Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 30 (2015) 215 – 220

www.elsevier.com/locate/procedia

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

SErvice Engineering Methodology in Practice: A case study from power and automation technologies

Alice Rondini [a], Fabiana Pirola[a], Giuditta Pezzotta[a]*, Mohamed-Zied Ouertani[b], Roberto Pinto[a]

[a]CELS – Research group on Industrial Engineering, Logistics and Service Operations – Università degli Studi di Bergamo, viale Marconi 5, 24044, Dalmine (BG) – Italy

[b] ABB Corporate Research Centre, Wallstadter Straße 59, 68526, Ladenburg, Germany

* Corresponding author. Tel.: +39-035-2052005; fax:+39-035-2052077.*E-mail address:*giuditta.pezzotta@unibg.it

Abstract

The global crisis and the fierce competition of emerging countries make companies struggling to stay ahead of competition. The number of companies that are enlarging their offer portfolio looking forward to new and increased sources of revenues is always increasing but the number of companies failing in successfully implementing *servitization* strategy is even more. One possible reason behind this is the lack of tools to support companies while dealing with services that by definition are characterized by high level of intangibility and perishability.
The Service Engineering (SE) discipline that is currently working for an integrated development of tools and methodologies specifically related to services is still under development and the existing methodologies are more oriented to the manufacturing context. In the SE context Pezzotta et al., in 2014 suggested the SErvice Engineering Methodology (SEEM) for the engineering and the re-engineering of new service or Product-Service System (PSS) helping the companies in balancing their internal performance with the service value perceived by the customer. This paper aims at understanding the industrial applicability of such methodology. It presents a real case study carried out in collaboration with ABB Spa, a leading provider in power and automation technology. In the paper, all the steps performed during the application of the SEEM are described, together with the difficulties encountered. Some insights obtained with the application are also described.

Peer-review under responsibility of the International Scientific Committee of the 7th Industrial Product-Service Systems Conference - PSS, industry transformation for sustainability and business
*Keywords:*Service Engineering, PSS Design, Discrete events simulation,

1. Introduction

Manufacturing companies have undertaken an evolutionary path towards *servitizing their business* [1] in the continuous quest for new sources of revenues [2]. Those companies are shifting towards proactively providing their customers with new integrated Product-Service System (PSS) [3] while keeping the break-fix business model to fulfill explicit customers' requirements.
However, the shift from products to PSSs turned out to be quite problematic, and many companies bumped into the so called "service paradox" [4,5], these companies were not able to obtain adequate revenues with respect to the initial investments and sometimes incurred in higher costs than expected. One of the possible causes behind such paradox lays in the lack of tools supporting enterprises in designing, developing and managing PSS through its lifecycle [6].
In this context, Service Engineering (SE) [7,8] has emerged as a discipline addressing the design and development of an integrated PSS offering, focusing on delivering value to customers by applying specific models, methods and tools. In spite of the theoretical SE advantages [6,7], few proposals, such as MEPSS [9] and Service CAD [10], are available with practical mechanisms making it easy for practitioners to benefit from the full potential of SE and the related methodologies [11,12]. In this context, Pezzotta et al. [13] proposed the SErvice Engineering Methodology (SEEM) aiming at developing an easy to use framework to support companies in systematically engineering and re-engineering their PSS offering.

Peer-review under responsibility of the International Scientific Committee of the 7th Industrial Product-Service Systems Conference - PSS, industry transformation for sustainability and business
doi:10.1016/j.procir.2015.02.151

The goal of this paper is to demonstrate the industrial applicability of the SEEM through its implementation in a real manufacturing environment. This case study has been carried out in collaboration with ABB, a leading power and automation technologies provider. ABB has been selected among others due to i) the servitization strategy adopted and characterizing its business, ii) the variety of the PSS offering iii) the complexity of the available service portfolio, and iv) the strong company commitment in satisfying really heterogeneous service customers' needs.
The remaining of the paper is structured as follows. In the next session, the theoretical concepts of the SEEM methodology are briefly described. The third section illustrated how SEEM has been used and implemented in the industrial partner.. In the final part of the paper, the managerial implications and the conclusions related to the case are presented.

2. Methodology

SEEM aims at supporting companies in making the shift to a service-dominant logic as well as re-engineering an already servitized business. In particular, SEEM supports companies in engineering and re-engineering their PSS while balancing the value perceived by customers with the internal efficiency and productivity of the service delivery processes.
To this purpose, SEEM is divided in two main areas (further detailed in [13])

1) *Customer area*: it entails i) the analysis of customer needs, that represents the starting point to design new product-services, and ii) the re-arrangement of the company service portfolio.
2) *Company area*: it deals with the design and assessment of the service delivery process.

With regard to the company area, we further consider two main activities:
1) *Process prototyping:* it aims at defining one or more process prototypes that are the former suggestion of a process structure. This phase is further divided in two steps:
   a) *Step 1 - Requirements and specifications design:* this step deals with the definition of the Service Requirement Tree (SRT) that defines the relationship between the customer needs and the provider's resources. The SRT, deploying four main levels, starts from the identified customer *"Needs"*, defines the "*Whishes"* (how the customer wants to satisfy his needs) and the "*Design Requirements"* (DR) (how the company can satisfy customer whishes). The last level allows defining the "*Design Specifications"* (DS), representing what a process is intended to deliver in terms of macro activities and resources. Resources are all the entities – i.e. people, tools and material - used in the activities (such as the spare parts). In this step, the methodology also envisions the definition of the relative importance of all the relationships. To do this, the Quality Function Deployment (QFD) [13] approach has been adopted: specific weights to each branch of the SRT tree have been given in order to understand the impact of each DR, DS and the resources in satisfying the customer's need.
   b) *Step 2 - Process Design*: it consists in the design and representation of one or alternative service delivery processes. In this case, the blueprinting methodology [14] is suggested. In order to understand how much the process is able to satisfy the customer's need, this step also includes the connection between the DSs of the SRT and the activities of the blueprint.
2) *Process Validation:* the aim of this phase is to validate and assess the performance of the alternative service delivery processes previously designed, as well as to identify the most suitable process and its best resource configuration. To this end, the SEEM adopts a process simulation approach, since it allows for the dynamic analysis of a system (the service process, in our case) under different conditions and scenarios.

After introducing the SEEM methodology, we focus in the following section in describing the industrial case. It is important though to highlight that for the purpose of this paper, the authors only focused on the service engineering of the Product-Service System the industrial partner offers.

3. Industrial case

This section presents the industrial partner and describe the application of the SEEM for the reengineering of the ABB service portfolio.

3.1. The company

ABB is a global leader in power and automation technologies. ABB's business is comprised of five divisions that are in turn organized in specific business units (BUs) in relation to the customers and industries they serve. The ABB product portfolio is composed of complex offerings such as across voltage power products, power systems, solutions for industrial processes optimization, discrete automation products, and low voltage products for electrical application. As could be seen, this diversified product portfolio needs different service requirements, i.e. features, price and lifecycle intervention. The service offering at ABB is organized around 11 categories that apply to all five divisions. Those eleven categories are: Service Agreements, Maintenance, Advanced Services, End of life Services, Engineering and Consulting, Installation and Commissioning, Repairs, Replacements, Training, Spares and Consumables and Extension – Upgrades – Retrofits. Such an extensive service offering and heterogeneous product portfolio makes the sharing of best practices challenging among BUs. Harmonization and standardization of service delivery is therefore crucial to make it possible to expand the service offering and increase the service revenues. This motivated the testing and implementation of SEEM in ABB.
This paper will focus on one specific BU that provides low voltage breakers and switches and is located in Bergamo (Italy).

3.1.1. SEEM application to ABB

Due to the fact that we were dealing with a re-engineering case, the implementation of the SEEM in ABB started with the analysis of the existing service portfolio and its comparison with customer needs. The following paragraphs describe in detail all the steps and the results obtained in the case application. For each step, various meetings with ABB managers and employees involved in the service delivery were required to understand the processes and to collect all the data. This allowed the researcher to avoid any misunderstanding and cross-check the data collected. This phase consists mainly on a series of face-to-face meetings and workshop with the company representatives.

3.1.2. Customer area: customer needs analysis and company service portfolio

The initial step of the application of the SEEM to the re-engineering case in ABB has been about the identification of the main customer needs and the analysis of the company service portfolio. The former task has been carried out considering marketing and customer's data already available in ABB [15]. A key learning from this analysis is the number of customer types that the service provider deals with. In this paper, we will focus on the most relevant customer types that are offered services related to low voltage equipment:

- *Customers type I*: are those they trust ABB capabilities to maintain their installed base in a good operating condition;
- *Customers type II*: are those they directly take care of their installed base maintenance, and only resort to ABB support for complex service jobs and for spare parts.

Both of these customers types share the same need: the maximization of the availability of the installed base ("to maximize availability" in short hereafter). Considering this need, the SRT has been developed.
Having identified the most important customer need, the next step has been on analyzing the service portfolio. About 90% of the revenues of the BU service business is currently resulting from the following offerings:

- *Preventive and corrective maintenance* (both performed at the customer site and at the ABB plant in Dalmine - Italy);
- *Replacement* (provision of breakers currently out of production, for customers who have plant's specific needs);
- *Retrofit* (add new functionalities to an old product);
- *Spare parts provision*.

Following from this analysis, it has been decided that the focus of the reengineering task performed in the next two phases of the methodology should be on both customers' types and on the four service products.

3.1.3. Company area: Process prototyping

The process prototyping phase uses the customer need identified in the first step as an input to define the service delivery process. The first tasks envisioned by the SEEM into the process prototyping is the definition of the main requirements of the process. Starting from the main customer need – i.e. to maximize availability - the three levels of the Service Requirement Tree (SRT) have been deployed through the definition of the wishes, the design requirements (DRs) and design specifications (DSs) and their relations. It is important to highlight here the important effort spent by ABB managers as they had to define both existing and hypothetical DRs and DSs. At the end, the single initial need allowed the deployment of three wishes, 13 DRs, 20 DSs also including 18 different resources roles. An extract of the SRT is depicted in figure 1. After the definition of the tree, a QFD analysis has been carried out The service delivery manager and customer interfacing engineers were responsible in assigning those weights considering the different behaviours of the two customer categories towards achieving higher availability of their installed base. When prioritizing the resources' impact in satisfying customer's needs, it appeared that both customers types value different kind of resources involved in the service delivery chain. For customer Type I, the most important resources are the sales people called "proposals", the "training operators", the "spare parts" and the "warehouse operators". This result is aligned with the definition of the customer Type I: if they want to perform the maintenance by their own, they would definitely need a good training and a fast spare parts delivery for which the "warehouse operator" and the "proposal" are the key resources. On the other hand, the customer type II, who completely rely on ABB, recognize the importance of the "proposal" who defines the contract terms and conditions and the technicians who perform the service job.

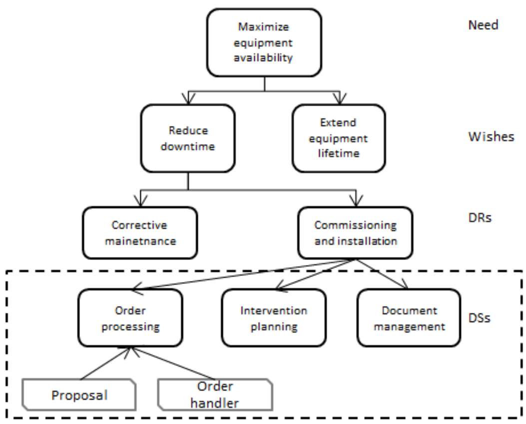

Figure 1 Short extract of ABB LPBS SRT

The second step related to the process prototyping is the process design though the use of the blueprinting methodology [14]. Four service delivery blueprints have been drawn (one for each service offering analyzed). The set of activities identified (about 120 for each blueprint) are performed by either the customer or by ABB front-end resources (e.g. proposal, onsite technicians), or by ABB backstage resources (order handlers, workshop technicians) or support processes (e.g. logistics, administration).

A brief description of the general service delivery at ABB is:

- *Handle customer request*. The process starts with a service request from the customer. The sales people ("proposals") receive these requests, perform some analysis on the customer sustainability, and define a quotation for the required service.
- *Confirm capability.* The customer reviews the ABB offer and determines whether it fits its requirements. The customer sends then a service order to ABB.
- *Manage order.* Once the service order is received, it is compared with the offer and uploaded in the ABB's ERP system with all the related information.
- *Mobilize and plan*. This phase strictly refers to the case of intervention at the customer's plant. ABB and the customer would agree on a date to perform the service. The "dispatcher", responsible for that task, also selects the technician(s) to perform it according to staff availability.
- *Prepare service job*. In this phase, the technicians define the spare parts and the material needed for the intervention. In the case of workshop maintenance, the customer sends the breaker to ABB's premise.
- *Perform service job*. In the case of onsite maintenance, the technician(s) go(es) to the customer whereas in the other cases they perform the service job or assemble the retrofitting kit or the spare parts in the ABB facility.
- *Complete service job*. The final part of the process entails the shipment of the materials to the customer (if needed) and the collection of all the documents. Finally, the invoice is sent to the customer.

Once the service blueprinting maps were complete, a good static overview of the processes was available. In order to be able to assess the performance of the delivery process towards satisfying the customer's need, the identified DS have been linked to the blueprint activities. Such a link allowed for a formal check to verify whether there exists any activity in the blueprint not assigned to any DS and vice versa.

The case study analyzed presents a good correspondence between the blueprint activities and those identified in the SRT (DSs), therefore no changes in the service delivery structure was needed. This final mapping together with the QFD analysis have allowed to identify the critical part of the service delivery that should be specifically monitored. However for the sake of completeness, all the service delivery operations were monitored. The next section will focus on how the service delivery operations devised on the blueprint were validated.

3.1.4. Process validation

In the reengineering case, the main goal of the process validation step is the assessment of the current processes performance and the identification of the resource configuration that maximizes the tradeoff between customer satisfaction and internal efficiency, taking into account also the company future target. To this purpose, the SEEM suggests the use of simulation to develop a "what-if" analysis. Thus, considering the ABB predicted targets in its service business, a "what-if" analysis has been carried out in order to understand how the current process ("AS-IS") would perform when the future targets are set. Based on these results it would be then possible to identify the best solution that ensures a proper balance between the customer value and the process performance.

In this case, the process validation has been done using Discrete Event Simulation (DES) as suggested by [16, 17, 18]. In particular, Arena Rockwell Simulation Software has been selected due to the advantages underlined by literature [18]. The translation of the blueprinting maps into a simulation model is probably the most time consuming phase of the process validation. The main reason behind this is the broad difference between the static and the dynamic maps, due to the following motivations:

- *Unique simulation model.* Since the different service processes analyzed share several resources, such as sales people, technicians and order handlers, a single simulation model should be defined. The amount of time that each resource dedicates to each specific service could not be defined a priori, since it depends on many factors such as the period of the year, the priority of each request and the specific intervention. That is why a single simulation model was built.
- *Level of detail.* The service blueprinting maps present all the different processes in a very detailed way. In the simulation model, such a detailed representation may be a problem, since the duration and time variability need to be included when setting the process parameters. Setting the time for many detailed activities increases significantly the variability at levels that do not reflect reality. In this case, the result can be a distorted system with a too high intrinsic variability. In order to avoid this problem, it is crucial to group together some activities that are sequential and logically linked and that, together, can become a significant process in the final model.
- *Hierarchical structure.* Given the complexity of the process, two different levels were defined. These two levels have been designed according to [19] to obtain a suitable overview of the company and customer performance.

In the simulation model, the *entities* are the customer requests of the different services and the *events* represent the process activities. The entry distributions of the entities has been inferred from ABB historical data using the "Arena input analyzer", that calculates the best fitting distribution from a given set of data.

With regard to activities duration, a distribution function has been specified, according to the available data or to ABB employee's experience. Furthermore, each activity has been coupled with a resource or a group of resources that performs the specific task (or role). Moreover, for each resource the working schedule has been appointed to define the amount of their time dedicated to the service processes considered in the model. In total, 55 different delivery resources have been modeled. The 55 resources belong to the 18 different roles identified in the SRT.

Once validated, the simulation has been run over a period of three years for ten replications to ensure proper results.

3.1.5. Simulation results

At the end of the simulation, the results has been collected and analyzed. The main variables considered in the analysis were the following:

- Number of completed service jobs in one year;
- Lead time to complete a service job, split for the different services;
- Saturation of the resources;
- Customer perceived performance, mainly measured in terms of time or waiting time needed to perform the macro activities of the DSs (e.g. the interval between the time when the customer sends a request of offer and the time when ABB send its quotation, the amount of time before having an available technician to fix a problem or the amount of time to have the breaker fixed). These performance have been identified considering the link between the DSs defined in the SRT and the activities in the blueprinting.

Table 1Description of developed scenarios

	SCENARIO A	SCENARIO B
Change in the process		
Change in the proposal process- Higher standardization	50% reduction of the time to define a standard offer and 25% reduction of the development time of a complex offer	-
Change in the analysis of the order - Higher standardization	Reduction of 50% of the time to check order coherence with the proposal	-
Change in the working hours of resource (Hours)		
Proposals	-	Increase of 12 hours per day
Dispatcher	Increase of 2 working hours per day	Increase of 6 working hours per day
Technicians	Increase of 21.5 hours per day	Increase of 29.5 hours per day

First, the model simulating the current process have been built (AS-IS scenario). The results obtained from the simulation, have been qualitatively checked by the ABB service managers who confirmed their alignment with the reality. Then, considering the ABB targets for the following three years in terms of both customer satisfaction and increase in service requests, a "what if" analysis has been performed. These data, which cannot be reported for privacy reasons, have been used to define the "TO BE" scenario. In this scenario, the entry distributions of entities have been modified according to the ABB forecasts. The "TO-BE" showed how ABB would face the forecasted demand with the current organization. As expected, increasing the demand, the customer waiting time and the resources utilization increased, causing a negative impact on the customer satisfaction. In particular, the "TO BE" showed bottlenecks in three areas: i) the development of the offers (performed by the "proposals"), ii) the scheduling of the intervention at the customer site ("dispatcher") and iii) the intervention ("technicians"). These bottlenecks, the high resources utilization (a threshold of 65% was considered the maximum [20]), the poor results obtained in terms of customer performances and some ABB guidelines for the future, have been considered as starting point to develop the different scenarios of the "what if" analysis.

In total, 16 scenarios have been developed before obtaining those really providing an improvement. In this paper, only the two most significant ones are presented, referred to as scenario A and B in table 1.

Both scenarios define an improvement in the performance from both the company and the customer point of view. For each kind of services the improvement actions suggested in the scenarios helped in reaching an acceptable lead time (aligned with the actual one) and a proper resources utilization (lower than 80%). A 80% threshold have been accepted considering possible extra working hours that are not taken into account in the simulation model. The extra hours also explains the high utilization of resources in the "AS-IS" model.

In addition, the results in terms of customer perceived value have been monitored. For example, the DS "handle customer request", that considers the time that sales people spent to define a proposal for the customer, is currently around 2 days. Setting the ABB future targets in the "TO-BE" scenario, this time significantly increased to 10 days, and then it has been reduced back to the initial value (about 1,5 days) with the scenarios A and B. This example shows that, in both the suggested scenarios, the performance have been improved and aligned with those provided in the "AS-IS" model.

Summarizing, the "what if" analysis provided some suggestions that should be taken into account when the company is expected to change its service offering or the customer requests are expected to change. The results emerged represent just a possible way to solve future issues related to services, and they would be used as hints to balance the service organization to the future needs. The results indeed did not have the aim to tell ABB to hire exactly *x* proposal or *n* technicians; they just show how the waiting time, the schedule utilization of resources and the customer perceived performance vary when changing the demand or other process inputs. The two scenarios represent a possible solutions where delays and resources utilization can be considered as acceptable.

4. Managerial implications and conclusions

Today, industrial companies lack such tools to support them in assessing the performance of their service delivery. This study sheds some light on how a tool such *SEEM* could be applied in a real manufacturing context. In particular the services provided by ABB Low Voltage Breakers and Switches in Italy are complex in nature and resources intensive which require a careful capabilities (i.e. resources, tools and spare parts) planning. The application of the *SEEM* in an industrial case study showed its appropriateness and robustness in re-engineering the service side of complex PSS offerings. In particular, the main benefits of this methodology demonstrated with the application on ABB low voltage services are: i) the adoption of a systematic procedure to analyze the existing service portfolio; ii) the improvement of the delivery performance by the identification of entities (resources or service activities) directly affecting customer needs, iii) a better definition of the process changes in order to properly manage an increase/decrease of demand or changes in service portfolio.

The company has been able following from this case study to improve its capabilities planning to better service its customer needs. This led to savings in service delivery and higher efficiency in dealing with customer requests translated in higher number of service orders fully satisfied.

The case study has also demonstrated the robustness of the SEEM to re-engineer a service process providing a useful support while making decision. In addition the case demonstrates that the use of the SEEM allows for i) a clear evaluation of internal and external performance of the as-is process, ii) the analysis of possible trade-off between internal values and customer's values, and iii) the comparison of different delivery configurations. The specific PSS oriented methodology and the identification of the trade-off between customer and company's values in the PSS scenario represents the relevant value added of the methodology with respect to existing tools. Indeed, the team has been able during this case study to test several configuration of service delivery not only for low voltage products but also for other business in order to test the generalization of the methodology.

Furthermore, the implementation of the methodology underlined the necessity of an integrated tool or platform aligned with the methodology. The use of different tools for specific parts of the work (design of the SRT, blueprinting mapping and simulation) is very time consuming as well as confusing to some extent. In addition, so far the methodology focuses only on the service part of the PSS. The integration of the service design with the product design represents one of the future improvement.

Future works will be related to the adoption of the methodology in other cases or in other industries and to its better integration with the company's existing product portfolio. This would further generalize the SEEM and to better integrate it inside the company Having a more generalized and mature theoretical framework would finally help in developing proper integrated tools.

Acknowledgements

This research has been partly funded by ABB research grant and the European Commission through the ProSSaLiC (GA-2010-269322). The authors gratefully acknowledge extremely valuable collaboration of all ABB managers involved in the project.

References

[1] Vandermerwe, S., Rada, J. Servitization of business: adding value by adding services. European Management Journal. 1988. 6(4): 314-324.

[2] Laperche, B., Picard, F. Environmental constraints, Product-Service Systems development and impacts on innovation management: learning from manufacturing firms in the French context. Journal of Cleaner Production. 2013. 53:118-128.

[3] Goedkoop, M. Product Service Systems. Ecological and economics Basics. The Hague, PWC

[4] Gebauer, H., Fleisch, E. and Friedli, T. Overcoming the Service Paradox in Manufacturing Companies. European Management Journal. 2005. 23(1): 14-26

[5] Turunen, T., Finne, M. The organizational environment's impact on the servitization of manufacturers. European Management Journal. 2014.603-615.

[6] Cavalieri S., Pezzotta G. Product–Service Systems engineering: state of the art and research challenges. Computers in Industry. 2012 63:278-288.

[7] Bullinger, HJ., Fahnrich KP., Meiren, T. Service engineering-methodical development of new service products. International Journal production Economics. 2003. 275-287

[8] Aurich, J.C., Mannweiler, C. , Schweitzer, E. How to design and offer service successfully. CIRP Journal of Manufacturing Science and Technology. 2010. 2(3):136–143

[9] Halen CV, Vezzoli C, Wimmer R. Methodology for Product Service System Innovation: How to Implement Clean, Clever and Competitive Strategies in European Industries. The Netherlands:Koninklijke Van Gorcum BV; 2005.

[10] ShimomuraY, Tomiyama T. Service modeling for service engineering. In: Arai E, Fumihiko K, Goossenaerts J, Shirase K editors. Knowledge and Skill Chains in Engineering and Manufacturing. Springer;2005. p. 31-38

[11] Kimita, K., Shimomura, Y. Development of the Design Guideline for Product-Service Systems. Procedia CIRP 16 (2014) 344 – 349

[12] Sakao, T., Sandström, G. ö., Matzen, D., Framing research for service orientation of manufacturers through PSS approaches. Journal of Manufacturing Technology Management.2009. 20(5):754-778

[13] Pezzotta, G., Pinto,R., Pirola,F., Ouertani, M. Balancing Product-Service Provider's Performance and Customer's Value: the SErvice Engineering Methodology(SEEM), The 6th CIRP Conference on Industrial Product-Service Systems; 2014.

[14] Bitner, M. J., Ostrom A., Morgani, F. Service Blueprinting: a practical technique for service innovation. California Management Review. 2008. 50(3):66 – 94.

[15] Pirola, F., Pezzotta, G., Andreini, D., Galmozzi, C., Savoia, A., Pinto, R. Understanding customer needs to engineer Product-Service Systems. Proceedings of International Conference on Advances in Production Management Systems (APMS), Ajaccio, France, 20-24 September 2014.

[16] Ganjar, A., Jongtae R., Byungun Y. A simulation tool for prioritizing product-service system (PSS) models in a carsharing service. Computers & industrial Engineering; 2014; 70:59-73

[17] Harpring, R.,Evans G. W., Barber, R., Deck S.M. Improving efficiency in social services with discrete event simulation. Computers & industrial Engineering; 2014; 70:159-167

[18] Abu-Taieh, E., El Sheikh, A. Commercial simulation packages: a comparative study. International Journal of Simulation . 2007. 8 (2):66-76

[19] Rondini, A., Pezzotta, G., Pirola, F., Pinto, R., Ouertani Z.M. Service Engineering framework: the adoption of simulation to design and configure Product-Service solutions. Proceeding of 21st ICE Conference, "Engineering Responsible Innovation in Products and Services". Bergamo 23rd – 25th June, 2014

[20] Dutta, S., Ali, P. Field Service 2011-Key Trends in Workforce Management. January 2011. Aberdeen Group