Design and Engineering of Product Service Systems (PSS): the SEEM Methodology and Modeling Toolkit

Fabiana Pirola[1], Giuditta Pezzotta[1], Danial Mohammadi Amlashi[2], Sergio Cavalieri[1]

[1] Department of management, information and production engineering, University of Bergamo, Bergamo, Italy

[2] University of Vienna, Vienna, Austria

Abstract Servitivation is a global trend in manufacturing industry that requires a challenging and complex transformation. In this context, engineering and design Product-Service System (PSS), capturing both product and service perspectives and balancing customer satisfaction and internal efficiency, are becoming more and more essential. To this purpose, the SEEM (SErvice Engineering Methodology) methodology is proposed and the SEEM Modeling toolkit supporting its implementation is presented. Lastly, this chapter describes the metholodgy and the tool implementations in a case study in an Italian manufacturing company.

Keywords: Product-Service System (PSS), service engineering methodology, SEEM tool,

1. Introduction

Success stories such as Rolls-Royce, Alstom, Ericsson, Thales, ABB, IBM and Xerox, have highlighted the opportunity to exploit a "servitization" strategy in manufacturing (Vandermerwe and Rada, 1988). Servitisation is described as the integration of traditional product-based offerings with value-added services, defined in the literature as Product-Service Systems (PSS) (Mont, 2002; Pirola et al., 2020).

Although it is evident that selling product-service solutions fosters closer relationships with customers and generates higher and more stable revenue streams than pure product offerings, the literature points to several cases of failure where the solutions are not properly developed (Kowalkowski 2016). Above all, manufacturing firms generally do not think systematically about the solution as an overall, because historically, while product design has a focal role in the business development, services have only a marginal role and are typically defined, not engineered, only after the product has been released on the market and managed either by the after-sales or marketing departments.

In this perspective, the definition of methodologies and tools for engineering Product-Service Systems has been discussed in the literature for about 20 years. Although different methodologies and methods have been developed over these years to support companies in systematically engineering their solutions, many of them are still on paper and require a computer-based tool to be largely adopted. This can help companies correctly use the theorized engineering processes and create a repository of knowledge and projects already developed.

In addition, companies still encounter difficulties in formulating a PSS value proposition that primarily focuses on fulfilling customer needs. In particular, there is still a lack of modeling methods and computer-based tools that support the PSS design and engineering taking customer satisfaction as a starting point but also looking at the internal efficiency of the service delivery processes.

In this chapter, the SEEM Modeling Toolkit implementing the SEEM (SErvice Engineering Methodology) methodology (Pezzotta et al. 2016) developed in the ADOxx platform is described to fill the gaps. The SEEM methodology is focused on the engineering and re-engineering of the PSS offering and specifically on the modeling of the service delivery process within the PSS solution, balancing customer satisfaction and internal efficiency. This methodology is composed of four steps and in each step, one or more methods are suggested.

To this purpose, the following section describes the SEEM methodology highlighting its main perspectives and the model requirements, section 3 presents the model conceptualization, while section 4 describes the SEEM Modeling toolkit implementation in a case study in an Italian manufacturing company. Then, section 5 concludes the chapter with some remarks and further developments.

2. The SErvice Engineering Methodology (SEEM): Perspectives and Modeling Requirements

SEEM aims to support companies shifting from a traditional product-based service offering toward a more advanced PSS value proposition. In particular, SEEM supports companies in engineering and re-engineering their PSS while balancing the value perceived by customers with the service delivery processes' internal efficiency and productivity. The SEEM methodology, shown in Fig. 1, is divided into two main areas:

- **Customer area:** The analysis of customer needs, representing the starting point to design new product-services, and the re-arrangement of the company service portfolio.

- **Company area:** It deals with the design and assessment of the service delivery process to support the definition of a service delivery process considering the company's external and internal performance.

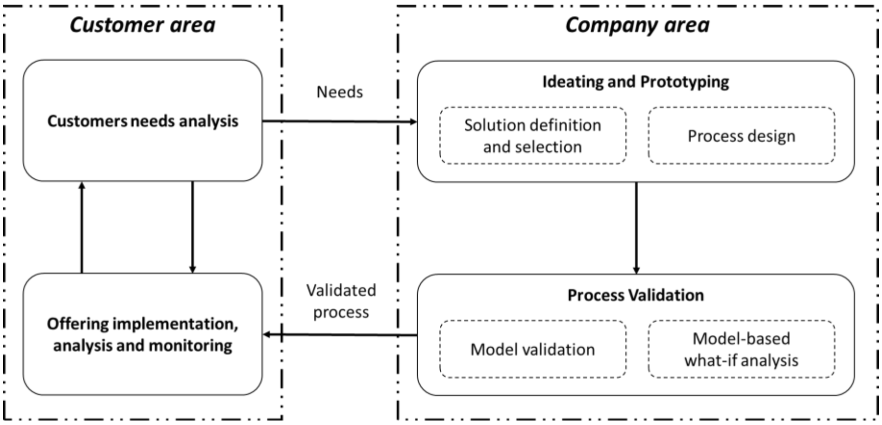

Fig. 1 - The SErvice Engineering Methodology (SEEM) (Pezzotta et al., 2016)

As shown in Fig. 1, the first two phases belong to the customer area, while the remaining two address the company area. These four phases have been used as guideline in the development of the conceptual model and the metamodel described in the following section. In particular, the development of these two models have been led by the three main perspectives at the basis of the SEEM methodology, namely:

- *Customer perspective* aims at modeling the main characteristics of the customers in terms of demographics, needs, values, issues, and so on, also considering the offering already available on the market. This perspective is the starting point based on which the company can conceptualize a new PSS solution.
- *Solution perspective* defines the combination of products and services (namely solution) offered to customers to satisfy their needs. This dimension also comprises the main resources (both tangible and intangible) needed to deliver the solution.
- *Process perspective* aims at modeling the service delivery process of the identified solution, taking into consideration the internal activites and decisions carried out by the company to provide the solution to customers and highlighting the activities made in direct contact with the customers. This perspective is useful to evaluate internal performance and ensure a balance between company efficiency and customer satisfaction, with the final aim to provide successful and profitable PSS solutions.

Fig. 2 shows these three main perspectives along with the main elements and their relationships.

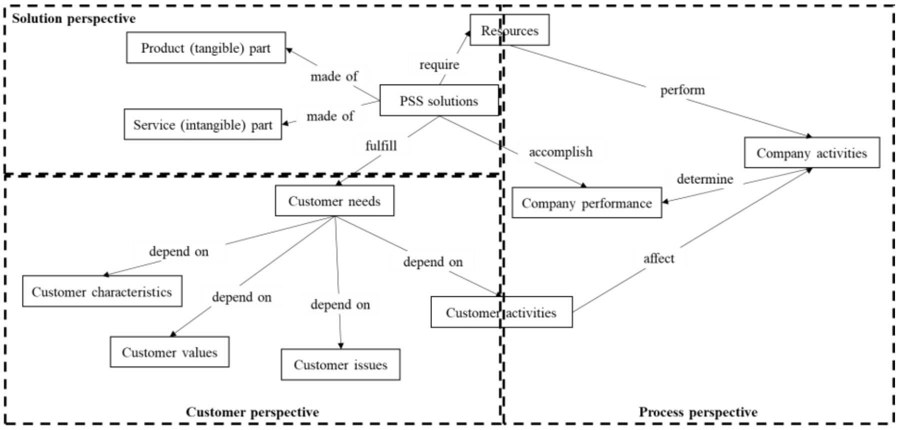

Fig. 2 – The SEEM Perspective Views

In the remaining of this section, the SEEM phases are described highlighting the links with the three above-mentioned perspectives and the models suggested in each of them.

2.1. Phase 1: Customer Needs Analysis

Focusing on the *customer perspective*, the main objective of the customer analysis is the representation of the customers' needs (expressed or not expressed), defined through feedback and complaints analysis (if an offer already exists), market research, interviews, focus groups, or more innovative tools such as sentiment analysis. Thus, the purpose of this phase is to obtain a clear understanding of the customers' needs and requirements in terms of products, services, and expected performance. This analysis can also lead to the segmentation of customers in several homogeneous classes in terms of main needs. In this phase, the modeling type **Persona Model (PM)**, coming from Design Thinking theory, is proposed as a model to collect and present information about customers. This model is based on Personas, fictional people describing the prototypical users of a product or service in terms of demographics and main values or needs. These Personas are the company reference point when engineering and defining the service offering (Pirola et al., 2014).

In addition, especially in the case of PSS re-engineering, the **Customer Journey Model (CJM)** is suggested to highlight all the customer's decision-making moments and all the interactions between customer and company.

2.2. Phase 2: Ideating and Prototyping

Starting from the customer's needs defined in the previous phase and represented in the PM, the process prototyping phase includes the generation of the PSS concepts, their evaluation, the selection of the concept to be added to the value proposition, and, finally, the delivery process's design. This phase covers both the PSS *solution perspective* and the *process perspective*.

2.2.1. Phase 2.1: Solution Definition and Selection

The *solution perspective* is implemented through the model **Product Service Concept Tree (PSCT)** (Rondini et al. 2016), which is based on the principles of design thinking and functional design. This model aims to support customer needs analysis, defining the relationship between customer needs, the PSS solutions to be provided to the customers, and the provider's resources. The PSCT Model is presented in Fig. 3 as a tree consisting of four hierarchically arranged levels:

- *Needs* (N): Elements that customers consider essential or desirable.
- *Wishes* (W): How customers' wish to satisfy their needs *x*.
- *Solutions* (S): Possible solutions (product, services or a bundle of them) that the company can identify to fulfil customers' wishes and needs *x*.
- *Resources* (R): What are the main human/software resources and/or products and related features necessary to implement a solution.

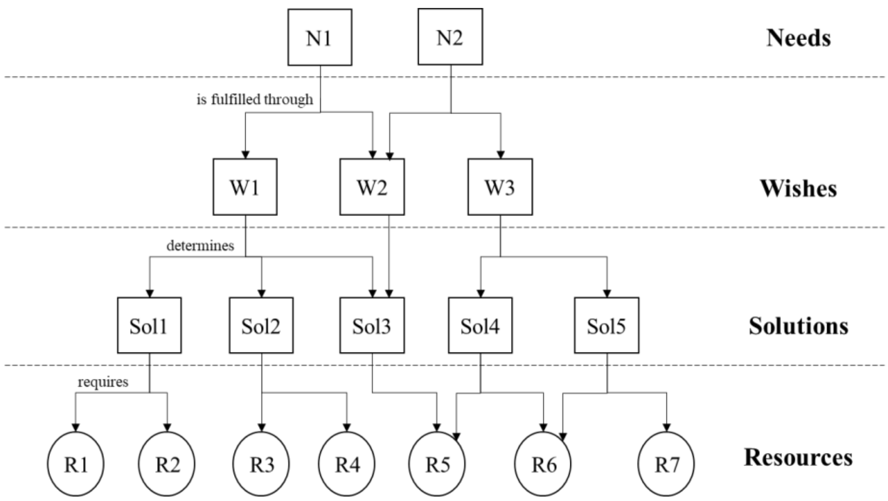

Fig. 3 - Product Service Concept Tree (PSCT)

The solutions, defined in the PSCT, are evaluated using the Engineering Value Assessment (EVA) (Rondini, Bertoni, and Pezzotta 2020), a multi-criteria decision-making approach supporting the selection of the most suitable solution(s) to be added to the company offering.

The EVA method (Rondini et al., 2018) systematically considers both customer value and provider value in the evaluation. It proposes a comprehensive set of value criteria for the assessment, which can be generalized and reused for PSS across industrial domains. It also considers all relevant 'ilities' for engineering systems and value aspects such as knowledge-, emotion- and experience-related dimensions from a customer perspective. At the same time, the provider value evaluation proposed in the EVA method is not limited to the provision of the best value for customers with the most limited amount of investments but also aspects related to the long-term survival and profitability of the enterprise.

The EVA method is composed of two different steps. The first step uses as input the list of PSS solutions identified thanks to the PSCT for a high-level evaluation of the concepts. The output of this phase is the selection of solutions with higher customer and provider values. It could also entail a refinement and/or a combination of the solutions into new PSS solutions with high customer value and provider value. Then, these selected PSS solutions are assessed in more detail in the second step to come out with the final selection of PSS solutions to be designed and implemented into the company. Two exhaustive sets of evaluation criteria (one for the provider and one for the customer point of view) are also proposed at each step. To perform the assessment, the EVA leverages on a mixture of existing methods either already used in PSS engineering or belonging to other fields. In particular, step 1 uses the Weighted Pugh Matrix, while step 2 uses the TOPSIS method. At the end of each step, EVA foresees the adoption of the Importance-Performance Analysis (IPA) matrix) to combine the evaluation scores of the two actors involved (Rondini *et al.*, 2018).

This phase represents one of the most critical aspects for manufacturing companies that tend to develop services without analyzing the most appropriate solution in detail.

Once selected, the PSS solution should be designed in detail, considering both the product and service components. Product and service design activities will follow separate paths by staying connected thanks to the work done in these preliminary phases. In particular, if a new product design is foreseen, it will follow the traditional approaches already available in most companies using the widely spread product design methods and tools (e.g. CAD tool). Instead, the SEEM methodology concentrates on the service part of the PSS, providing guidance in the design, engineering and validation of the service delivery process.

2.2.2. Phase 2.2: Process Design

Since the PSS solution should be customer centred, the starting point of this phase is the customer journey analysis to understand how the customer will use the designed solution. Thus, with the focus on the *process perspective*, the **Customer Journey Model** related to the specific PSS solution is the model used in this phase.

After this, the focus moves to the internal company process. The detailed service design consists of the definition of possible alternative delivery processes. In the re-engineering case, this phase involves mapping, first, the existing process (if any) and identifying possible alternatives for improvement. The models proposed to describe the service delivery process are the **BPMN2.0** and the **Service Blueprinting** approach. In particular, the pools in BPMN2.0 should correspond to the resources identified in the PSCT. The activities in the customer pool should reflect those in the CJM of the PSS solution. At this stage, in order to balance the customer perspective with the internal process, the CJM can be modified to allow a better service delivery.

Referring to process modeling, the SEEM integrates the BPMN2.0 with the Service Blueprinting (Bitner et al., 2008; Shostack, 1982) structure for simultaneously depicting the service delivery process, the points of customer contact, and the physical evidence of the service delivery from the customer's point of view. Indeed, the activities composing the process are classified into four categories: (i) customer's activities (performed by the customer), (ii) front-end activities (performed by the company interacting with the customer), (iii) back-end activities (performed by the company, but hidden from customer view), and (iv) support activities (general management activities performed by the company to support several processes).

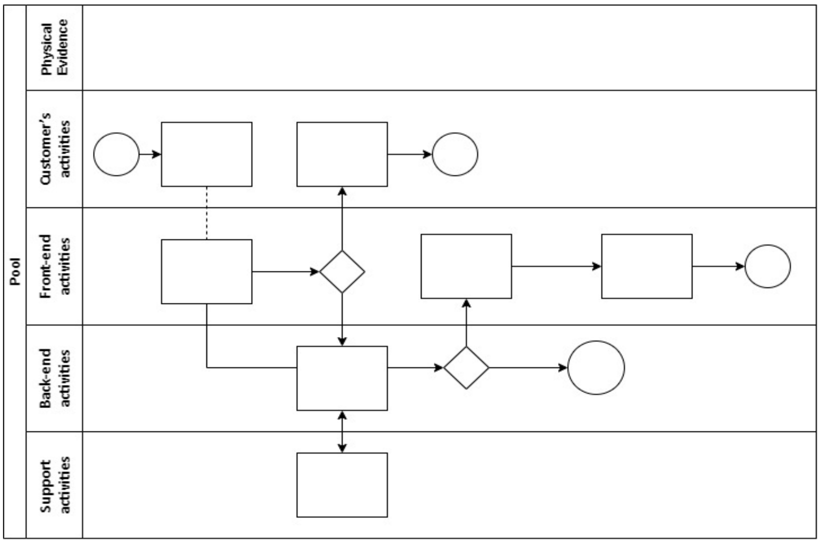

Fig. 4 - Service Blueprinting Architecture

2.3. Phase 3: Process Validation

Keeping the focus on the *process perspective*, process validation assesses qualitatively and quantitatively the performance of the service delivery processes previously designed, identifying possible alternatives, as well as identifying the most suitable process and its best resource configuration. To this end, starting from the static model developed in the BPMN2.0, SEEM adopts a process simulation approach (e.g., discrete event simulation, agent based simulation, hybrid approaches), since it allows for the dynamic analysis of a system (the service process, in our case) under different conditions and scenarios.

2.4. Phase 4: Offering Implementation, Analysis and Monitoring

Once the solution has been designed in terms of product and service components, the new PSS solution can be added to the company portfolio. In this phase, KPIs are defined to monitor performance, to have an effective and efficient value proposition with close market fit. The analysis carried out in this phase to understand how the solutions are performing on the market and if there are possible competitors/alternatives, can then be used to start a new design or re-engineering process.

3. SEEM Conceptualization and Metamodel

In this section, the metamodel derived during the conceptualization of the SEEM methodology is introduced. The conceptualization process concernes with the identification of concepts, characteristics and connectors of the SEEM methodology to establish a formal representation and to enable the transfer towards model processing capabilities and interactions applying metamodeling techniques. As such, the conceptualization process is driven by the methodological steps and derives, based on design decisions, the required specificiations of a coherent and adequate metamodel definition, which will act as a blueprint for implementing tool support.

As a guiding framework, the Generic Metamodelling Framework introduced by Karagiannis/Kühn in (Karagiannis, Kühn 2002, Metamodelling Platform) is applied. The purpose of the framework is to classify the requirements of the methodology into requirements related to the a) *structural aspects* (modelling language as syntax, notation and semantic) and b) *behavioural aspects* (mechanisms and algorithms that operate upon this structure and provide model value to the user). A metamodeling approach has been selected for this purpose to enable an agile engineering of concepts (extension, adaptation); mechanisms and algorithms are defined on the abstract constructs of the metamodel where concrete instances inherit the behaviour defined.

This adds value to the methodology as a formal representation is established as input for later implementation and deployment phases of a tool environment for the SEEM methodology considered, at this stage, as a proof-of-concept implementation utilizing available functionalities of the ADOxx Metamodelling Platform. Implementation results and their evaluation are presented in the following section, utilizing a case study in the domain of automation sector.

The conceptualization results are presented in the following, using UML class diagram notation to represent the structural aspects of the metamodel, extended with functionality annotations (marked in green) as requirements of the conceptual structure and input for the tool implementation.

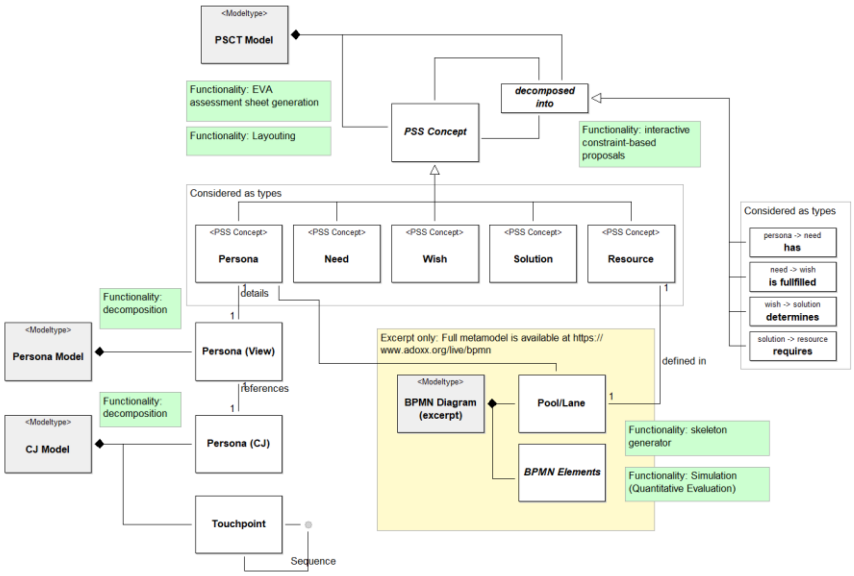

Fig. 5 – SEEM Metamodel

The SEEM metamodel consists of 4 modeltypes supporting phases 1- 3 of the SEEM methodology.

3.1. Phase 1: Customer Need Analysis

Model structure: Utilizing the *"Persona model"* as a container to identify different viewpoints of involved stakeholders. Each persona is defined using the "Persona (View)" element considering attributes to describe the specific persona (image, age, name, role, slogan, a list of wishes). The structure of the modeltype is in the form of a list, assuming that each instantiation of the modeltype results in a set of personas which describe the needs of the organization.

In addition the "Customer Journey Model (CJM)" is defined that utilizes the list of personas as an input, and allows the descriptive design of touchpoints in the sequence of their occurrence.

Model processing functionality: For the persona concept, a decomposition functionality is defined. This functionality generates the first layer of the PSCT tree (persona as a virtual persona object and wishes derived from the structure) as well as the skeleton for the customer journey modeling (virtual persona object derived from the Persona model).

3.2. Phase 2: Ideating and Prototyping

Model structure: The ideation and prototyping phase is considered the core element of the SEEM methodology and its conceptualization. The metamodel consideres a hierarchical tree structure that is defined on an abstract level ("PSS Concept" and "decomposed into") contained in the modeltype "PSCT Model". The tree representation enables a structural analysis of contained elements.

The structured design approach utilizes the BPMN metamodel as a foundation. The metamodel is based on the standard specification by OMG (BPMN 2.0) and only relevant concepts for the model processing functionality are considered in Fig 5. The full metamodel applicable for SEEM is available at https://www.adoxx.org/live/bpmn/.

Model processing functionality: The design decision on PSCT level is based on the capabilities of metamodeling techniques. As the abstract constructs (class and relation) are concretized from a semantic perspective, they inherit on one hand the tree-based model representation format and are extended by constraint evaluation rules that support the ideation process. This means that the modeler is guided in the process of decomposition based on the initial input from Phase 1.

Evaluation: Assessment templates are embedded in the constructs to provide possibilities for a distributed and collaborative evaluation of ideas based on the PSCT representation

Utilizing rule-based mapping techniques, the PSCT tree structure is resolved into a process representation skeleton as "Resources" in the tree are mapped to pools/lanes in BPMN, representing actor responsibilities in the process notation.

3.3. Phase 3: Process Validation

Model structure: The validation phase in SEEM is concerned with the evaluation of the process design of Phase 2. Available structural elements are considered on BPMN 2.0 level, more specifically the available conceptualization for process simulation using BPMN 2.0. This concerns extension for quantitative facets during process design.

Model processing functionality: Simulation algorithms are available as building blocks that operate upon an annotated graph structure (typing) and quantitative facets of nodes and edges.

The outcome of the conceptualization shows that the SEEM modelling method is established by defining a small set of semantic primitives (specifically for the PSCT model) that are concretized during their use (dynamic typing). This approach is considered relevant for the SEEM methodology in order to provide domain-specific extensions on type-level without loosing processing capabilities.

The above conceptual metamodel has been transformed into a prototype implementation utilizing the ADOxx Metamodelling Platform, resulting in the SEEM Modelling Toolkit presented in the following using a real case study.

4. SEEM Modeling toolkit: Proof of Concept

The SEEM Modelling Toolkit used as computer-based tool in a case study aiming at supporting an Italian company in the selection, design and engineering of new PSS solutions. This section has the objectives to describe the SEEM Modelling Toolkit with an application in a real case and to show the tool main features and validate its potentiality, feasibility, and easiness to use in real-world settings.

The case study company is an Italian producer of automation systems for residential use, namely automation systems, and the related accessories (e.g. remote controls, photocells, flagship light), for gates and garages. Historically, the company has always been strongly product-oriented and its service offering is limited to support installers and final users through an external call center. Given the possibilities offered by technological advancement and the global trend toward servitization, the company is willing to move towards PSS provision to increase its revenue and customer loyalty.

To support the company in its journey towards servitization, the first two phases of the SEEM methodology have been applied and implemented using the SEEM Modelling Toolkit, namely the customer needs analysis and the ideating and prototyping.

4.1. Phase 1: Customer Needs Analysis

The first phase of the methodology is the analysis of the customers and the actual service offering. As mentioned in the "The SErvice Engineering Methodology (SEEM): Perspectives and Modeling Requirements" section, this phase adopts traditional models coming from Design Thinking to support the PSS designers in describing and analyzing the main company customers (i.e. Persona Model and the Customer Journey Model). The information needed in this phase generally comes from the company unstructured knowledge, brainstorming, interviews with customers, focus groups, etc. Thus, the main value-added of the SEEM Modelling Toolkit is to provide a computer-based tool supporting the adoption and visualizing of these models in a unique environment and enhancing the development of common knowledge in the scope of PSS engineering. In particular, the Persona Model summarizes the main characteristics of the customer analyzed, such as picture, name, age, role, company, slogan, needs. The Persona model is possible to generate the following models ensuring a guided and improved design experience.

During the case study, interviews with the company managers were allowed to gather all the information related to the market and customers. The company has the following three main kinds of customers through which sell its products to final consumers :

- *Wholesalers of electrical* equipment: This is the most important customer in terms of sales volumes since it accounts for about 60% of the company's turnover. The company sells its products to wholesalers, who, in turn, sell to "small" installers who sell and install the products to the final users. The installers are mainly generic electricians who carry out about 5-6 interventions of this type per year.

- *Professional installers:* It accounts for 30% of the company turnover and addresses professional installers specialized in automation, who carry out a higher number of interventions per year.
- *OEM:* It guarantees 10% of the turnover and is characterized by the direct sale to manufacturers of civil and industrial doors and gates.

The market addressed by the company has the following criticalities that hamper the introduction of services: i) The value chain is quite long with several intermediaries and, then, the final user is difficult to reach, ii) Final users consider the product as a commodity and focus more on the price rather than on its functionalities and added services, and iii) The generic installers are not prone to innovation, leading to failure when new technologies and services are proposed to them.

Given the market characteristics, the focus of the analysis has been the generic installer, namely the generic electricians who sell and install the product into the final customer (i.e., the customer house). Thus, the aim is to identify the services that can be offered to the installers and the product to increase the market share and the related revenues.

To this purpose, the Persona Model of the generic installer has been built using the SEEM Modelling Toolkit. A brainstorming session involving the company employees with deep knowledge on products and customers led to define the main characteristics of the customers that are summarized in Fig. 6. Obviously, the Persona Model reports only the most useful customer elements for the design purposes, but more information related to the main issues and values of the customer have been gathered during the analysis. The typical customer is a fifty-year-old electrician that owns a small company that provides several installation and maintenance services of the house electrical system (Fig. 6). His main expertise is mainly in the electrical field and he has very little or no competence in software and, for this reason, he is averse to any technological innovation in the field of software. The analysis of the customer allows to identify its main needs that are:

- *Easiness to install*: Since he is not specialized in automation (on average, he carries out 5-6 installation per year), but he is a generic electrician dealing with all the electrical systems of a house, his main need is to have a product easy to install. He does not want to encounter problems during installation that will force him to contact the service support centre of the company asking for support and waste time.
- *Reliability of the product*: Since this kind of customer generally owns a micro company with 1 or 2 technicians, he considers more profitable the new installation instead of repairing already installed automation. This activity can require a long time and huge effort to identify causes and fix the problem.

Fig. 6 - Persona Model of the Installer

To better understand the characteristics of the customer, its Customer Journey Model has also been defined in this phase to highlight its main activities, decisions and contact points with the company. This helped the company define possible PSS solution in the following phase.

4.2. Phase 2: Ideating and Prototyping

Based on the Persona Model, the following phases of the SEEM methodology have been applied, namely the Product Service Concept Tree. Starting from the main characteristics of the customer identified in the previous phase (e.g. needs, issues, values) and summarized in the Persona model, the PSCT supports the designer in identifying possible PSS solutions to be offered to the installers, the selection of the most convenient PSS solution(s) to be proposed and the design of the delivery process of the identified PSS solution(s).

In the SEEM Modelling Toolkit, clicking on the button "Generate First Layer of PSCT" in the notebook window of the Persona Model (shown in Fig. 8), it is possible to automatically generate the first layer of the PSCT, namely the need layer. Then, from the need level, the lower levels can be created in the PSCT model adding new boxes and defining their type (i.e. need, whish, solution, resource). When connecting the different boxes in the PSTC, the PSCT model automatically generates the relationships between the elements. In this way, a persona "*has*" a need, the need "*is fulfilled through*" a wish, the wish "*determines*" a solution which "*requires*" a resource (Fig. 7).

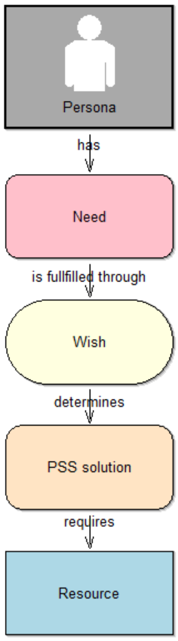

Fig. 7 - Relationship in the PSCT

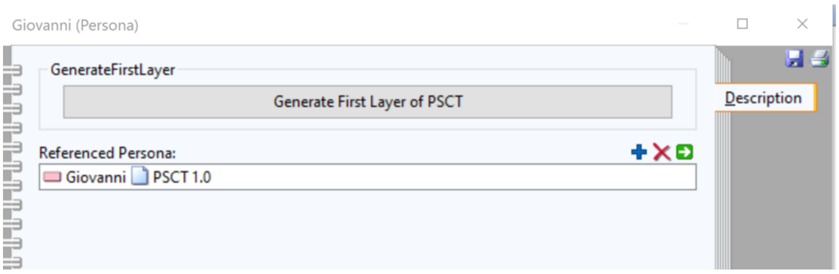

Fig. 8 – PSCT Generation

The PSCT (Fig. 9) has been implemented through a brainstorming session with the main company decision-makers: R&D manager, division manager, sales manager, product marketing managers, product manager, training and service manager, and business area manager. These people have direct contact with customers or have high knowledge of the products and the technologies available to improve them. The brainstorming session lasted about 4 hours. After identifying the whishes (represented in the yellow ovals) that allow to fulfil the customer needs, the PSS solutions reported in Table 1 have been devised (represented in the orange boxes).

Table 1: PSS Solutions

PSS solutions	Description
Training software/hardware	To ensure quick and legally compliant installation, it entails documentation and courses that allow respecting the type of product in terms of the law (with a study of the impact curves)
Installation with augmented reality	Use of augmented reality trough smartphone to support installation.
Visual manuals	Provision of visual manuals with drawings explaining the installation phases; these could be provided through an app to reduce printing costs and make constant updates.
Youtube tutorial	A QR code placed on the product linked to Youtube content to view videos. This solution can be seen as an intermediate between manuals and augmented reality.
Customized kit configurator	Possibility to configure the product and the installation kit via an app, reducing the complexity of the installation and the number of calls due to installation problems. In addition, the configurator would allow the installer to have a "shopping list" based on the solution chosen to buy everything from the wholesaler.
App for configuration and quotation	Product configurator offered through an app to customize the product and get a quotation.
Installers list	The installer can become a “recommended installer” by the company and be included in a list freely accessible by end-users.
Accreditation programs	Training and events to get known and trained in products and then be included in the “recommended installer” list.
Automatic certificate	Checklist that allows the installers to automatically generate a certificate assuring that the installation complies with the local regulation.
Safety procedures for installers	Courses and events that allow developing knowledge in this field.
FAQ/troubleshooting	Dedicated area in the website/app where the installer can find answers to frequently asked questions.
Maintenance supported by augmented reality	The maintenance of the automation system is performed through augmented reality which ensures a more effective and efficient intervention.
Free assistance in pre-series	Offer a period of free service to the pre-series product, that would also allow the company to improve the knowledge about the behaviour of the new product and its main problems.
Preventive maintenance programs	Possibility of creating contracts between the installer and the end user for scheduled maintenance.

Finally, for each PSS solution the main resources involved in its service delivery process have been identified and represented in the blue boxes.

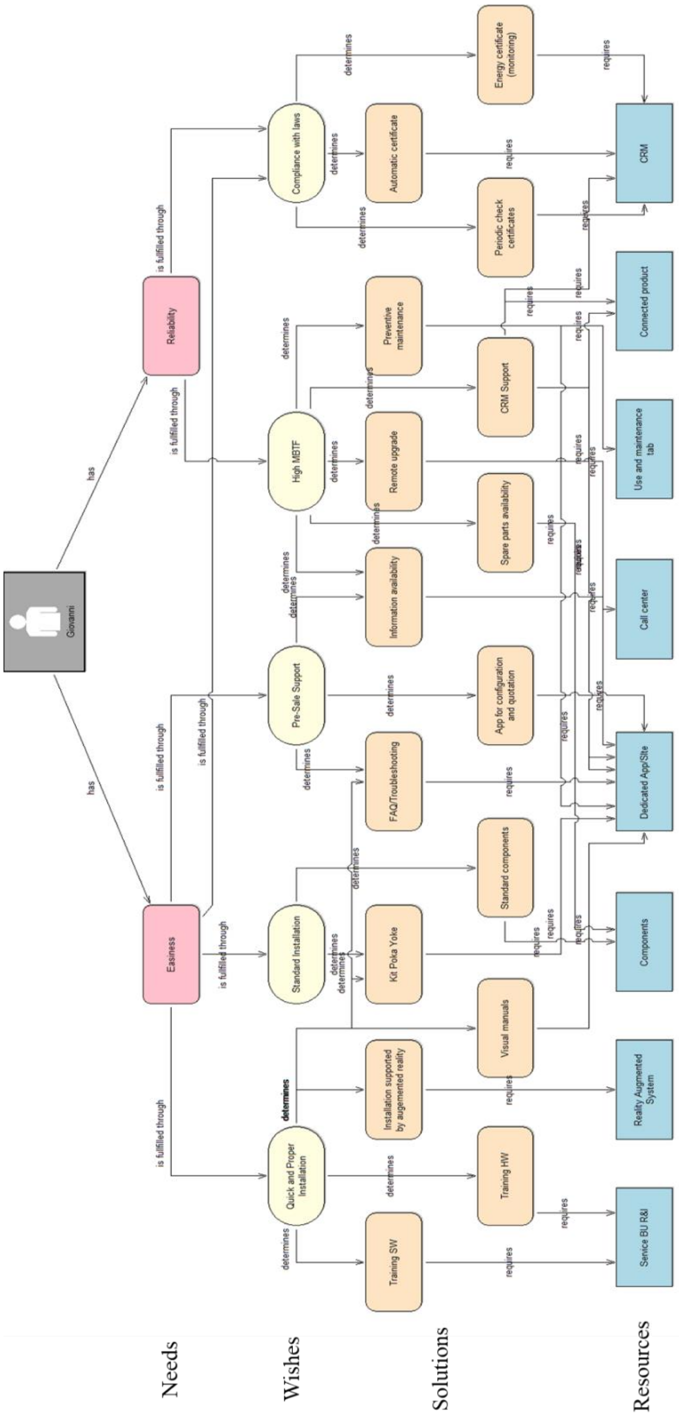

Fig. 9 – The Product Service Concept Tree

The PSCT is allowed to define several possible PSS solutions but it is important to assess them based on multiple criteria and select the best solution able, from one side, to fulfil customer needs and, from the other side, to ensure company profitability and alignment with its long-term strategy. To this purpose, the first step of EVA method (explained in section 2) has been partially implemented. As shown in Fig. 10, selecting one solution generated in the PSCT, the SEEM Modeling Toolkit generates two excel files, one from the provider and one from the customer viewpoints, each of them containing the list of pre-defined criteria for the assessment (Rondini et al., 2018). Then, all the people involved in the PSS design process have to fill out the excel files generated for each solution of the PSCT, providing their assessment. All the first step evaluations are summarized by the PSS designer who is also responsible to carry out the second step (not implemented in the SEEM modeling toolkit yet) to define the solution that should be designed in detail.

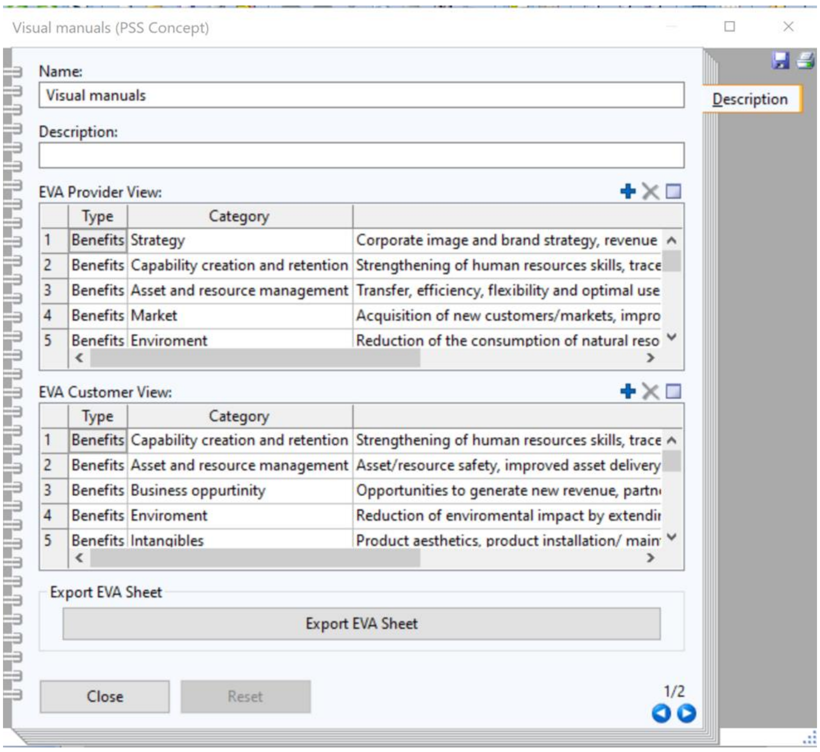

Fig. 10 – Generation of EVA Sheet

Thus, the two steps of the EVA method have been carried and the fourteen solutions identified in the PSCT have been assessed. To this purpose, two single interviews (one per step) with the main decision-makers have been carried out. Each interview has been assisted by one of the authors acting as a facilitator. In the first step interviews, the facilitator provided a general description of the overall method, its steps, and the categories for the high-level assessment to create a shared understanding among the participants. For the second step of the EVA method, further interviews have been carried out with the same people involved in the previous phase.

The analysis of all the scores provided by the company led to the final selection of the PSS solution concepts to be developed and added to the PSS portfolio of the target company. The most valuable PSS is the delivery of *visual manuals* (preferably through an app).

It is important to emphasize that, thanks to the SEEM Modeling Toolkit, all the analyses carried out starting with the definition of the persona, the generation of the different solutions and their evaluation become an important part of the company's knowledge and can be used for future projects. In fact, these models have the great advantage of becoming a methodological base supporting how the company manages the engineering process and generates a fundamental knowledge base for companies that want to servitize.

Starting from the most valuable solution, the Customer Journey Model and the BPMN model of the service delivery process have been defined. In the solution options of the SEEM Modeling toolkit, it is possible to automatically create the template of these two models, as shown in Fig. 11.

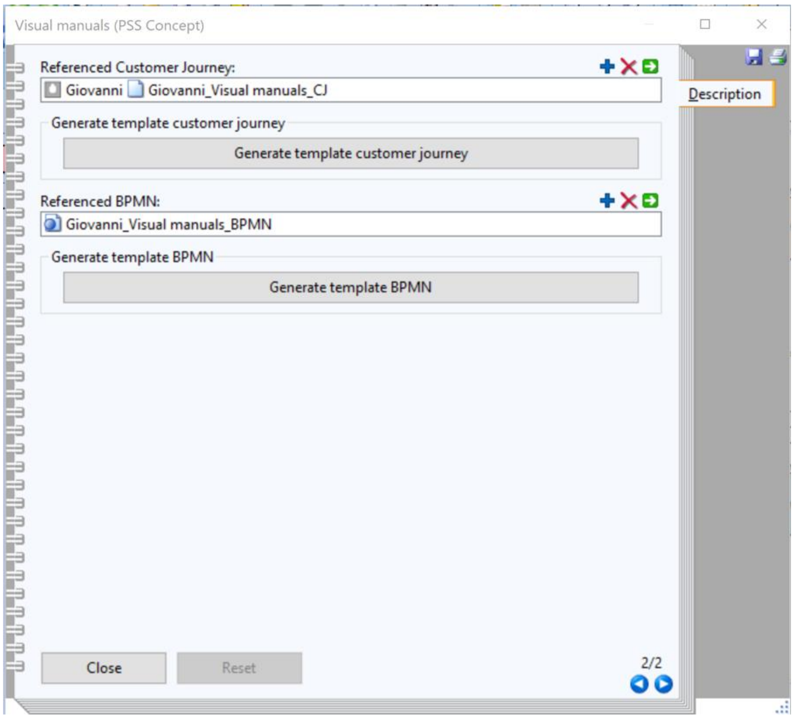

Fig. 11 – Generation of Customer Journey Model and BPMN

Then, the Customer Journey Model (Fig. 12) has been built adding in the template all the activities carried out by the installer, since when he receives the call from his customer that need an automation system until when the automation is installed. As it is possible to notice, after having received the customer request, the installer analyses the plant where the automation must be installed, makes an offer, and, if it accepted, he buys the automation from a wholesaler and installs it to the customer site. During installation, he can consult the visual manual provided along with the product or in the company app, which allows him to follow step by step in an easy way installation procedure, fastening the entire process. Once the installation is concluded, he makes the needed tests for the product, releases the certificate, sends the invoice to the customer, and receives the payment.

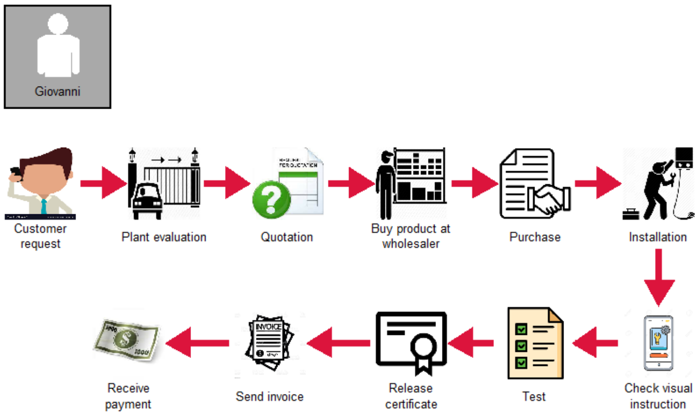

Fig. 12 - Customer Journey Model of the Selected Solution

To model the activities considering also the company point of view, the process is also modeled using BPMN2.0, as shown in Fig. 13. The BPMN template is generated from the selected PSS solution: clicking on the button “Generate template BPMN” in Fig. 11, a new BPMN model is created with the pool corresponding to the resources linked in the PSCT. In this model, then are added not only the activities of the installer but also the activities of the other resources involved in the delivery process (in this specific case, the installer customer and the app), highlighting the contact points and allowing to statically test different process configurations.

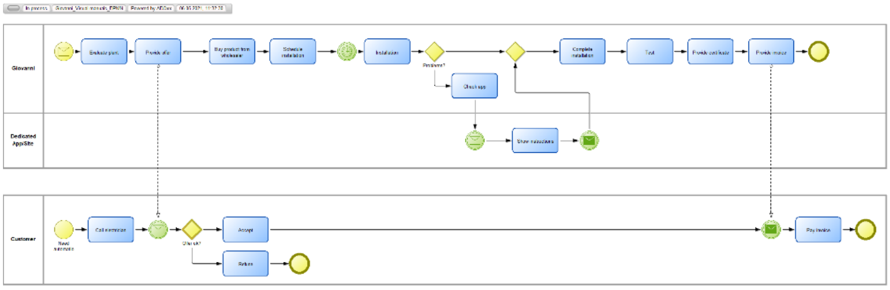

Fig. 13 - BPMN of the Service Delivery Process

Once the statical process configuration has been defined, a quantitative evaluation of the process could be carried out leveraging on the time and cost assessment available in the SEEM Modeling toolkit, as shown in Fig. 14. This assessment will be possible to estimate, considering several scenarios, the lead time of the process, the waiting time, the resource utilization, the cost associated with the process, and so on. This will be helpful to make further decisions related to the process and support the decision-maker in defining its optimal configuration.

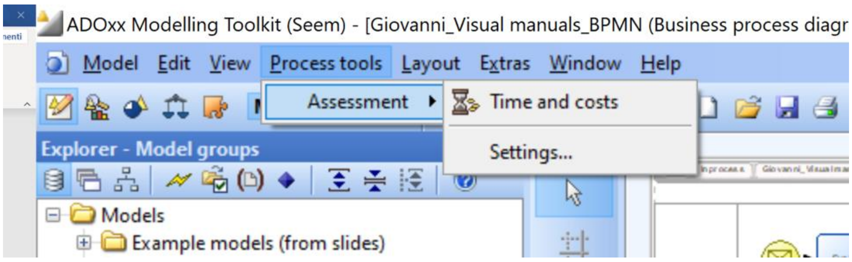

Fig. 14 – Process Assessment

5. Conclusion

Nowadays, companies are struggling to move from a product-oriented towards a more PSS oriented business model. The academic and scientific literature reveals a lack of suitable computer-based tools to support early PSS design activities, integrate product and service concepts since the beginning, and evaluate PSS concepts based on customer needs and company profitability. To fill this gap, the SEEM Modeling Toolkit has been proposed to implement the methods suggested in the SEEM methodology (Pezzotta *et al.*, 2016), and, then, to support the PSS designer in the different phases of designing and engineering PSS.

The chapter shows an application of the first two phases of the methodology and the implementation of the SEEM Modeling Toolkit in a case study focused on an Italian producer of automation systems for residential use. Thus, starting from the customer analysis, the case study has led to the definition of a set of PSS solutions, to the selection of the PSS concept to be added in the company portfolio and to the design of the solution delivery process, highlighting both the customer (in the Customer Journey Model) and resource interactions (in the BPMN) point of views.

From the case study point of view, the interviews and the methodology implementation have been highlighted as a cultural change inside the company that appears to be fundamental to successfully introduce PSS offering. Indeed, a willingness of the middle management to offer services that could change the habits of customers and could allow establishing a different relationship with them is still missing. Furthermore, customers are perceived as not very prone to services but still too focused on acquisition cost and selling price. In general, there is a lack of a long-term vision in which the relationship with customers can change and offer services effectively capable of anticipating their needs. Despite the need of a business and cultural change of the company and of the industry, the implementation of this methodology has been a first valuable attempt to change the mindset of managers since it has allowed them to analyze their products from a different point of view and to design new solutions starting from customer needs rather than from technology and product innovation point of view.

From a technical point of view, even if the SEEM Modeling Toolkit is still at the prototype phase, it has demonstrated to be easy to use and suitable to implement the phases foreseen by the methodology. During the design phase of the SEEM metatmodel, the following challenges have been identified from a conceptual point of view and can be considered as input for further research work. The first is related to model/view synchronization, where mechanisms in the metamodel are required for an intelligent synchronization of artefacts. This is specifically interesting for personas and potential changes during the decomposition and refinement phases. The second concerns time/variants. Variants might evolve during the design and this requires capabilities to synchronize and compare model artefacts.

In addition, the toolkit only covers a part of the methods suggested by the SEEM methodology. Further developments consist in the integration into the tool of the two steps of the EVA method. This can be done directly in the tool allowing to import the excel sheets with the scores assigned to the different criteria, create the excel files for the second steps, and visualize the results of the two step of assessment in a graphical manner. Furthermore, the last phases of the SEEM should also be tested with a case study, in particular, the integration of the time and cost assessment to quantitatively evaluate the performance of the process considering different scenarios.

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