The 7th CIRP IPSS Conference
21-22 May 2015
Saint-Etienne, France

TOWARDS A LEAN PRODUCT SERVICE SYSTEMS (PSS) DESIGN: STATE OF THE ART, OPPORTUNITIES AND CHALLENGES

by

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Overview

- Introduction
- State of the art
  - Product Service System
  - PSS Design
  - Lean Thinking and Lean Product Development
- Towards Lean PSS Design
- Conclusions and further researches

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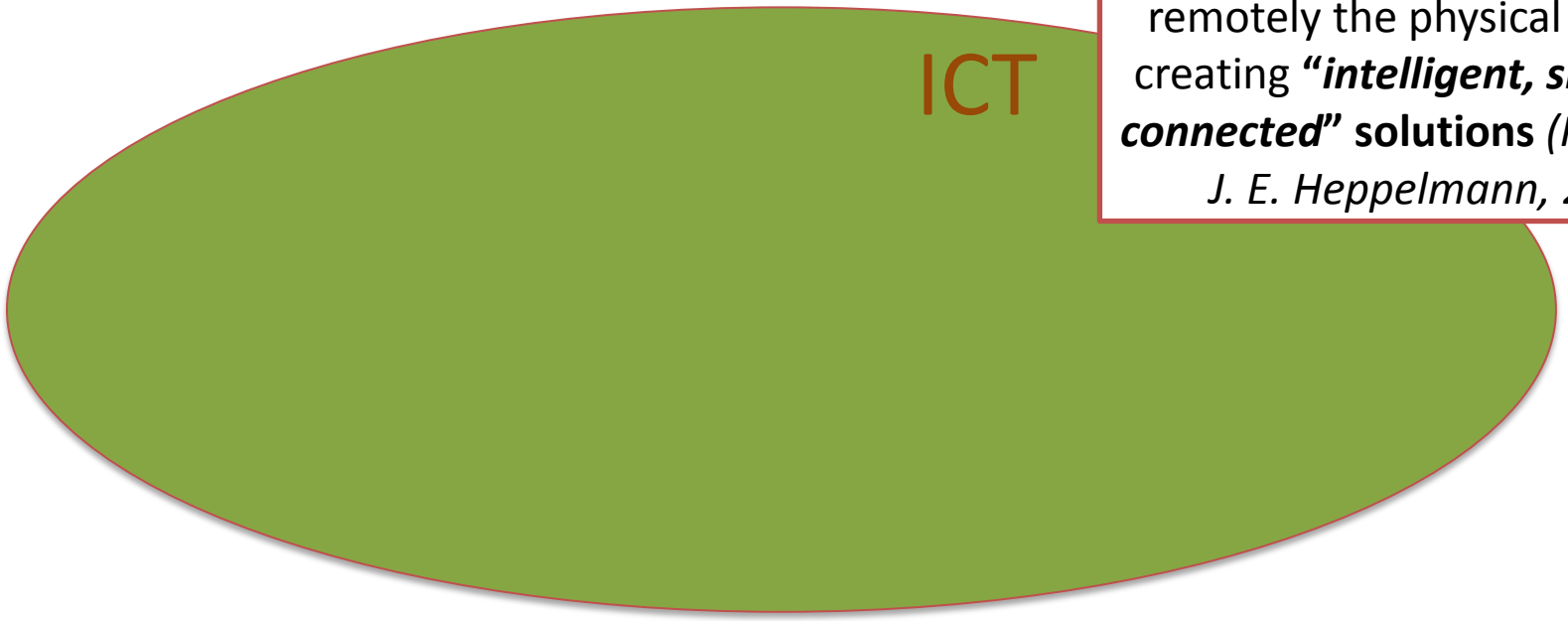
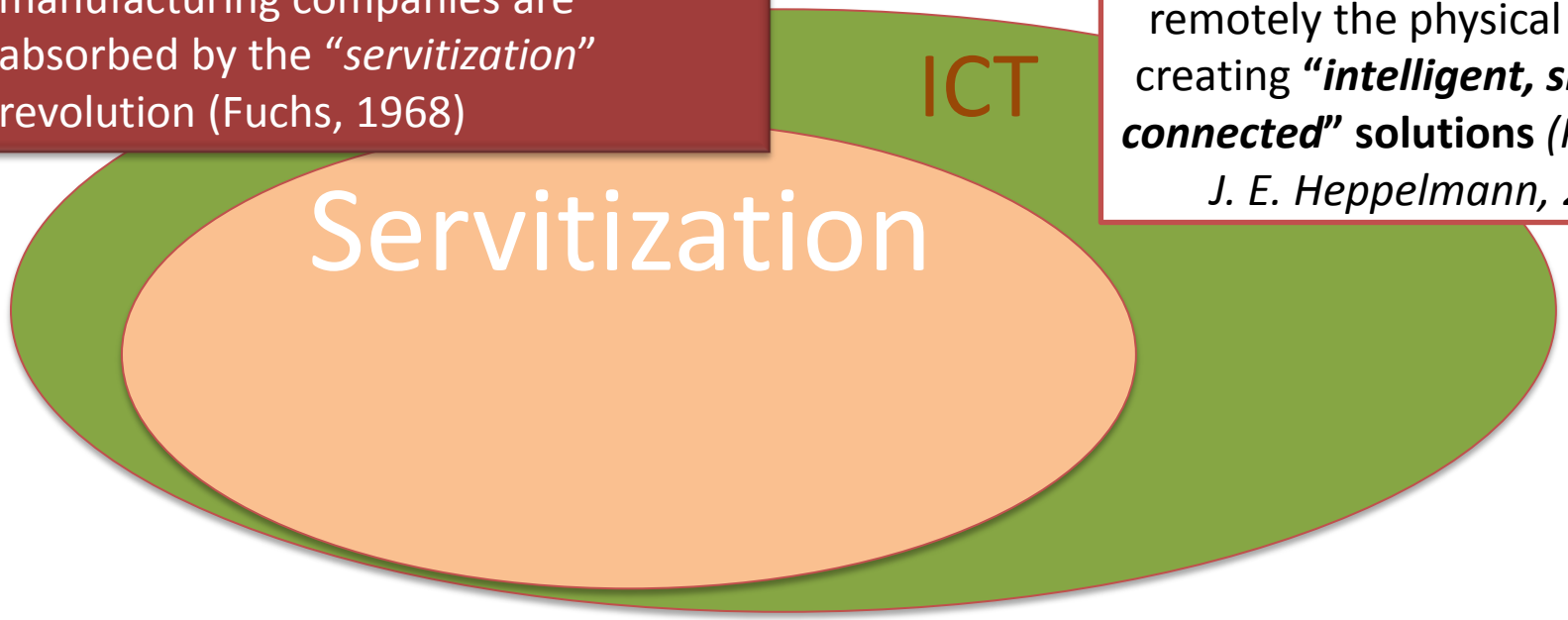
Introduction

New era of competition revolutionizing products: interconnected and embedded technologies permit to trace, track, monitor and control remotely the physical artefact, creating ***"intelligent, smart and connected"* solutions** *(Porter and J. E. Heppelmann, 2014)*



Introduction

Service Economy: 70% of global workers engaged on service tasks and manufacturing companies are absorbed by the "*servitization*" revolution (Fuchs, 1968)



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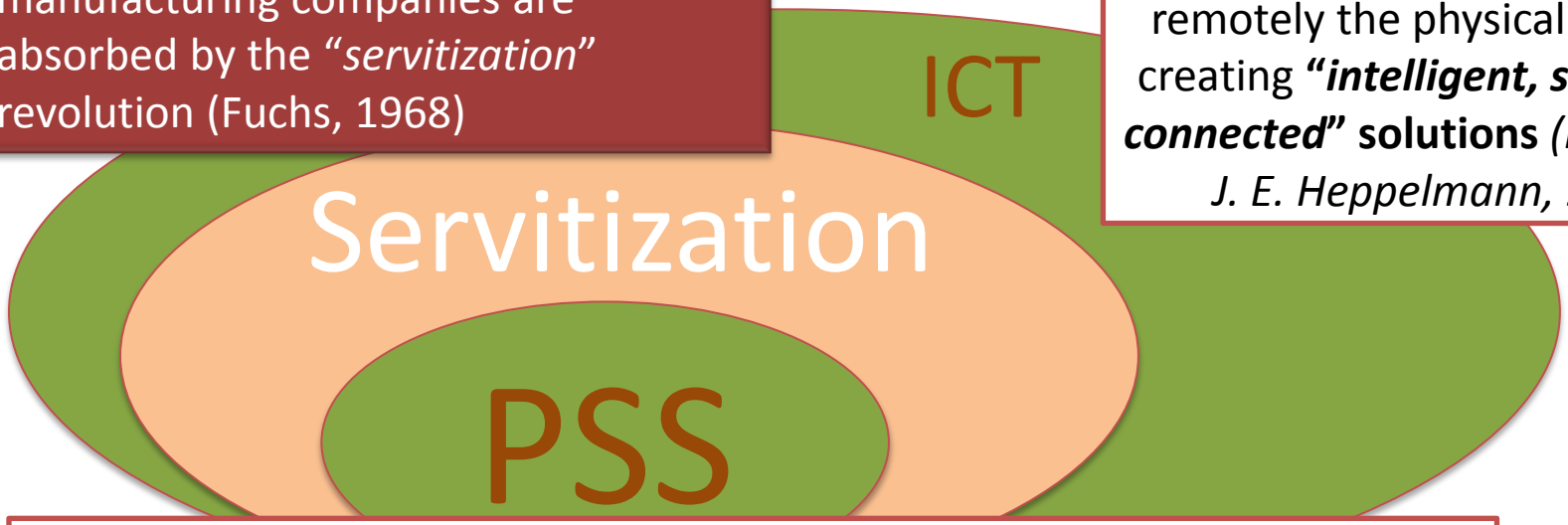

Solution for manufacturing companies that set their market proposition on extending the traditional functionality of their products by incorporating additional services *(Baines et al., 2006)*

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PSS

Definition	Main definition		System's components				Objective					Other features
	System	Innovation Strategy	products	services	networks	infrastructure	competitive	satisfy customer needs	sustainability			self learning
									environmental	social	economic	
Goedkoop et al. (1999)	x		x	x	x	x	x	x	x			
Centre for Sustainable Design (2001)	x		x	x	x	x		x	x			x
Mont (2001)	x		x	x	x	x	x	x	x			
Manzini (2003)		x	x	x				x				
Brandstotter (2003)	x		x	x				x	x	x	x	
Wong (2004)		x	x	x				x				
ELIMA (2005)	x		x	x	x	x	x	x	x			

PSS

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Mont (2001)	x		x	x	x	x	x	x	x			
Manzini (2003)		x	x	x				x				
Brandstotter (2003)	x		x	x				x	x	x	x	
Wong (2004)		x	x	x				x				
ELIMA (2005)	x		x	x	x	x	x	x	x			

Generally **PSSs are made to pursue industrial competitiveness, customer satisfaction and also sustainable development** (Tukker, 2006).

Different authors (Tukker, 2006; Mont, 2003) have highlighted how this **win-win scenario can be realized only by a careful design of the PSS**, involving all the significant stakeholders since the early phases of the design stage.

PSS design

We know that….

…**several** are the **solutions** and methods to design PSSs from the **scientific literature**.

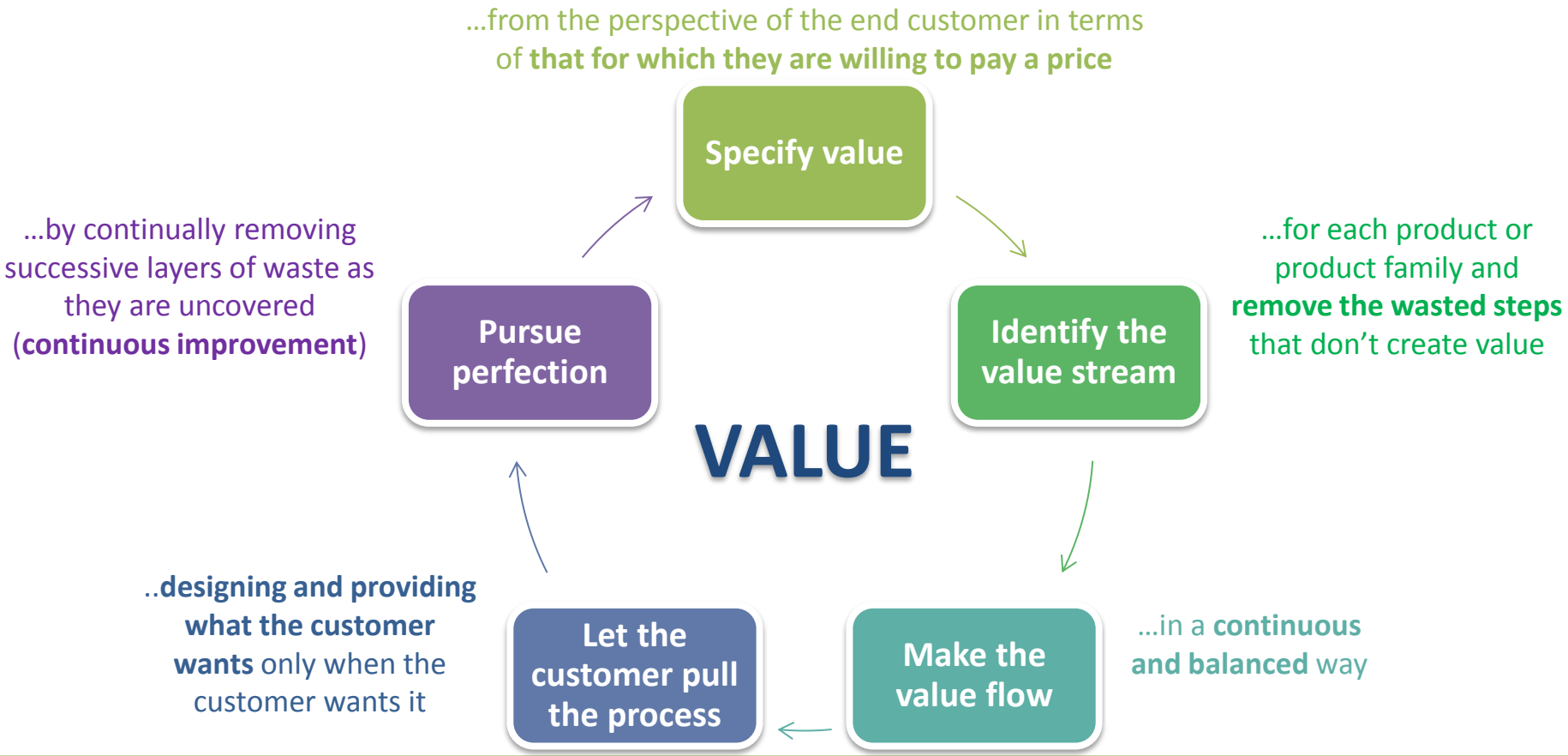
We believe that….

*…the **development level of PSS design** is slowly **evolving** through a path strongly **driven by** the **evolution of the technology** and the **progressive involvement of the industry** in its application.*

Companies still need procedures/best practices able to improve the PSS development processes performances in a more systematic way.

Lean Thinking and Lean Product Development

The 5 principles of Lean:



Lean Thinking and Lean Product Development

"there is much more opportunity for competitive advantage in product development than anywhere else" (Morgan and Liker, 2006)

Diffuse Lean Thinking all over the company, starting from creative processes

Lean Thinking from Manufacturing to Engineering [McManus, 2005]

Lean Principles	Manufacturing	Engineering
Value	Visible at each step, defined goal	Harder to see, emergent goals
Value stream	Parts and material	Information and knowledge
Flow	Iterations are waste	Planned iterations must be efficient
Pull	Driven by takt-time	Driven by needs of enterprise
Perfection	Process repeatable without errors	Process enables enterprise improvement

Lean Thinking and Lean Product Development

The 3 main elements of Lean Product Development:

- **"*Waste Identification and Value Focus*"** *(Morgan e Liker, 2006)*

the 5Cs (1. clear out, 2. configure, 3. clean and check, 4. conformity and 5. custom and practice)

the 7 wastes (1. Defects, 2. Overproduction, 3. Transportation, 4. Waiting, 5. Inventory, 6. Motion, 7. Processing)

visual control

standardization of processes

- **"*Set-Based Concurrent Engineering*" (SBCE)** *(Ward et al., 1995)*: more design alternatives are evaluated in parallel step-by-step, supporting the selection of the best solution along the process, taking care of constrains of the different involved actors and lifecycle phases

- **"*Effective Knowledge Management*"** *(Grover and T. H. Davenport, 2001)*

IT collaborative systems (e.g. PDM, PLM, databases, web platforms)

Authoring software (e.g. CAD, simulation tools, etc.)

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Towards Lean PSS design

PSSs intrinsic complexity

Different needs and expectations to satisfy in a fast and adaptive way

The majority of the **methodologies proposed in literature for PSS design and development** "*have a **clear heritage in Concurrent Engineering and Lean Product Development methodologies:** identification of customer value, early involvement of the customer in the system design, effective communication, information sharing and continuous improvement*" (Baines et al. 2007).

Towards Lean PSS design

In which way and how much the existing **Lean Product Development approach** could be able to **improve the development level of PSSs?**

Towards Lean PSS design

How Lean Product Development elements are mentioned and used by the PSS design methods?

PSS Design	Lean Product Development			
	Waste Identification and Value Focus		*Set-Based Concurrent Engineering*	*Effective Knowledge Management*
	5C	*Standardization*		
(Komoto & Tomiyama 2008)	X	X	X	X
(Shimomura et al. 2009; Sakao et al. 2009)	X	X	X	
(Aurich et al. 2006)	X	X	X	X
(Welp et al. 2008)	X		X	
(Maussang et al. 2009)	X	X	X	X
(Alonso-Rasgado et al. 2004)	X		X	
(Morelli 2002; Morelli 2006)	X		X	
(Garetti et al. 2012)	X		X	X
(Pezzotta et al. 2014)	X	X	X	X

Main results:

1. **all the methods involve Lean Thinking approaches** even if **they don't refer to them directly**.

Towards Lean PSS design

Main results:

2. SET-BASED CONCURRENT ENGINEERING (SBCE)

appears to be the most appropriate approach to manage the PSS design process, even if almost none of the papers quote SBCE directly!

PSS Design	Lean Product Development			
	Waste Identification and Value Focus		*Set-Based Concurrent Engineering*	*Effective Knowledge Management*
	5C	*Standardization*		
(Komoto & Tomiyama 2008)	X	X	X	X
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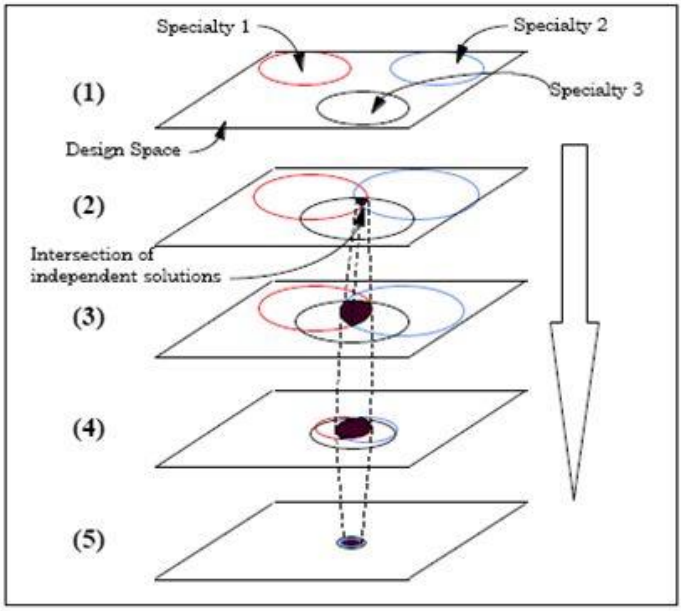

SBCE should **support the identification and the definition of the most appropriate integration of components and services,** aiming at the resolution of the possible design trade-off along the whole development process, stage-by-stage.

Towards Lean PSS design

Main results:

3. **Relevance of an EFFECTIVE KNOWLEDGE MANAGEMENT**, generally proposing the adoption of **IT solutions**:

PSS Design	Lean Product Development			
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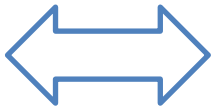
(Alonso-Rasgado et al. 2004)	X		X	
(Morelli 2002; Morelli 2006)	X		X	
(Garetti et al. 2012)	X		X	X
(Pezzotta et al. 2014)	X	X	X	X

Only Garetti et al. (2012) proposes the adoption of a **collaborative design platform** typically used in engineering processes



Other authors suggest the adoption of **simulation IT-based tool** specifically defined for Service Engineering.

Towards Lean PSS design

Main results:

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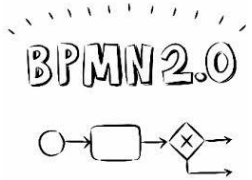
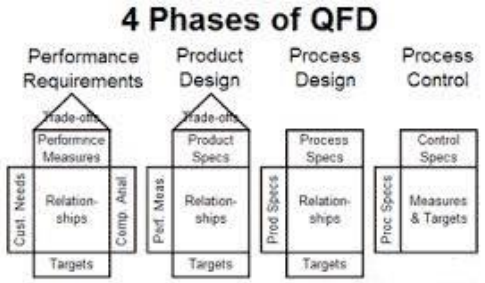
4. WASTE ELIMINATION AND VALUE IDENTIFICATION

Proposition for the PSS design process of:

- **methods and tools for eliminating *muda*** (5C approach: *Clear out, Configure, Clean and Check, Conformity, Custom and Practice*) or similar;
- **standardization practices**:
  - BPMN (Shimomura et al. 2009; Sakao et al. 2009),
  - UML 2.0 (Aurich et al. 2006),
  - SADT (Maussang et al. 2009);
- **standard models and templates**:
  - QFD (Shimomura et al. 2009; Sakao et al. 2009),
  - View model (Shimomura et al. 2009),
  - Service Requirement Tree (Pezzotta et al. 2014).





Towards Lean PSS design

Main results:

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Proposition for the PSS design process of:

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- **standar...**
  - ... 2009; Sakao et al. 2009),
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  - Service Requirement Tree (Pezzotta et al. 2014).

Standardization practices: basis for promoting continuous improvement consciousness!

Towards Lean PSS design

What it missing in the analyzed contributions, in a Lean Product Development perspective?

1. None of the contributions has clearly and systematically identified **which are the typical *muda* to be considered in a PSS design process** and defined **what is a *value-added* activity**.

2. **None of the contributions is quoting SBCE**, even if all of them are proposing/suggesting a design process structured according to the SBCE archetype (Morgan and Liker, 2006).

Towards Lean PSS design

What it missing in the analyzed contributions, in a Lean Product Development perspective?

3. Practically no contribution is investigating the **role which could be played by computer-aided design and engineering tools** already existing in the normal engineering practice.

4. The application of the **proposed PSS design methodologies** is most of the time **at a prototype/piloting stage** and **no detailed guidelines on how lean-inspired mechanisms should be implemented** are given.

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Conclusions and further researches

✓ **Great involvement** of the **academic context** in PSS design,

X **Few scientific contributions and industrial experiences** considering the potential role of Lean Product Development methodologies and tools.

Needs to improve PSS design with the support of the **Lean:**

- Knowledge sharing among different academics communities (e.g. experts in PSS design, lean, computer aided engineering, etc.).
- Involvement of industrial practitioners for considering the real state of practice of design processes.

Opportunity for further researches

RESEARCH QUESTION

Conclusions and further researches

RESEARCH QUESTION: How the so-called Lean Product Development discipline could support the design and development of PSSs?

RQ1. Which is a proper definition of **what is waste and what is value in a PSS design process**? How *muda* and value-added activities should be detected? Thus, what are the **best practices for eliminating wastes in PSS design**?

RQ2. Is the **Set-Based Concurrent Engineering paradigm** implemented in a PSS design process and how is it applied? Which are the **constrains and the trade-off to solve along such a design process**?

RQ3. How **computer-aided tools could support the PSS design process**? How **IT tools** available in the market of engineering solutions should be **used or reshaped to support the PSS design process in a lean-oriented way**?

Conclusions and further researches

DIVERSITY Project → testing and experimenting the proposed PSS design methodologies and lean principles: it aims to support PSSs designers, putting in place a detailed guideline for managing the process according to the Lean principles and also re-shaping market-available computer-aided tools (PDM / PLM platforms).

THANK YOU!


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PSS

Goedkoop et al. (1999)	'a system of products, services, networks of "players" and supporting infrastructure that continuously strives to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models'.
Centre for Sustainable Design (2001)	'a pre-designed system of products, supporting infrastructure and necessary networks that fulfil users' needs on the market, have a smaller environmental impact than separate product and services with the same function fulfilment and are self-learning'.
Mont (2001)	'a system of products, services, supporting networks and infrastructure that is designed to be: competitive, satisfy customer needs and have a lower environmental impact than traditional business models'.
Manzini (2003)	'an innovation strategy, shifting the business focus from designing (and selling) physical products only, to designing (and selling) a system of products and services which are jointly capable of fulfilling specific client demands'.
Brandstotter (2003)	'consists of tangible products and intangible services, designed and combined so that they are jointly capable of fulfilling specific customer needs. Additionally PSS tries to reach the goals of sustainable development'.
Wong (2004)	'may be defined as a solution offered for sale that involves both a product and a service element, to deliver the required functionality'.
ELIMA (2005)	'is defined as a system of products, services, supporting networks and infrastructure that is designed to [be]: Competitive, Satisfy customer needs, & Have a lower environmental impact than traditional business models'.

Legend: **Main definition** **System's components** **Objective** **Other features**

PSS design

State of the art on PSS design methodologies proposed by (Vasantha et al., 2012)

- **Service CAD** (Komoto & Tomiyama, 2008): method to support design decision making evaluating the design concepts and suggesting alternatives to improve them, and **ISCL (Integrating Service CAD with a life cycle Simulation)**, which aids quantitative and probabilistic PSS design using life cycle simulation.
- **Service Explorer** (Shimomura et al., 2009), a SW tool related to Service CAD, for designing service activity and products concurrently and collaboratively during the early phase of product design, representing together human and physical processes in service activity through BPMN and evaluating them with QFD. A simulation tool has been also included to predict service availability (Sakao et al. 2009).
- **Integrated product and service design processes** approach (Aurich et al., 2006) tried to introduce a systematic link between the technical-services design and the corresponding product design process, using the UML 2.0.

PSS design

State of the art on PSS design methodologies proposed by (Vasantha et al., 2012)

- **Heterogeneous IPS² concept modelling** (Welp et al., 2008): a model based approach supporting designers to generate heterogeneous PSSs concept, fostering the functional behavior of PSS artifacts.
- **PSS design** (Maussang et al., 2009): a methodology providing technical engineering specifications to complete precisely system requirements, using SADT (Structured Analysis and Design Technique) representation.
- **Fast-track Total Care design process** (Alonso-Rasgado et al., 2004): approach to choose the most suitable combination of products and services to provide the best solution for all parties involved, considering the two main aspects of Total Care Products, architecture and business. It is the result of the integration of service design, simulation of services, hardware architecture, hardware and service support system costs.
- **The design process for the development of an integrated solution** (Morelli, 2002) set in a two dimension space, problem space (often leading to new solutions) and solution space.

Towards Lean PSS design

Some contributions already applied Lean principle into PSSs context:

- **Lean Thinking on service operations** (Arbòs, 2009): introducing some **general criteria** that could be **provided in order to attune service companies with the lean approach**;

- how to systematically configure PSS through a lifecycle-oriented management (Aurich et al. 2009): a **tool able to** obtain an appropriate combination of products and services in order to **develop consistent procedures for the lean continuous improvement of the** PSS configuration model);

- Services generally under-designed and inefficiently developed, many lean-oriented tools from product and software engineering are transferred to services (Cavalieri and Pezzotta, 2012) → **Service Engineering** (Komoto and Tomiyama, 2008; Shimomura 2009) framework for PSS development **able to integrate product and service contents with a systematic perspective** (intensifying, improving and automating the whole framework of service generation, delivery and consumption);

Towards Lean PSS design

Some contributions already applied Lean principle into PSSs context:

- a **lean-oriented platform** (Garetti et al., 2009) connecting **Service Engineering methods to a support tool of LCS (Life Cycle Simulation)**, based on four requirements: Modularity, Stochastic Behaviour of Modules, Life Cycle Cost perspective, Social and Environmental Impacts);

- From the review of the 8 most referred PSS design methodologies (Vasantha et al,2012), definition of **twenty design dimensions required to develop effective PSS, grouped into six categories** (context specification; positioning and importance of stakeholders; design stages; development cycle; life cycle consideration; representation), **most of inspired by Lean Thinking**;

- most of the existing methodologies for service mainly adapted and derived from the traditional engineering, business and computer science approaches → ***SErvice Engineering Methodology*** **(SEEM) aimed at balancing company's internal performance and customer satisfaction** (Pezzotta et al., 2014).