MISTRA
Resource-Efficient and Effective Solutions

# *Literature review and consolidation of PSS design methods as a foundation for REES design support*

**Authors:** Abhijna Neramballi, Tomohiko Sakao
**Department:** Division of Environmental Technology and Management, Department of Engineering and Management, Linköping University
**Contact person:** Tomohiko Sakao (tomohiko.sakao@liu.se), Project Manager
**Report number:** LIU-IEI-RR--19/00311—SE
**Date:** 22-03-2019

LINKÖPINGS UNIVERSITET LUND UNIVERSITY CHALMERS

# Introduction

This report is a part of the deliverables from the Mistra REES[1] programme (www.mistrarees.se) work package (WP) 2.2 of Project 2 (the project concerning design). The objective of the report is to present the details of a literature search carried out in 2018. It describes the search process, results and findings of a review of the state of the art of Product Service/System (PSS) design methods. The outcome and the subsequent analysis of the literature review will be a set of recommendations for PSS conceptual design, based on a synthesis of the existing PSS design methods in the state of the art.

PSS is defined "a mix of tangible products and intangible services, designed and combined so that they jointly are capable of fulfilling final customer needs" (Tukker and Tischner, 2006). The role of design is critical in the development of PSS (Morelli, 2006). To realize effective and efficient design of REES, services such as maintenance need to be considered in an integrated manner with products on question. Therefore, PSS is an essential concept for REES design. Industries seeking to develop PSS have been increasingly demanding for design methods and tools to aid their efforts (Vasantha et al., 2012). In recognition, several such methods and tools have been proposed in academia (ibid). However, these address different issues involved in PSS designing, and there is no systematic procedure that presents the various key issues that is required to be addressed during the design stage. The objective of this report is to review a select few scientific articles that provide comprehensive support for the design of PSS, identify key issues and subsequently synthesize the findings in the form of an aggregated procedure.

[1] An acronym for "Resource-Efficient and Effective Solutions".

# Literature review process

An extensive literature search was undertaken in the Web of Science database. The following sets of keywords were utilized in different combinations to carry out the search. Set 1: PSS, product service systems*, integrated product service systems*, integrated product service offering*, integration of product* and service*, functional product*; Set 2: design, development; Set 3: methods*, tools*, support*, framework*, procedure*.

An initial search result of 1,804 hits was obtained, and the search was subsequently refined to 1,161 hits by selecting articles as the document type. The following refining criteria were applied to check for relevance of the articles: 1) The articles should include a detailed description of a comprehensive PSS design method; 2) The design method should have been validated in empirical settings/illustrations; and 3) The article should be well accepted within academia, with a minimum of 50 citations in the Web of Science database. Relevant research areas were selected to further refine the results to 240 articles. Titles and abstracts of these articles were scanned for relevance to further narrow down the list to 20 articles. These 20 articles were read through, and articles discussing issues such as PSS implementation, decision support tools, knowledge support framework, etc. were not considered as the objective was to identify comprehensive design methods for PSS development in the state of the art. A final list of 5 articles with more than 50 citations in the Web of Science database was selected for further analysis (Alonso-Rasgado et al., 2004; Aurich et al., 2006; Geum and Park, 2011; Maussang et al., 2009; Maxwell et al., 2006).

# Results

The selected list of literature was analysed and certain common key features were extracted. Following key issues need to be addressed systematically during PSS design. During the initial stages of design of a PSS offering, identification of requirements expected from the design offering is crucial (Shimomura et al., 2018). Decisions taken during PSS designing should be based on the value to be generated from the or functionality of the offering, along its lifecycle (Isaksson et al., 2009) that can fulfill the requirements. Furthermore designers need to consider the various actors or stakeholders involved in the co-creation of value of the PSS (Morelli, 2006). To create the required value to the involved stakeholders, relevant product and service elements need to be designed and integrated (Baines et al., 2007) as solutions from a lifecycle perspective (Lindahl et al., 2014). These solutions have to be assesed systematically before deliverying to the customers (Kimita et al., 2017). The key features and their recurrence across the selected literature are reported in Table 1.

Table 1: Result of PSS design literature analysis

| | Alonso-Rasgado et al. (2004) | Aurich et al. (2006) | Geum and Park (2011) | Maussang et al. (2009) | Maxwell et al. (2006) |
|---|---|---|---|---|---|
| Requirement identification | ✔ | ✔ | | ✔ | ✔ |
| Functionality or value to be provided | ✔ | ✔ | ✔ | ✔ | ✔ |
| Lifecycle perspective(ISO, 2006) | | ✔ | ✔ | | ✔ |
| Stakeholder identification | ✔ | ✔ | ✔ | ✔ | ✔ |
| Integration of elements | ✔ | ✔ | ✔ | ✔ | |
| Assessment of solutions | ✔ | ✔ | | ✔ | ✔ |

Note: ✔ Indicates that the corresponding key feature is addressed by the respective article.

# Synthesis

After analysing the selected list of articles, the following recommendations were summarized as an outcome of the synthesis of the various PSS design methods proposed by the articles. The recurring key features in the methods were identified during the synthesis (see Table 1). The following recommendations to support PSS design, in the form of a generic aggregated procedure that comprehensively addresses the key features, are suggested. They are recommended to be applied in the given order, with iterations wherever required.

1. Identification of a functional unit for the offering being designed.

*Functional unit* is originally defined as a *measure of the performance of the functional outputs of the product system (ISO, 2006), and it is extended to PSS in this paper. It represents what precisely is being designed, providing a reference to which the inputs and outputs can be related.*

2. Identification of all potential stakeholders along the value chain with respect to the functional unit from a systems perspective.
3. Identification of requirements regarding the offering from the various stakeholders.
4. Identify value provided (existing and potential) to the stakeholders.

*Value in this context is considered as the trade-off between various perceived benefits and sacrifices (Ulaga and Chacour, 2001).*

5. Identify relevant criteria for evaluation of solutions based on the requirements and value.
6. Identify and integrate product, service or other elements that can collectively, as a solution, fulfil the requirements and create value, i.e. function (availability of jet engines), product (jet engines) service (maintenance activities), etc.
7. Examine the balance between these elements from a systems perspective.
8. Select feasible combinations of these elements to synthesize solutions.
9. Evaluate the solutions against the criteria (see step 5).
10. Select the best solution.

# Conclusions and future work

The literature review and analysis arrived at the ten-step procedure as described. This enables to extend research for further development. For instance, researchers could build upon this to find and make synergy between PSS design and new emerging technologies in a concrete manner.

# References

Alonso-Rasgado, T., Thompson, G., Elfström, B.O., 2004. The design of functional (total care) products. J. Eng. Des. 15, 515–540. https://doi.org/10.1080/09544820412331271176

Aurich, J.C., Fuchs, C., Wagenknecht, C., 2006. Life cycle oriented design of technical Product-Service Systems. J. Clean. Prod. 14, 1480–1494. https://doi.org/10.1016/j.jclepro.2006.01.019

Baines, T.S., Lightfoot, H.W., Evans, S., Neely, A., Greenough, R., Peppard, J., Roy, R., Shehab, E., Braganza, A., Tiwari, A., Alcock, J.R., Angus, J.P., Bastl, M., Cousens, A., Irving, P., Johnson, M., Kingston, J., Lockett, H., Martinez, V., Michele, P., Tranfield, D., Walton, I.M., Wilson, H., 2007. State-of-the-art in product service-systems. Proc. Inst. Mech. Eng. Part B J. Eng. Manuf. 221, 1543–1552. https://doi.org/10.1243/09544054JEM858

Geum, Y., Park, Y., 2011. Designing the sustainable product-service integration: A product-service blueprint approach. J. Clean. Prod. 19, 1601–1614. https://doi.org/10.1016/j.jclepro.2011.05.017

Isaksson, O., Larsson, T.C., Rönnbäck, A.Ö., 2009. Development of product-service systems: Challenges and opportunities for the manufacturing firm. J. Eng. Des. 20, 329–348. https://doi.org/10.1080/09544820903152663

ISO, E., 2006. 14040: 2006. Environmental management-Life cycle assessment-Principles and framework. London. https://doi.org/10.1016/j.ecolind.2011.01.007

Kimita, K., Sakao, T., Shimomura, Y., 2017. A failure analysis method for designing highly reliable product-service systems. Res. Eng. Des. https://doi.org/10.1007/s00163-017-0261-8

Lindahl, M., Sundin, E., Sakao, T., 2014. Environmental and economic benefits of Integrated Product Service Offerings quantified with real business cases. J. Clean. Prod. 64, 288–296. https://doi.org/10.1016/j.jclepro.2013.07.047

Maussang, N., Zwolinski, P., Brissaud, D., 2009. Product-service system design methodology: from the PSS architecture design to the products specifications. J. Eng. Des. 20, 349–366. https://doi.org/10.1080/09544820903149313

Maxwell, D., Sheate, W., van der Vorst, R., 2006. Functional and systems aspects of the sustainable product and service development approach for industry. J. Clean. Prod. 14, 1466–1479. https://doi.org/10.1016/j.jclepro.2006.01.028

Morelli, N., 2006. Developing new product service systems (PSS): methodologies and operational tools. J. Clean. Prod. 14, 1495–1501. https://doi.org/10.1016/j.jclepro.2006.01.023

Shimomura, Y., Nemoto, Y., Ishii, T., Nakamura, T., 2018. A method for identifying customer orientations and requirements for product–service systems design. Int. J. Prod. Res. 56, 2585–2595. https://doi.org/10.1080/00207543.2017.1384581

Tukker, A., Tischner, U., 2006. Product-services as a research field: past, present and future. Reflections from a decade of research. J. Clean. Prod. 14, 1552–1556. https://doi.org/10.1016/j.jclepro.2006.01.022

Ulaga, W., Chacour, S., 2001. Measuring customer perceived value in business markets. Ind. Mark. Manag. 30, 525–540.

Vasantha, G.V.A., Roy, R., Lelah, A., Brissaud, D., 2012. A review of product-service systems design methodologies. J. Eng. Des. 23, 635–659. https://doi.org/10.1080/09544828.2011.639712

Yang, X., Moore, P., Pu, J.S., Wong, C.B., 2009. A practical methodology for realizing product service systems for consumer products. Comput. Ind. Eng. https://doi.org/10.1016/j.cie.2008.05.008