Available online at www.sciencedirect.com
ScienceDirect
Procedia CIRP 30 (2015) 54 – 59
www.elsevier.com/locate/procedia

7th Industrial Product-Service Systems Conference - PSS, industry transformation for sustainability and business

An integrated method to support PSS design within the Virtual Enterprise

Eugenia Marilungo[a]*, Margherita Peruzzini[a], Michele Germani[a]

[a]Università Politecnica delle Marche, via Brecce Bianche 12, Ancona (AN) 60131, Italy

* Corresponding author. Tel.: +39 0712204101; fax: +39 0712204708. *E-mail address:* e.marilungo@univpm.it

Abstract

Nowadays Product-Service System (PSS) is a widespread trend consisting of adding services to the physical product in order to increase their market share, add value to their products, and create a new value proposition. Anyway, its application is still far from real industrial scenarios mainly due to difficulties in choosing the right partners, lack of collaboration among the partners, poor integration among the companies' system platforms, and lack of knowledge about the available technologies. In such context, this paper presents an integrated methodology to support the PSS design process into a Virtual Enterprise (VE). It involves different stages, from idea management to global network definition. Furthermore, the business model items can be defined in parallel along the design process and benefit the design itself by supporting decision-making, according to a concurrent engineering approach. In order to demonstrate the benefits of the proposed approach, it has been applied to a real industrial use case represented by a Virtual Enterprise working in the field of household appliances. In particular, the method supported the PSS design by the definition of the PSS requirements and functions, as well as the selection of the global network partners. The as-is and to-be processes are described and compared. The use case represents a valid example of how a product-oriented manufacturing company can open its strategic vision creating a PSS Virtual Enterprise in a structured way.

Keywords: Product-Service System (PSS); Virtual Enterprise (VE); design tools for PSS; PSS design process.

1. Introduction

The concept of Product-Service System (PSS) can be realized by adding services to a physical product to increase the value proposition and better satisfy the customers' needs [1]. However PSSs represents also new challenges. In fact, within manufacturing companies the design process is still structured as for traditional products, even if recently several researchers have started to address also PSS design issue. Consequently, companies are pushed to move from a product-oriented to an innovative service-oriented scenario, when a new interpretation of the basic design concepts is adopted and design involves both product and services [2].

Several methodologies to manage PSS design and development can be found in literature [3]. In some cases they also achieved a preliminary industrial prototype [4]. However, industrial research is strongly focused on the technological aspects instead of the design strategies or human aspects. Creating PSSs entails two important changes in company processes: firstly, traditional product lifecycle has to be enhanced by including also service management; secondly, the product-oriented company model must be extended to realize a service-oriented ecosystem [5]. Indeed, interrelations between physical products and intangible services are complex to model and manage; they require creating relationships with different stakeholders working in the context of the Virtual Enterprise (VE), seen as a temporary operational network of business partners able to share skills, competencies and resources in order to exploit business opportunities on the market. In a VE, each partner involved is defines by means of its key resources and strategic factors [6]. For these reasons, the PSS design process must be properly supported.

The paper proposes a methodology to support PSS design from the earliest lifecycle stages until the definition of the production network. It interests the main design steps and

doi:10.1016/j.procir.2015.02.021

defines a set of tools combining User-Centered Design (UCD) principles and business modeling practices. Indeed, the early design stages are strongly user-centered to guarantee the satisfaction of the customer needs and the involvement of the most proper partners into the design process. Contemporarily, each process step is also business-centered since business modeling runs in parallel to traditional design activities and effectively supports feasibility analysis and comparison among alternative use scenarios.

2. Research background

2.1. PSS in the Virtual Enterprise

PSS started from the idea of the Extended Product (EP) [7], according to which services can be used to differentiate and support the product by the integration of tangible assets (i.e. materials, technologies, processes, and all staff typically related to the product) and intangible assets (i.e. skills, competencies, services, and all information related to human factors). Several examples of PSS co-creation exist in literature [8]: they mainly focus on the production phase while there is a lack on the design phase, even if designing PSSs is crucial since numerous and interrelated activities to create the complex architecture and different types of actors are required [9]. As a consequence, the construction of a proper network of people and workflow of tasks is fundamental for the PSS development. The importance of actor network in the analysis of design methods has been studied by [10].

Numerous researchers lately paid growing attention to methods and tools to design tailored networks for PSS within the VE. Gebauer et al. [11] deeply proved that a partners' network better drives PSS creation rather than a single firm by identifying four different types of service networks. Krucken and Meroni [12] proposed a pro-active approach based on communication and strategic conversations among the network stakeholders to deliver PSSs. Wang and Durugbo [13] proposed a method based on fuzzy technics to support PSS design and delivery considering the service-oriented operations. Watanabe [14] and Nemoto [15] proposed a preliminary model to describe interactions among the partners and identify the best partners to be involved.

Despite the above-mentioned researches facing different aspects of the PSS design, they remain linked to specific cases and too theoretical to assume a generic value and to be transferred into general-purpose models. Moreover, they did not give contribution in terms of how define the VE and what are the main competences and skills needed to involve. The paper added value consists of the definition of the VE in relation to the specific PPS issues.

2.2. PSS design methods

For the literature review it can be stated that, while many researchers have developed design methods and evaluation tools for PSSs and validated their effectiveness, guidelines for how to use these methods and tools concretely in the design process are rare.

In fact, previous researches in literature tend to assess only one PSS issue at a time, without considering the entire design process and the specific context of application. This means that researchers have investigated in deep only one of the following themes:

- the PSS business aspects, in order to identify the customer requirements or the business model to apply;
- the PSS value proposition, to satisfy the customer requirements according to the product to extend;
- the VE to create, in order to design, to develop and to deliver the PSS.

A recent study [16] stated that PSSs are perceived by customers thought their "value in use". Therefore, for the realization of value in a PSS, designers need to focus more on customers and their requirements instead of pursuing a benchmarking strategy determined by a competitor analysis. It is true more for PSS than for traditional products. Müller [17] composed a checklist of clustered criteria to enable designers to retrieve and describe PSS requirements systematically. In this checklist, users requirements are extracted from both object-oriented (i.e. structure, technical artifact, contract, and so on) and process-oriented (i.e. behavior, service, lifecycle activities, and so on) aspects. Differently, Ota [18] proposed a method for requirement analysis that considers the environmental factors (i.e. political, social, and technological). In such context, Favi et al. [19] offered a preliminary approach about the adoption of lifecycle design methods. Furthermore, for requirements evaluation Akasaka [20] proposed a method that considers both perspectives using SWOT analysis. Another important aspect is represented by the evaluation of the PSS value proposition. A recent study [10] proposed a review of such approaches from different viewpoints: from value to cost, functions, qualities, or performances. Among them, Peruzzini et al. [21] used a structural design approach in order to obtain a sustainable PSS.

A new trend about PSS design is the configuration of a tailored set of partners or stakeholders able to guarantee the right design, development and delivery of the PSS involved. According to this new aspect, Wang et al. [13] showed a methodology to evaluate the uncertainty of service networks that deliver a PSS. Following the same issue, Krucken and Meroni [12] presented an approach to design communication material in the aim to develop strategic alliance in order to deliver a complex product service system. Diversely, Gebauer et al. [11] focused more on the service network design phase, identifying four different service networks and the capabilities needed to use such networks. Finally, Peruzzini et al. [22] provided an assessment of a PSS in the VE context. Finally, in the last years also business aspects assumed more and more attention to support PSS design. Barquet et al. [23] proposed a framework to support PSS adoption by using the Business Model (BM) concept. Armstrong et al. [24] was interested to define an innovative business model for clothing industry with the final aim to reduce its environmental footprint; in such context, the authors found that PSS may provide many opportunities to identify positive or negative perceptions in the clothing sector. Finally, Guidat et al. [25] gave a set of guidelines to define innovative business models for remanufacturing by exploiting both remanufacturing and PSS characteristics.

3. The design methodology

The goal of this paper is to provide a combined method to support PSS design by integrating different methodologies to overcome the main limitations emerged from the literature review and achieve a successful PSS design process focused on the satisfaction of the customer needs. The research defines a structured method to correlate the different design steps, from the analysis of the customers' needs to the global production network definition. It considers the reference model proposed by Pahl et al. [26] for design, but enhances the product-center vision by using specific tools to support PSS design. The design flow is based on a set of correlation matrices to map the relationships between input and output data that are faced at each stage according to the Quality Functional Deployment (QFD) technique [27]. In this way the output of each matrix becomes the input of the following ones. The method steps can be summarized as follows:

1. Market analysis: it analyses the target market to define the customer needs as well as the demands for the new PSS solution. It can be carry out in different manners according to the specific sector and the market typology (e.g. focus group, involvement of sample users, desk research). It is carried out by the Marketing department and allows defining a set of needs and their relative weights (usually expressed according to a 5-point scale);
2. Matching between needs and demands: it elicits the inner correlation between demands and needs, which is extremely important to achieve a high perceive value. It is defined by the direct or indirect contribution of the consumers using UCD techniques. In particular, ethnography and survey [28] are used for eliciting the correlations, expressed by a 0-3-9 scale where 0 represents no correlation, and 9 is high correlation; though this it is possible to find out the most relevant needs and the most significant demands. At this stage, the customers and the Marketing staff are the main actors involved;
3. Definition of the user tasks: it adopts UCD techniques (i.e. role-playing) to highlight the tasks to be executed to satisfy the selected user needs. Role-playing is performed by experts who play as characters into the real context of use simulating the actions and moods of the consumers. Such technique allows a vivid and focused exploration of situations and generation of ideas in order to "being in the moment" and share with the customers their experiences [29];
4. Requirements elicitation: it uses Cognitive Task Analysis (CTA) and in particular by Hierarchical Task Analysis (HTA) [30] to define a list of basic, technical and attractive requirements is determined on the basis of the most significant demands from step 2. CTA addresses the underlying mental processes that give rise to errors during task execution, and is strongly connected with the higher-level mental functions. HTA specifically allows addressing functional requirements as well as the specific actions that are required to satisfy these requirements;
5. Definition of the PSS functions: it correlates requirements and tasks by the FAST method, which allows analyzing both functions and relationship among them. The research refers to the Kano's model to model the customer satisfaction by QFD [31]. This step is carried out by the Marketing, R&D and Service staff;
6. Assets definition: it exploits functional modeling to relate functions and tangible and intangible (T/I) assets. In this step, designers use Unified Modeling Language (UML) to model the detailed functional structure of PSS and to identify the necessary assets to create the new PSS architecture. The result is the list and description of the T/I assets needed;
7. Partner selection and definition of the Global Production Network (GPN): it is based on the matching between the assets identified in the previous step and the specific partners' resources on the basis of risk assessment. Risk assessment focuses on the supply chain due to the distributed character of PSS, so that Supply Chain Risk Management (SCRM) methods are used: they consider risks within the supply chain in terms of supply costs, delivery time, supplier reliability, supply quality, and risks external to the supply chain according to a coordinated approach amongst the chain members to reduce the supply chain vulnerability as a whole [32]. In this second case, the so-called Social, Technological, Economical, Environmental and Political (STEEP) analysis is applied. At this stage the main actors are Marketing, R&D and Purchasing staff.

Figure 1 provides the method approach overview and schematizes the above-mentioned steps. In the figure correlations are represented by Houses of Quality (HoQs) according to the QFD technique. Number in circles indicate the exact step number they refer to.

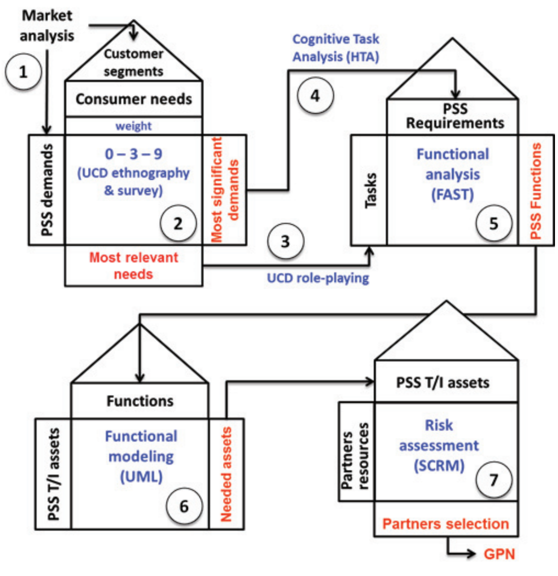

Fig. 1. Methodology overview for PSS design

Contemporarily, the proposed methodology has a direct correlation with the definition of the PSS Business Model (BM). In fact, each step is linked to a specific business area to define, at each step, a specific item of the Canvas Model [33]. Specifically, information coming from step 2 can be used to identify different BM areas. For instance, the most relevant needs are related to the Customer Segments, while the most significant demands are used to identify the Value Proposition. Information coming from step 3 (i.e. tasks) are used to define the Key Activities to realize and develop in order to realize the value proposition. Similarly, functions coming from step 5 are useful to define the best Customer Relationship, according to the PSS idea proposed, while the needed assets resulted from step 6 are used to recognize the Key Resources to be realized. Finally, the ecosystem partners selected in step 7 are used to identify the Key Partners involved in the PSS network. Figure 2 shows the connection between each step of the design methodology proposed and the BM Canvas areas. In this way the proposed method allows to cover the main business areas (i.e. Value Proposition, Key Partners, Key Resources, Key activities, Customer Relationship, Customer Segments).

This correlation represents a great advantage for PSS designers, because the BM definition can be anticipated at the early design stage to support feasibility analysis in easy and fast way. For this reason, the method allows simplifying the connection between PSS technical design phase and BM definition, which can be carried out concurrently.

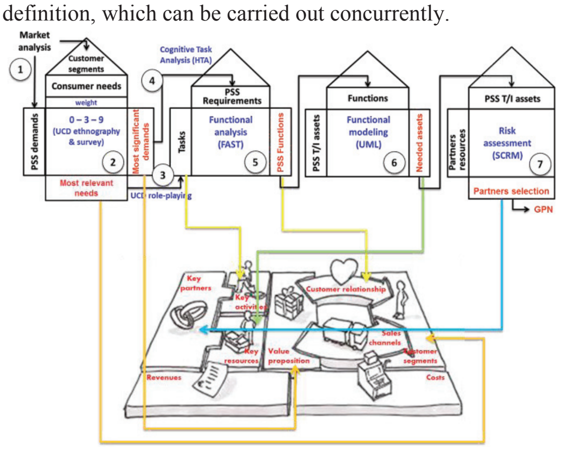

Fig. 2. Business model definition during the design steps

About the governance model, all the method actions are structured considering a service system governance model, which should be implemented by the main organization (i.e. leader company of the supply chain) or by the different companies of the network independently. In both case the governance model adopted allows continuously assessing the performance of the service according to the three decision levels of the organization (i.e. strategic, tactic, operational), its functions and its detailed objectives. For the present study the Graph with reference Active Interrelated (GRAI) model [34] is considered and objectives and performance indicators for each decision center of the PSS is defined according to a reference list of performance indicators, categorized by domain and aggregation level (i.e. enterprise or virtual enterprise) according to [35].

The method proposed in this paper has several advantages in respect with the literature issues. Methods in literature usually deal with specific PSS design issues (i.e. the definition of a tailored business model, the configuration of the partner's network, methods for support designers, requirements elicitation) and do not adopt a holistic viewpoint, while the proposed method goes beyond to guide designers in both designing PSS features and defining the related business model at the same time. Indeed, currently BM definition is one of the most critical stages and is usually defined at the end of the process being almost disconnected from it. In this way BM is static and not related to the specific design features. As a consequence, BM is usually not suitable to effectively promote the specific PSS idea. Contrarily, the proposed method proposes a co-definition of BM and design features according to the concurrent engineering paradigm.

Another advantage is the configuration of the production network, which takes into account the hypothetical risk assessment at both technical and business levels. In this context, both tangible and intangible assets are analyzed from technical and business viewpoints, and technical and business models are defined concurrently.

4. The industrial use case

4.1. The industrial context and issues

The industrial case study used to validate the proposed methodology is represented by the design of an innovative PSS solution by an Italian company producing household appliances. Such company actually has a worldwide network made up of numerous suppliers and commercial branches distributed all over the world, and is particularly interested in innovating its actual business through services (i.e. it moves from product to product-service). Recently, it started working on connectivity issues and actually is proposing a set of connected devices (e.g. washing machines, dryers, fridges, ovens) addressing the smart home concept. However, they are still producing and selling products while services are almost commercial add-ons, so that the real benefits for final users are still hidden.

In this context the idea is selling a new Product+Service solution to really innovate the company commercial offer and provide tangible benefits for its customers. In particular, services will be oriented to support final users in their everyday life and within their homes by making the us of the new devices easier, safer and more comfortable. The main challenge is designing a PSS able to satisfy the market needs and identifying the right business model able to satisfy the customers' expectation. In fact, such conditions represent the motivation to sell a PSS instead of a traditional product.

The current PSS design process can be divided into three main stages: 1) idea generation where customer needs are analyzed and elicited, 2) technical design where the PSS functionalities are defined, and 3) implementation where the idea generation stage and the implementation stage assets are defined and partners involved. The process involves both technical and business aspects, but technical aspects are concentrated in the technical design stage, while the business aspects are defined later on during the implementation stage. AS a result, technical and business issues are faced separately.

Due to paper length constrains, the case study focused on step 1 and step 2 of the proposed methodology. After the analysis of the AS-IS design process, the new TO-BE process is defined with attention to the early design process stages.

4.2. The PSS design: customer needs and PSS demands

The adoption of the new methodology allows simplifying the PSS development process because it merges the main phases of the implementation stage (mainly the business model definition) directly into the design stage. In this way, at each step of the PSS design process described in section 3, one or more areas of the related business model are directly defined. Figure 3 shows the results came from the first matrix (step 1 and step 2), which defines the customer segments and the value proposition. In matrix 1, PSS demands are listed in rows and consumer needs in columns taken from step 2. Each requirement is defined through the assignment of a weight (grey row) defined by the marketing staff in accordance to the market analyses conducted in step 1. The correlation between the consumer needs and the PSS demands is expressed by a 0-3-9 scale. As a result, most relevant needs and demands are identified. Needs are calculated by summing all the correlation values in corresponding rows and multiplying for the related weight; demands are calculated by multiplying all the correlation values in lines for the need weight and summing all values from the sum product at the end. According to the results obtained, the most relevant needs for the case study are: appliance control, high performances, and energy efficiency. At the business level, the target customers pay attention to the device's energy consumption, device's control and performance quality along its lifetime. At the same time, the most significant demands are: appliance with remote control, appliance with energy and resources monitoring, and smart maintenance. According to these results, the value proposition as defined in the BM can be expressed as follows: "*a connected device able to monitor energy and other resources consumption, to guarantee the remote control and to support the customers when a failure occurs*". In this way, two areas of the BM are automatically filled in from the early conceptual design stages.

The case study demonstrates the application of first step of the proposed method focusing on the definition of the PSS design guidelines and the preliminary business aspects. It demonstrates how to overcome one of the main limits of PSS as described in section 2. Indeed, traditionally the PSS idea is firstly designed and than evaluated from a business point of view, with a lack of technical foundations in the business aspects analysis. Furthermore, the process implies that the customer segment is defined at the beginning, but the satisfaction of the customers' needs is not controlled along the process, so during the design process we don't know if the PSS fully respects the market demands. Finally, the partners' network, the key resources and the key activities are decided without considering their impact of the PSS design and they frequently tend to be not coherent with the design specifications.

	CUSTOMER NEEDS								
PSS DEMANDS	Appliance control	High performances	Sustainability	Reliability and Durability	Energy efficiency	Other resources efficiency	Easy to use	Function personalization	
WEIGHT	**5**	**4**	**4**	**2**	**5**	**3**	**4**	**5**	
Appliance with energy control	3	3	0	3	9	0	0	0	**87**
Appliance with cycle monitoring	9	3	0	3	0	0	9	9	**153**
Appliance with energy and resources monitoring	9	3	3	3	9	9	0	3	**171**
Smart maintenance	9	9	3	9	0	0	3	3	**165**
Appliance with remote control	9	9	3	9	3	3	9	3	**213**
	195	**108**	**36**	**54**	**105**	**36**	**84**	**90**	

Fig. 3 Results from methodology application for the case study (step 2)

5. Conclusions

The research proposed a method integrating technical and business aspects according to a strategic approach to support PSS design. In particular, it reorganizes the traditional design activities by combining technical aspects with business modelling and providing useful guidelines from designer and. The research proposed a QFD procedure to valorise the outputs from each stage as the inputs for the following stages. In this way designers can take into account technical aspects more consciously, and can add the evaluation of also business aspects during the PSS design process. As a result, such a method allows overcoming the main limitations of traditional product-centred design process, which obstacle manufacturing companies moving to PSS. By means of an industrial case study we applied in practice the methodology for the conceptual design of a new PSS. The industrial case focuses on the early PSS design of an Italian company producing household appliances and moving from product to PSS. It clearly demonstrated how easily needs and demands can be defined, and how successfully technical and business aspects could be integrated and concurrently faced. Indeed, after market analysis, the method allowed analysing both customers' needs and technical demands, and their correlation enabled the definition of some business aspects of strategic importance from the beginning of the design process. Furthermore, the business features could be used to support the following technical analysis based on the definition of the PSS requirements and T/I assets. The method has been proved to validly guide designers to define the new PSS value proposition and support the mutual analysis of customers' needs and PSS demands. The study is under development and the results of the method application in the following stages will be published soon. Such a method presents some limitations in its actual form concerning the manual execution of the operations at each method steps, which can become also heavy for very complex PSS. Indeed, the main assumption is considering quite simplified products and services to be modelled. For complex systems, the matrix analysis could be complicated and time consuming. In this direction a dedicated software tool could be developed to support designers in a more effective way. Furthermore, any correlation is actually considered with specific Computer-Aided Design (CAD) model features as well as Product Lifecycle Management (PLM) system attributes. Indeed, the method matrices could retrieve useful information about product-service features and partners' characteristics from the company systems to be reused effectively. It will be possible by using a structured software tool and creating an integrated data sharing with existing systems.

References

[1] Goedkoop MJ, Van Halen CJG, Riele HRM, Rommens PJM. Product-Service Systems. Ecological and Economic Basic, PWC, The Hague, 1999.

[2] Manzini E, Vezzoli C. Product–service systems and sustainability. Opportunities for sustainable solutions. United Nations Environment Programme, CIR.IS Politecnico di Milano: Milan; 2002.

[3] Ducq Y, Agostinho C, Chen D, Zacharewicz G, Goncalves RJ. Generic Methodology for Service Engineering based on Service Modelling and Model Transformation. Manufacturing Service Ecosystem. Achievements of the European 7th Framework Programme FoF-ICT Project MSEE: Manufacturing SErvice Ecosystem (Grant No. 284860). Eds. Weisner S, Guglielmina C, Gusmeroli S, Doumeingts G. 2014, p.41-49.

[4] Peruzzini M. A White Goods Manufacturing Service Ecosystem. Manufacturing Service Ecosystem. Achievements of the European 7th Framework Programme FoF-ICT Project MSEE: Manufacturing SErvice Ecosystem (Grant No. 284860). Eds. Weisner S, Guglielmina C, Gusmeroli S, Doumeingts G. 2014, p.158-165.

[5] Peruzzini M, Germani M, Favi C. Shift from PLM to SLM: a method to support business requirements elicitation for service innovation. Proc. International Conference PLM, Montreal, Canada; 2012. p.1-15.

[6] Ghaziani A, Ventresca M. Keywords and cultural change: Frame analyses of of Business Model public talk, 1975 to 2000. Sociological Forum, 2005; 20(4):523-529.

[7] Thoben KD, Jagdev H, Eschenbaecher J. Extended Products: Evolving Traditional Product Concepts. Proc. 7th International Conference on Concurrent Enterprising, Bremen, 2001.

[8] Hosono S, Shimomura Y. Towards Establishing Production Patterns to manage Service Co-creation. Proc. 5th CIRP International Conference on Industrial Product-Service Systems, Bochum, Germany, 2013.

[9] Mont O. Clarifying the concept of product–service system. Journal of Cleaner Production 2002;10(3):237-245.

[10] Kimita K, Shimomura Y. Development of the Design Guideline for Product-Service Systems. Proc. 6th CIRP International Conference on Industrial Product-Service Systems, Windsor, Canada, 2014.

[11] Gebauer H, Paiola M, Saccani N. Characterizing service networks for moving from products to solutions. Industrial Marketing Management 2013;42:31-46.

[12] Krucken L, Meroni A. Building stakeholder networks to develop and deliver product-service-systems: practical experiences on elaborating pro-active materials for communication. Journal of Cleaner Production 2006;14:1502-1508.

[13] Wang X, Durugbo C. Analysing network uncertainty for industrial product-service delivery: A hybrid fuzzy approach. Expert Systems with Applications 2013; 40:4621-4636.

[14] Watanabe K, Shimomura Y. Design of Cooperative Service Process for Effective PSS Development. Proceedings of the 4th CIRP IPS2, 2012.

[15] Nemoto Y, Akasaka F, Shimomura Y. Knowledge-Based Design Support System for Conceptual Design of Product-Service Systems. Proc. 5th CIRP International Conference on Industrial Product-Service Systems, Bochum, Germany, 2013.

[16] Vargo SL, Lusch RF. Evolving to a New Dominant Logic for Marketing, Journal of Marketing 2004;68(1):1-17.

[17] Müller P, Schulz F, Stark R. Guideline to elicit requirements on industrial product-service systems, Proc. 2nd CIRP International Conference on Industrial Product-Service Systems, 2010;109-116.

[18] Ota K, Kurita Y, Akasaka F, Kimita K, Shimomura Y. Extraction of Customers' Potential Requirements Using Service Scenario Planning, Proc. 5th CIRP International Conference on Industrial Product-Service Systems, Bochum, Germany, 2013. p.63-74.

[19] Favi C, Peruzzini M, Germani M. A Lifecycle design approach to analyze the Eco-sustainability of industrial products and product-service systems, Proc. 12th International Design Conference, 2012;879-888; ISSN 1847-9162; ISBN 978-95377-817-4.

[20] Akasaka, F, Hosono S, Kimita K, Nakajima M, Shimomura Y. Requirement Analysis for Strategic Improvement of a B2B Service, Proc. 2nd CIRP International Conference on Industrial Product-Service Systems, 2010. p.117-124.

[21] Peruzzini M, Germani M. Design for sustainability of product-service systems. Int. J. Agile Systems and Management 2014;7(3-4):206-219; DOI 10.1504/IJASM.2014.065355.

[22] Peruzzini M, Germani M, Marilungo E. Product-Service Sustainability Assessment in Virtual Manufacturing Enterprises, in Collaborative Systems for Reindustrialization. IFIP International Federation for Information Processing AICT 408, Eds. L.M. Camarinha-Matos and R.J. Scherer, 2013; 13-21; ISSN 1868-4238; ISBN 978-3-642-40542-6; DOI 10.1007/978-3-642-40543-3.

[23] Barquet APB, de Oliveira MG, Amigo CR, Cunha VP, Rozenfeld H. Employing the business model concept to support the adoption of product–service systems (PSS). Industrial Marketing Management 2013;42:693-704.

[24] Armostrong CM, Niinimaki K, Kujala S, Karell E, Lang C. Sustainable product-service systems for clothing: exploring consumer perceptions of consumption alternatives in Finland. Journal of Cleaner production 2014;1-10.

[25] Guidat T, Barquet AP, Widera H, Rozenfeld H, Seliger G. Guidelines for the definition of innovative industrial product-service systems (PSS) business models for remanufacturing. Proc. 6th CIRP Conference on Industrial Product-Service Systems, 2014;16:193-198.

[26] Pahl G, Beitz W, Feldhusen J, Grote KH. Engineering Design: a systematic approach. Wallace K. (Ed.), United Kingdom, Springer-Verlag, 1994.

[27] Cohen L. Quality Function Deployment, How to Make QFD Work for You, Addison-Wesley, 1995.

[28] Sharp H, Rogers Y, Preece J. Interaction Design; 2. John Wiley & Sons, Ltd, 2007.

[29] Simsarian KT. Take it to the Next Stage: The Roles of Role Playing in the Design Process. CHI 2003, 2003, Ft. Lauderdale, Florida, USA.

[30] Kirwan B, Ainsworth LK. A Guide to Task Analysis, Taylor & Francis, London, 1992.

[31] Matzler K, Hinterhuberb HH. How to make product development projects more successful by integrating Kano's model of customer satisfaction into quality function deployment. Technovation 1998;18(1):25-38.

[32] Jüttner U, Peck H, Christopher M. Supply chain risk management: outlining an agenda for future research. International Journal of Logistics: Research & Applications 2003;6(4);197-210.

[33] Osterwalder A, Pigneur Y. Business Model Generation, Modderman Druckwerk, 2009.

[34] Doumeingts G, Vallespir B, Chen D. Decisional Modeling GRAI GRID, Handbook on Architectures of Information Systems, International Handbooks on Information Systems 2006;321-346.

[35] Heydari M, Taisch M, Zanetti C, Carossi A. Service performance monitoring and control Toolset. Procedia CIRP 2014;16;62–67.