (PSC) comprises a model (cf. chapter 4.1) to describe the different levels, the method regarding the procedure for self-assessment as well as the action recommendation (cf. chapter 4.2).

##### 4.1. PSC model

The PSC model consists of five reflected (product and service perspective) stages which lead to nine main stages. Stage 1 describes a pure product provider whereas stage 9 defines a pure service provider. The main objective for both sides is stage 5, which describes a company with the ability to provide a flexible combination of services and products based on the individual customer needs. Nevertheless, companies can have different goals, for instance only focusing on use-oriented PSS. This is not a contradiction to this model and will be explained in chapter 4.3. The stages can be subdivided into different levels in a matrix into 19 numbers (cf. Figure 2). The visualization emphasizes the integration as the core aspect of the underlying principle. Nevertheless, further characteristics are inherent. The criteria for each stage can be divided into three categories. Firstly, the product overview defines the customer integration in the product design process, the type of production and the portfolio share of the product. Secondly, the service overview defines the customer integration in the service design process, the service type and the portfolio share of the service. Thirdly, the system overview defines the strategy, the technical integration (compatibility), the customer loyalty and ownership.

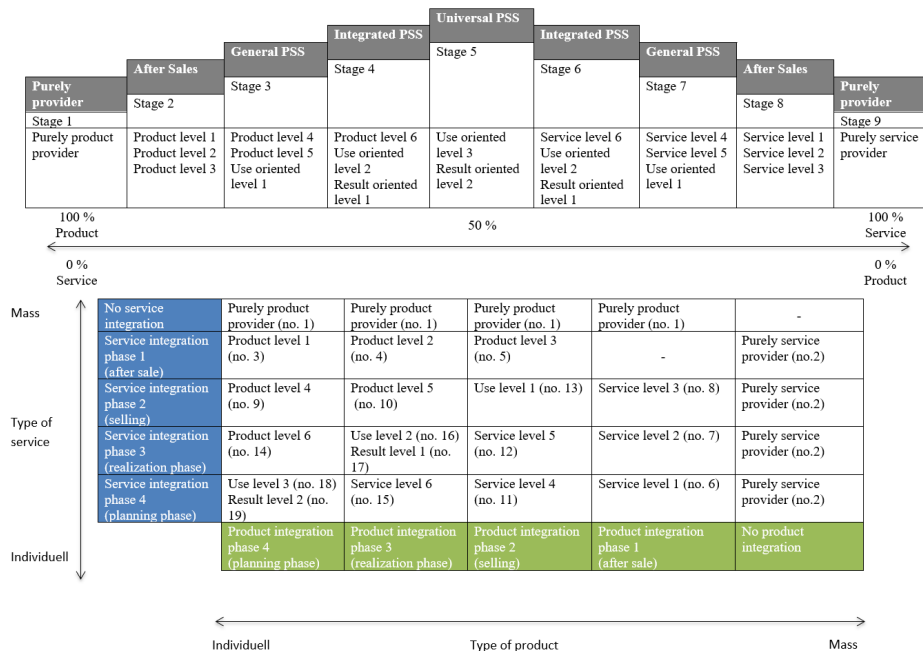


Fig. 2. PSC model.

The defining criteria can be specified as follows:

- Design process: 1. design (planning, development), 2. realization (production, service (selling, after sales), 3. end of life (cf. Figure 5)
- Type of production / service: mass production / service, series production / service, individual manufacturing / service
- Portfolio share: 0 – 100 %
- Strategy: product- or service oriented, use oriented or result oriented
- Customer loyalty: three-step scale from very good to poor
- Ownership: customer or provider
- PSS compatibility: three-step scale from strong to weak

It has to be stated that the criteria have been designed for a first self-assessment. Therefore, fundamental and easy to differentiate specifications have been chosen.

4.2. PSC method

The Product-Service-Change (PSC) method is based on a basic change formula with five qualitative variables: benefit if the change occurs, status quo, desired future status, roadmap and company culture. The final procedure of the method is illustrated in Figure 3. In a first step the customer integration regarding the product (1a) and service (1b) design processes is analyzed. As a result the priority towards product or service centered thinking can be assessed (2a). Additionally, the comparability, customer loyalty and strategy are based on product /service integration (1a, 1b) and on product / service priority (2a). In the third step the usage of the product (3a) and service (3b) solutions is analyzed. The complete product and service analysis results in the as-is maturity level of the company. It has to be stated, that more than one maturity level can result from the analysis. In step five the company can choose the to-be maturity level according to the PSC model (cf. Figure 2). In combination with the PSS analysis the action recommendations can be derived.

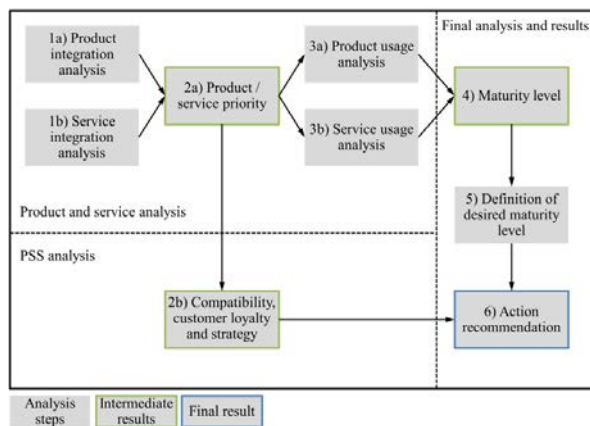


Fig. 3. PSC method.

For each analyzing step a set of questions has been defined in order to extract the needed information. The criteria and one

example of the questions from the questionnaire are shown in Table 2:

Table 2. Assessment criteria and excerpt of the questionnaire.

Step	Criteria	Exemplary question
Product integration analysis	Product integration phases: design, realization, selling, after sales, no integration	Is customer integration planned and realized for the product design phase?
Service integration analysis	Service integration phases: design, realization, selling, after sales, no integration	Does the first customer contact occur on the sale of the service?
Product usage analysis	Type of production: mass-, series, individual production	With which manufacturing processes are the products produced?
Service usage analysis	Type of service: mass-, series, individual service	Are the services identical for each client?

Regarding the assessment one simplifying assumption has to be considered. If a company provides several products and services, the most advanced level (e.g. highest customer integration) will be chosen.

4.3. PSC action recommendation

As a first research result four generic action recommendations have been defined in order to enable a holistic evaluation of the research approach. Therefore, the transitions between the main stages have been defined (cf. Figure 4). Eventually, the company should be able to choose a specific level of the model as the desired to-be situation in order to receive a specific action recommendation.



Fig. 4. Four steps of action recommendation.

The action recommendations are based on the core factors: company culture, product / service integration and simultaneous engineering. The generic recommendations are presented in the following section. In step one the systematic change in the companies' culture is considerable important due to the establishment of a new revenue stream. Employees have to be integrated in the change process and PSS have to be introduced. Therefore, a systematic change process across horizontal and vertical changes has to be conducted according to established Change Management (e.g. Kotter [19] and Streich [20]) approaches. Additionally, a new division which has to develop services has to be vertically integrated in the company. Therefore, existing knowledge and abilities have to be exploited. Simultaneous engineering is not advisable in the first step due to a pure product support of the services. In step two the intended integration of product and service development need to be emphasized. This transformation is the most important factor to become an OSP and induces further changes in the employees (division thinking) mindset. Therefore, the horizontal

integration in order to strengthen the service aspect has to be focused. Additionally, the sales structure needs to be adapted regarding the marketing of the new integrated solutions. The development streams should be aligned, but simultaneous engineering is not mandatory. In step three the companies' culture should support an equivalent significance of products and services. This objective needs to be constantly supported. In order to enable an integrated PSS the customer has to be actively integrated in the design process. Additionally, a simultaneous development of product and service department has to be enabled. Therefore, processes need to be aligned and equivalently adapted. In step four, the cultural change should be completed and consistently introduced to new employees. The integration of product and service development has to be supported with specific PSS design methods and tools. Therefore, the interdependent development of service and product components will be fulfilled. Regarding the simultaneous engineering approach two possibilities can be pursued. Either a strong capability to manage the diverse development streams can enable a sufficient integrated development or a merging of all design processes and divisions would facilitate a high alignment.

## 5. Findings

The method has been applied and evaluated in a case study with a machinery and plant manufacturer. The company has approx. 6.900 employees and is a supplier for pharmacy, automotive, airlines and diverse other branches. The results of the case study (cf. chapter 5.1) and the evaluation (cf. chapter 5.2) are presented in this chapter.

### 5.1. Results of a case study

A pre-study [21] has been conducted in order to assess the model and the method. The main objective has been to verify the consistency and applicability of the research results. The procedure can be described as follows: a) completion of the questionnaire by the company, b) analysis of the results by the research team, c) conjoint discussion of the as-is and to-be situation and compiling of the specific action recommendation.

The analysis of the questionnaire indicated a difference of the customer integration regarding the product design and the service design process of the company, see Figure 5:

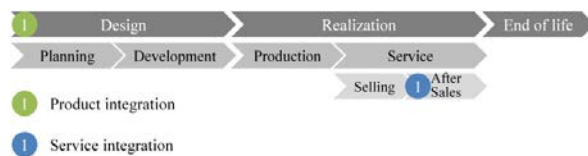


Fig. 5. Four steps of action recommendation.

The visualization expresses clearly, that the customer integration regarding the product design process is conducted much earlier (design phase), thus can be considered as very good. In comparison, the customer integration for services occurs not until the after sales phase. In conclusion, the priority is clearly inclined towards the product design. Furthermore, the comparability can be determined as weak due to the considerable difference of the customer integration regarding products and services.

The next analyses determine the type of production (series production, individual manufacturing) and services (mass service, series services). Based on these results the as-is maturity level could be assessed as product oriented after sales (level 3, no. 5). Therefore, the maturity level is allocated to stage 2 of the model (cf. Figure 2). In a next step the results of the analysis including maturity level and detailed description of all criteria have been provided to the company. For instance, the compatibility has been assessed as weak, whereas the customer integration regarding the product design is very good. In a next step the action recommendation has been conducted. Therefore, the transformation towards an integrated PSS provider has been specified as the to-be situation (cf. Figure 4). The action recommendation comprises three core factors (cf. chapter 4.3), however, in the next section only one factor is described exemplarily. On the one hand service thinking and service design should be strengthened within the company and, on the other hand, take up a more important part in the company's portfolio. Therefore, the existing service department should be enlarged and qualified regarding the development of service and eventually PSS (horizontal integration). For instance, the sales department requires new knowledge, skills and a changing mindset regarding the convincing selling of new integrated solutions. Eventually, the services do not only support the products and increase the revenue, but can be sold independently and finally only conjointly as a solution. In order to enable the integrated development service and product design departments need to align their processes and build up synergies. Furthermore, barriers between both disciplines have to be overcome, thus, communication is a crucial key factor for a successful cooperation. Moreover, the vice of the customer has to be strengthened in order to develop customer centered solutions which fulfill specific customer needs. In order to enable a greater flexibility regarding design and functionality of the solution the customer integration for the product and service design process has to be intensified in early design phases. These changes for the realization of more customized solutions demand new structures and communication channels within the company and to their customers. As a side effect the comparability will be improved. Further action recommendation regarding the companies' culture and simultaneous engineering has been provided to the company.

### 5.2. Evaluation

The evaluation has been conducted with a senior top manager of the company. The evaluation results can be summarized as follows. The developed questionnaire which derives all necessary information regarding the analysis is very well structured. The question can be easily and spontaneously answered. The questions are understandable, but could be formulated more clearly. Additionally, the action recommendation should be described in more detail. The final results of the evaluation are:

- Revision of the questions in order to clarify the meaning
- Elaboration of the criteria and the description of the action recommendation

- Transmission of the recommendation action to all 19 numbers of the PSC model (cf. Figure 2)
- A cost benefit assessment is missing if the strategic development towards a new stage according to the PSC model is advisable

The identified aspects will iteratively revise the method. Therefore, a further evaluation will be conducted before addressing the prescriptive study II of the research approach (cf. Figure 1).

## 6. Summary and outlook

This contribution gives an overview of existing maturity models. Based on the analysis of a section of these models a new model and method with a set of criteria has been proposed. In the first iteration the method including a questionnaire has been successfully tested and evaluated. However, from a research perspective the criteria seem to be not elaborate enough. For instance, different levels of maturity can be assigned to a given company, which is contradicting the definition of a maturity model by itself. Therefore, the model in this form can be seen as a typology model. However, the final objective is the development of a maturity model. Therefore, the criteria will be emphasized in further studies. The results are promising and essential changes could be identified. In a next step the prescriptive study I and descriptive study I (cf. Figure 1) will be reiterated before proceeding with the next research steps. Therefore, research questions 1-3 could be satisfactorily answered. Nevertheless, a few open issues need to be addressed in the next cycle such as elaborating the action recommendation. Furthermore, the evaluation partner asked for a cost-benefit analysis supporting the action recommendation. The authors clearly state that this is out of scope for the self-assessment tool, due to high complexity of the criteria involved. Nevertheless, the addressed issue is valid and will be integrated in the overall action recommendation. Eventually, the questionnaire will be further developed to an online self-assessment tool, which allows a broad evaluation of this research. Furthermore, companies will be provided with a unique easy to use tool, which supports the first independent steps (self-assessment and action recommendation) in order to become an OSP. The main objective will be to increase the awareness regarding PSS for all kinds of companies. However, the development of a specific and detailed roadmap is indispensable and should be developed with PSS experts due to the various explicit challenges occurring on the road to become an OSP.

## Acknowledgements

The authors would like to express their gratitude to the case company for participating in the evaluation and providing valuable feedback to the method.

## References

- [1] Tukker A. Eight types of product-service system: eight ways to sustainability? Experiences from SusProNet. In: *Business Strategy and the Environment* 2004;13(4):246-260.
- [2] Arbeitskreis Smart Service Welt / acatech. *Smart Service Welt – Recommendations for the Strategic Initiative Web-based Services for Businesses*. Final Report. Berlin; 2015
- [3] Schnürmacher C, Hayka H, Stark R. Providing Product-Service-Systems - The Long Way from a Product OEM towards an Original Solution Provider (OSP). In: Brissaud D, Boucher X, editors. *7th Industrial Product-Service Systems Conference*; 2015. p. 233-238.
- [4] Mont O. Clarifying the concept of product-service system. In: *Journal of Cleaner Production* 2002; 10(3): 237-245.
- [5] Burger T, Schultz C. *Testen neuer Dienstleistungen: Ergebnisse einer empirischen Breiterehebung bei Anbietern technischer Dienstleistungen (en: Testing of new services. Results of a empirical large scale survey)*. Stuttgart: Fraunhofer Verlag; 2014.
- [6] Müller P. *Integrated engineering of products and services. Layer-based development methodology for product-service systems*. Stuttgart: Fraunhofer Verlag; 2014.
- [7] Di Francisco KC, Barquet APB, Rozenfeld H. Challenges for PSS Implementation: Identification and Classification. In: Meier H, editor. *Product-service integration for sustainable solutions. Proceedings of the 5th CIRP International Conference on Industrial Product-Service Systems*. Berlin: Springer; 2013. p. 275-285.
- [8] Exner K., Schnürmacher C., Stark R. Proactive maintenance as success factor for use-oriented Product-Service Systems. *Procedia CIRP IPSS 2017*, in review.
- [9] Blessing LT, Chakrabarti A. *DRM, a Design Research Methodology*. London: Springer Verlag; 2009.
- [10] Hersey P, Blanchard KH. Life cycle theory of leadership. In: *Training and Development Journal* 1969;23(5):26-34.
- [11] Verein Deutscher Ingenieure. VDI 2206: Design methodology for mechatronic systems. Berlin: Beuth Verlag; 2004.
- [12] Berkovich M. *Requirements Engineering for IT-enabled Product Service Systems*. München: Technische Universität München; 2012.
- [13] Buriánek F, Ihl C, Bonnemeier S, Reichwald R. *Typologisierung hybrider Produkte: ein Ansatz basierend auf der Komplexität der Leistungserbringung (en: Typology of hybrid products: an approach based of the complexity of the service provision)*. München: Technische Universität München; 2007.
- [14] Beyer M. *Service Diversifikation in Industrieunternehmen. Kompetenztheoretische Untersuchung der Determinanten nachhaltiger Wettbewerbsvorteile (en: Service diversification in industrial companies. Competence theory analysis of determinants of sustainable competitive advantages)*. Wiesbaden: Dt. Univ.-Verl.; 2007.
- [15] Becker J, Knackstedt R, Pöppelbuß J. Vergleich von Reifegradmodellen für die hybride Wertschöpfung und Entwicklungsperspektiven (en: Comparison of maturity models for hybrid added value and development perspectives). In: Böhm T, Leimeister JM, editors. *Integration von Produkt & Dienstleistung. Hybride Wertschöpfung*. Norderstedt: Books on Demand; 2010. p. 109-121.
- [16] Gaiardelli P, Resta B, Martinez V, Pinto R, Alboreo P. A classification model for product-service offerings. In: *Journal of Cleaner Production* 2014;66:507-519.
- [17] Rapaccini M, Saccani N, Pezzotta G, Burger T, Ganz W. Service development in product-service systems: a maturity model. In: *The Service Industries Journal* 2013;33(3-4):300-319.
- [18] Karni R, Kaner M. A review of maturity models and their application to PSS: Towards a PSS maturity model. Berlin: Springer; 2013. P. 393-398.
- [19] Kotter JP. *Leading change*. Boston: Harvard Business School Press; 1996.
- [20] Streich RK. *Fit for Leadership. Entwicklungsfelder zur Führungspersönlichkeit (en: development areas for leadership personalities)*. Wiesbaden: Springer Gabler; 2013.
- [21] Schnell R, Hill P, Esser E. *Methoden der empirischen Sozialforschung*. München: Oldenbourg; 2008.