



# Continuous improvement of industrial product-service systems

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## ABSTRACT

To systematically exploit the potentials of technical services for both manufacturers and their industrial customers, products and services need to be integrated. The resulting industrial product-service systems (PSS) are realized by the members of a value creation network in close cooperation with the customers. Thus, the organizational and operational structure of the value creation network has to be designed in order to guarantee the PSS-provider a continuous product, customer and market feedback. This feedback information provides the basis for a continuous PSS-improvement process, comprising customer specific and customer spanning improvement measures. This paper analyzes the demands on a continuous improvement process (CIP) of PSS and provides a framework concept for a PSS specific CIP. A real-world case study of an industrial PSS-CIP concludes the paper.

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## 1. Introduction

While in the past, capital goods manufacturers have largely focused on design, realization and distribution of high quality products, their industrial customers are increasingly expecting to be provided with services such as maintenance, upgrading, user trainings or process improvement. These services do not only contribute to keeping up existing product functionalities [1] but also provide additional ones along the whole life cycle [2].

In light of this, a gradual change of traditional manufacturing companies to producing service providers [3] that focus on customer solutions becomes necessary. To support this change and to provide the basis for realizing customer solutions in terms of customer life cycle-oriented product-service systems (PSS), processes for product and service planning, design and realization need to be integrated [4].

With respect to the phase of PSS-realization, PSS-providers focus both on providing the customers with a desired benefit through a specific configuration of products and services as well as on the establishment of measures for continuous customer specific and customer spanning PSS-improvement. In order to enable them to operate the processes connected therewith, both organizational and operational structures of the value creation network have to be designed according to resulting requirements.

This article analyzes the demands on a systematic performance measurement of PSS as well as the processes of information exchange connected therewith. Based on these two points, an

approach for a continuous improvement process considering the specific requirements of PSS is provided.

## 2. Industrial product-service systems

Industrial PSS are defined as customer life cycle-oriented combinations of products and services [5], realized in an extended value creation network, comprising a manufacturer as well as suppliers and service partners [6]. In the capital goods industry, PSS are made up of an often complex physical product core, which is enhanced along its life cycle by mainly non-physical services. Thus, a PSS represents an integrated product and service offering that delivers value in use [7].

For further understanding, a distinction between two different life cycle perspectives needs to be drawn [2]. From the point of view of the PSS manufacturer, the product life cycle starts with product design, followed by product manufacturing, servicing and remanufacturing. From the point of view of his customers it consists of product purchase, usage and disposal. Taking these perspectives into consideration, the manufacturer has to design physical products optimized for manufacturability, servicing and remanufacturing as well as non-physical services that support his customers during product purchase, usage and disposal.

After the PSS-design is finished, the product core is usually produced at a limited number of production locations whereas the services are provided later on at the place of product usage either by the manufacturer's service branches or by independent service partners. In any case, service is provided in close cooperation with the customer. As a consequence, the complete industrial PSS consists of customer and manufacturer related subsystems with multiple interrelations that lead to a continuous change of the state of both subsystems (Fig. 1).

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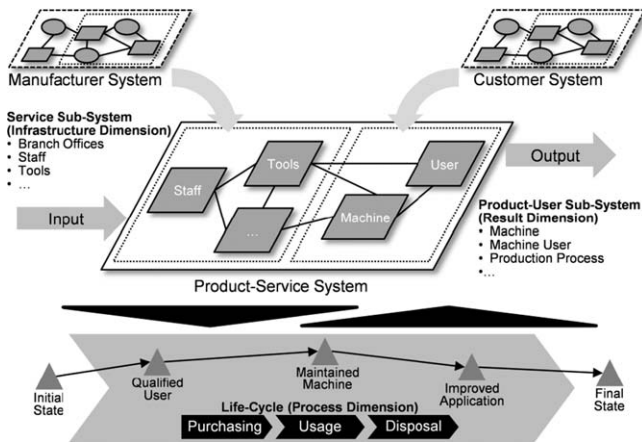


Fig. 1. Industrial product-service systems.

The aim of the product-user subsystem, comprising the physical product core as well as the staff of the customer responsible for its operation, is to provide an expected set of functions during a production process.

The second subsystem is represented by the service network with its elements: branches, service partners, personnel, technical equipment, etc. By means of the delivery of services its main functions are on the one hand to keep up and enhance the above-mentioned functionalities in a customer individual way and on the other hand to continuously provide the manufacturer with customer feedback [8,9]. For example, maintenance services contribute to the preservation of the functional level of a product, while trainings provide the user with the competencies, necessary for conducting different applications. Besides, due to their delivery implying direct product and customer contact, information on e.g. product reliability and usability can be obtained.

When designing and implementing industrial PSS, three dimensions need to be distinguished:

- The result dimension: physical (product) and non-physical (service) PSS components together provide the customer with a certain set of expected functionalities.
- The process dimension: PSS-realization is based on different processes such as product maintenance and training that continuously change the state of the product-user subsystem and the service subsystem along the life cycle.
- The infrastructure dimension: the service network provides the resources needed for executing status changes as well as for providing the manufacturer with continuous product, customer and market feedback.

Realization of information retrieval processes represents one of the basic functions of the PSS-service components. It represents the basis for a continuous improvement of both product and service offerings as well as corresponding processes and resources by complementing the already existing knowledge of the manufacturer [10]. Although the information aspect plays a key role, no information dimension of PSS is described separately. This is caused by the interdisciplinary character of information, i.e. that the necessary specification of information exchange processes can be covered by the result, process, and infrastructure dimension of a PSS.

### 3. PSS life cycle management

Product life cycle management (LCM) as it is known aims at organizing the interactions between the different life cycle partners by a set of methods and processes for the design and realization of physical products [11]. It supports the customer at

using his product in an economically and ecologically sustainable way. Product LCM can also be applied to support the implementation of industrial PSS. By doing so, maximum product benefit in terms of supporting the customer at using his product while at the same time contributing to the business objectives of the manufacturer can be achieved [11]. Thereby, focus is on the organization of the interactions between the different partners within the value creation network by a set of methods and processes supporting both design and realization of products and services [12].

Based on an analysis of current LCM concepts [11], the following fields of action for the implementation of PSS-LCM can be identified:

- Methods and processes for customer-oriented PSS-planning that support the proactive specification of Life Time Management measures in terms of services.
- Methods and processes for integrated PSS-design that allow the specification of the different models required for describing the three dimensions of a PSS.
- Methods and processes to exploit the service potentials for providing the manufacturer with product, customer and market feedback.
- PSS performance measurement systems for customer individual life cycle evaluation and definition of consequential PSS improvements.
- Life cycle-oriented process management based on standardized process descriptions to get all partners in the extended value creation network having a common understanding of the necessary design, production and servicing processes.

Based on the manufacturer point of view on PSS life cycle, the framework for PSS-LCM underlying this article consists of four phases (Fig. 2).

The implementation phase aims at laying the basis for PSS-LCM in terms of building up necessary design and realization processes. Besides this, the implementation of the required organizational and operational prerequisites within the extended value creation network of the PSS-provider takes place.

The PSS-planning phase pertains to the identification and definition of physical and non-physical PSS components contributing to the aims of both manufacturer and customer. Their model-based description is covered by the subsequent PSS-design phase, where focus is on the integration of product and service design processes.

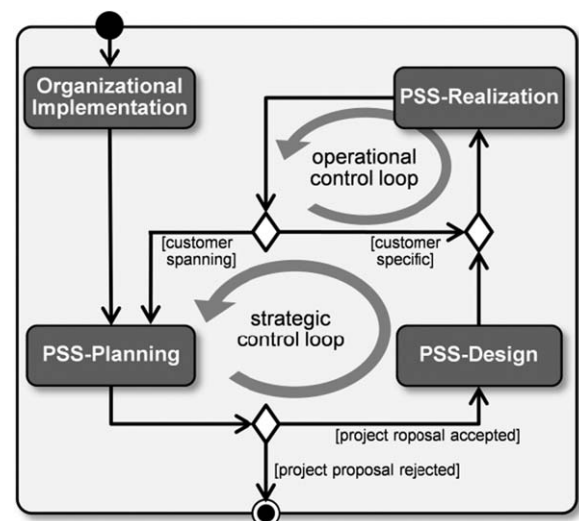


Fig. 2. Control Loop Model for PSS-LCM.

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