CIRP Journal of Manufacturing Science and Technology xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

CIRP Journal of Manufacturing Science and Technology

journal homepage: www.elsevier.com/locate/cirpj

Outlining an overall Functional Product lifecycle – Combining and coordinating its economic and technical perspectives

John Lindström [a,*], Magnus Karlberg [b]

[a] ProcessIT Innovations R&D Centre, Luleå University of Technology, SE-971 87 Luleå, Sweden
[b] Computer Aided Design, Luleå University of Technology, SE-971 87 Luleå, Sweden

ARTICLE INFO

Article history:
Available online xxx

Keywords:
Economic perspective
Functional Products (FP)
Lifecycle
Sub-lifecycles
Technical perspective

ABSTRACT

Currently, industry is showing increasing interest in performance-based business models. Functional Products is one such business model, where the provider offers a function to customers at an agreed-upon level of availability, productivity or efficiency, etc. A Functional Product comprises the following four main constituents: hardware, software, service support system and management of operation, which together deliver value to customers on a long-term basis. This paper, based on empirical data, provides an outline and starts the verification of a proposed overall Functional Product lifecycle combining and coordinating its economic- and technical perspectives. The perspectives are combined and the key aspects of the necessary coordination between and within the perspectives, i.e., sustainable win-win situations and coordination of sub-lifecycles for the economic perspective, and the need for coordination between the Functional Products' technical perspective's four sub-lifecycles (hardware, software, service-support system and management of operation), are elaborated and discussed. Further, addition of new functionality, contract management, and long-term management of operation are discussed in the light of managing fleets/individual customers, assets and availability. The proposed overall Functional Product lifecycle is further analyzed from a number of views and aspects.

Introduction

Building on [1,2] combined with additional empirical data, the aim of this paper is to outline and start the verification of a proposed overall lifecycle for Functional Products (FP) combining and coordinating its economic and technical perspectives. A current trend for manufacturing corporations is to incorporate service offers into their regular product offers and also to extend the providerś ownership of the product throughout the entire lifecycle of the product. This emerging change has been identified as a business opportunity as well as a requirement from customers in order for them to be able to focus on their core business and processes.

The concept of FP [3–6] incorporates hardware (HW), software (SW), service-support system (SSS) and management of operation (MO) into a combined effort to provide a function to customers. Throughout the FP lifecycle, operation of the FP must be managed, further developed and optimized, since the core intention with FP is to optimize the long-term value for both the customer and the provider, i.e., create a sustainable win-win situation. This value creation can be both an objective value (measurable in monetary units, time, availability, efficiency or productivity, etc.) and a perceived value. The perceived value, which comprises aggregated economic, ecologic and societal values, can include aspects such as avoidance of responsibility or risks by letting the FP provider take care of HW or SW properties. Further, the concept of FP has similarities with, for instance, Functional Sales (FS) [7], Extended Products [8], Total Care Product (TCP) [3], Product-Service System (PSS) and Industrial Product-Service Systems (IPS^2) [9,10], Servicizing [11], Service Engineering [12] or Through-life Engineering Services (TES) [13] in the sense of increasing the focus on soft parts such as services, knowledge and know-how etc., additionally offered. The FP, originating from hardware aspects, has most commonalities with PSS/IPS^2, TCP, TES and FS, adding, however, additional complexity development-wise.

The FP lifecycle, whose contracts for customer instances can range up to 30 years, has not yet been thoroughly outlined. A lifecycle approach is adopted in order to understand, on a high level, what to expect during the different phases of the FP lifecycle in terms of potential, possibilities, management, coordination, actions, responsibilities and risks, etc. Further, when looking

* Corresponding author.
E-mail addresses: John.Lindstrom@ltu.se (J. Lindström), Magnus.Karlberg@ltu.se (M. Karlberg).

http://dx.doi.org/10.1016/j.cirpj.2016.08.005
1755-5817/

forward and planning for future operation/production scenarios, FP may also appear in distributed, virtual or cloud manufacturing production contexts. Thus, this future outlook can pose requirements which need to be considered and factored in when making decisions about design, development and future operation/production strategies and plans. Since the four main FP constituents HW, SW, SSS and MO define the FP concept, the FP lifecycle can also be delimited and outlined by the perimeters of these main constituents. There is a difference between the technical perspective and the economic perspective. The FP technical perspective is mainly outlined by the technical sub-lifecycles of the HW and SW. The SSS ensures and extends the technical perspective through proactive as well as reactive service and maintenance. However, the SSS has a separate technical sub-lifecycle as well, since it depends on, for instance, access to spare parts, skills and knowledge, etc. The MO technical sub-lifecycle coordinates, manages and supports the others' technical sub-lifecycles. The FP economic perspective, which is supported by the technical one, depends upon the relation between the provider and the customers and is sustained as long as there is a win-win situation between the provider and the customers. When this win-win situation can no longer be sustained for the customer instances in question, the contracts or economic sub-lifecycles will be, or need to be, re-negotiated to find new win-win situation(s). If a win-win situation is not sustainable for most customer instances, the contracts will likely be stopped and the current economic perspective terminated.

The current research on the FP lifecycle is rather limited, apart from work done by Lindström et al. [1] outlining an FP lifecycle from an economic perspective and [2] expanding the FP lifecycle view with a technical perspective. Further, e.g., Lindström et al. [6], using a structural view, highlight the following FP lifecycle aspects: lifecycle management, business cases and business modelling, asset management, availability, risks, monitoring, maintenance, win-win and relations, etc. Further, similar such lifecycle aspects have been brought up and emphasized by, for instance, [3,6,14]. Karlsson et al. [14] conceptualize the aspects from a visionary perspective, whereas Alonso-Rasgado et al. [3] and Lindström et al. [4] consider them in development and partially operational contexts. Seen from an innovation model perspective, Lindström et al. [15] assert the requirement for a planned continuous innovation scheme from the very start of the FP lifecycle until its very end. In addition, Reim et al. [16] look at risks related to the value creation/delivery/capturing during different stages of the FP lifecycle.

Currently, there is a lack of literature addressing the overall FP lifecycle and how it can be outlined. However, several relevant FP through lifecycle aspects have already been covered in literature, and these papers do not give a comprehensive overview or outline the FP lifecycle. Thus, the research question addressed in this paper can be formulated as: how can an overall FP lifecycle be outlined and its economic and technical perspectives be combined and coordinated? The purpose of the paper is to propose an outline of an overall FP lifecycle and highlight its internal coordination needs, which can be used by FP providers and customers in industry as well as researchers. The overall FP lifecycle's economic and technical perspectives proposed are analyzed from a number of views and aspects including economic, ecologic and societal.

Functional Products and their constituents

In order to improve the understanding of the relations and inter-connectedness of the FP constituents, this section briefly outlines how this can be perceived. Brännström et al. [17] posit that FP consist of HW, SW and Services. Further, Alonso-Rasgado et al. [3] and Alonso-Rasgado and Thompson [18] extend the FP by outlining that the constituents of FP are HW and a support system. Here, the HW and the support system can be integrated with necessary SW. In addition, the FP constituents have been further extended and proposed as: HW, SW, SSS and MO, by Lindström et al. [4,6]. Thus, the FP concepts proposed by Lindström et al. [4,6], Alonso-Rasgado et al. [3] and Alonso-Rasgado and Thompson [18] are complex with inter-connected constituents, but however necessary in order to deliver a function. According to Brännström et al. [17] and Lindström et al. [4,6], success during the FP lifecycle requires high and planned integration between the constituents developed and later operated together. Fig. 1 outlines how the FP and their constituents' integration and inter-connectedness can be perceived.

Thus, to be successful with FP development and operation requires an overall lifecycle consideration and coordination, due to complexity and costly development, involving both technical and economic perspectives [1,2]. Further, each of the main constituents has a technical sub-lifecycle that needs to be managed over time with the integration and inter-connectedness (i.e., dependencies) in mind.

Related work

There is a breadth of related research within the closely related concepts TES, PSS and IPS^2, relevant for FP, addressing the overall lifecycle as well as aspects thereof. Regarding TES, Roy et al. [13] outline how the lifecycle can be embodied and cite a number of relevant aspects which need to be addressed to support, e.g.,

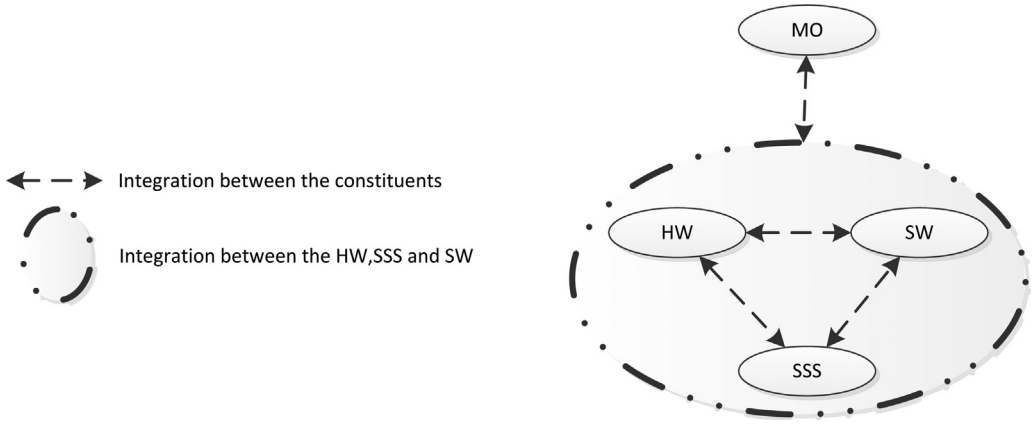

Fig. 1. FP main constituents' integration and inter-connectedness (based on [4,6]).

Please cite this article in press as: Lindström, J., Karlberg, M., Outlining an overall Functional Product lifecycle – Combining and coordinating its economic and technical perspectives. CIRP Journal of Manufacturing Science and Technology (2016), http://dx.doi.org/10.1016/j.cirpj.2016.08.005