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The Conceptual LeanPPD Model

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Abstract. This paper is presenting the conceptual Lean Product and Process Development (LeanPPD) model which is a project funded by the EU-PF7. The project is addressing the needs of European manufacturing companies of a new model that goes beyond lean manufacturing, to ensure the transformation of the enterprise into lean environment. This is a respond to the market demand of value creation, incorporating sustainability and customisation as well as ensuring business growth through the development of high quality products in a cost effective manner at the shortest time. The authors believe that significant change in enterprise performance can be achieved through the adoption of lean thinking throughout the product life cycle. The paper presents the LeanPPD enablers which represent the building block of the model.

Keywords: LeanPPD, Lean Thinking, KBE, SBCE, value creation,

1 Introduction

The increased international competition in the current open global market is putting pressure on companies to improve the performance of their product development. This is to sustain and improve market share through the production of a high quality product in a cost effective manner in shorter time. This is because organisational survival and long-term growth depends on the introduction and development of new products. The European manufacturing companies are in need of a new model that goes beyond lean manufacturing to ensure the transformation of the enterprise into lean environment. This is a respond to customers and market demands of value creation, incorporating sustainability and customisation. The authors believe that significant change in enterprise performance can come from the adoption of lean thinking through out the entire product life cycle. In this research; sponsored by the EU-PF7, we refer to it as Lean Product and Process Development (LeanPPD). Lean concepts were derived initially from the Toyota Production System, which in simple terms is defined as: producing what is needed, when it is needed, in the time that is needed, with the minimum amount of resource and space. The whole objective of lean is the elimination of waste. This is good to achieve an isolated success within a manufacturing company but is not sufficient. What is needed is a new paradigm that will take the Lean manufacturing and lean thinking concepts from waste elimination into value creation. In order to make a significant change in enterprise performance and saving ultimate system costs, there is a need for the entire enterprise to undergo a lean transformation. Lean design is going to be an important part of this lean transformation, as up to 80% of the manufacturing cost is determined in the design stage. It is important to note that a complex design product cannot easily be “leaned out” in production stage. Hence the production of affordable and sustainable products would require an effective lean design and engineering.

This paper is presenting the conceptual LeanPPD model through its enablers; which represent the building block of the model. These enablers are: lean assessment tools, the product development value mapping tool, the set-based lean design tool (SBLDT) and set-based concurrent engineering, the knowledge-based Engineering and the knowledge-based environment.

2 The Related Lean Product Development Literature

Lean principles proposed by Womack based on Toyota Production System (TPS) to improve the productivity of the shopfloor by eliminating wastes may be described as: specify value, identify the value stream and eliminate waste, make the value flow, let the customer pull the (value) process, and pursue perfection. These principles have been applied in the shopfloor what is commonly referred to Lean Manufacturing. In order to make a significant change in enterprise performance and saving ultimate system costs there is a need to have the entire enterprise undergo a lean transformation.

Karlsson and Ahlstrom carried out research based on observing several industries to come up with recommendations about the path to Lean Product Development. The research did not define the meaning of lean and the general recommendations were more related to CE applications such as supplier involvement, cross-functional teams, simultaneous engineering and integration of activities. There were two major lean thinking projects in USA and UK. The Lean Aerospace Initiative coordinated by MIT (USA-LAI 2010) and the UK Lean Aerospace Initiative (UK-LAI 2007). It is clearly noted they are specifically oriented to the aerospace industry and only to those companies in USA and UK as well as the information are available only to the projects’ members. The efforts started by understanding the Toyota Production System (TPS) through publishing the book “The Machine that Changed the World”. The book gave a name to TPS as Lean Manufacturing. Most of the efforts were put in understanding lean applications on the shopfloor and developing both practical models and lean techniques to help the implementation. This effort then evolved to the lean transformation of the enterprise. This is now called the Lean Enterprise that covers the adoption of lean thinking to the management of the enterprise as well as it supply chain. Some part of the UK Lean Aerospace Initiative started in April 1998 (ended in 2001) was addressing the issues of adopting Lean thinking in new production introduction. Haque and James-Moore used experiences of lean implementation in manufacturing processes, and process improvement initiatives in Lean Product Introduction (LPI) such as CE to make a comparison in order to make an argument about LPI. In addition, an extensive literature review was carried out to identify possible techniques or tools (based on both lean manufacturing and CE best practice) to support LPI. This led to a level of understanding to propose general characteristics of a LPI System.

Several books have been published with titles related to Lean Design or Lean product development; some are based on the research carried out in USA which observed and analysed the Toyota product development system (Kennedy, Morgan and Liker, and Ward). The general findings of these books are the following:

- System Designer Entrepreneurial Leadership: A technical leadership paradigm that efficiently brokers the right knowledge into the right product.
- Set-based Concurrent Engineering: An exploration paradigm that generates extensive knowledge from many perspectives to maximise product alternatives with minimal risk.
- Responsibility-based Planning & Control: A management paradigm that provides efficiency, flexibility, and knowledge as the backbone for project execution.
- Expert Engineering Workforce: A paradigm that assumes engineers have both the technical capability and access to the right knowledge to make the proper decisions to optimise the current product, while building the knowledge for future products.

According to the National Centre for Manufacturing (http://lpdi.ncms.org/), Toyota product development projects can take half the time of US equivalents, with four times their productivity (150 product engineers utilised by Toyota per car programme versus 600 for twice as long at Chrysler). Mr. Kosaku Yamada, Chief Engineer of Toyota's Lexus line said "***The real difference between Toyota and other vehicle manufacturers is not the Toyota Production System; it is the Toyota Development System***"

Mascitelli (2007) based his book on his long experiences as consultant in product design in many companies. His approach is to provide a toolbox of methods that enable manufacturing cost reduction to become a foundational part of product design and development. Fiore (2005) attempted to merge lean manufacturing with six sigma to develop a template of three main foundation pillars:1) the lean design, 2) the manufacturing process and 3) control pillars. Huthwaite (2004) put his experiences as consultant in Design for Manufacturing and Assembly (DFMA), process control and cycle cost into a new approach to provide designers with recommendations on how to avoid wastes and to create values in their design.

In the USA, several researchers (such as Durward Sobek II and James Morgan) made an effort to study the Toyota product development system, and the findings indicate that Toyota product development projects can take half the time of US equivalents, with four times their productivity. Toyota product development system is based on what is called a 'set-based concurrent engineering' (SBCE) that is different from so many other manufacturing companies. SBCE focuses on collaboration between different development departments and aims at shorter development times with an increased quality level by improving collaboration and by paralleling parts of the development process. Design participants practice SBCE by reasoning, developing, and communicating about sets of solutions in parallel and relatively independently. As the design progresses, they gradually narrow their respective sets of solutions based on additional information from development, testing, the customer, and other participants' sets. As they narrow, they commit to staying within the set(s), barring extreme circumstances, so that others can rely on their communication. SBCE processes starts with large design alternatives covering broad design spaces and then gradually narrowing the set of possibilities to converge to a possible design by eliminating the weakest alternatives rather than choosing one "best" alternative. It is a counter-intuitive approach and looks paradoxical to people trained in the traditional point based approaches. Various sets of alternatives are taken ahead for all parts of the product and the weakest ones are eliminated as one move in the product development life cycle. SBCE assumes that reasoning and communicating about sets of ideas leads to more robust, optimised systems and greater overall efficiency than working with one idea at a time, even though the individual steps may look inefficient. This approach may require more time early to define the solutions, but later stages can then move more quickly toward convergence, and ultimately production, relative to more point-based processes.

3 The New Paradigm of the Lean Product and Process Development

The fundamental issue in the new LeanPPD paradigm is the move from waste elimination to value creation. This is being realised through the development of an integrated set of tools and models that the current literature is missing. Performance measurement that considers human resources, technology factors and processes of an enterprise are going to be used to measure the readiness and level of adoption of lean thinking principles in current industrial practice of product design and development processes. This will lead to an understanding of how product and process development is structured and what is needed to streamline the process to maximise value creation. Hence, the project is addressing the mapping of product development process to measure the values from the customers' point of view and estimate the-cycle costs, including the manufacturing and in service components. The LeanPPD model being developed in this project will enable manufacturing companies to balance the need to react to value creation opportunities against the efficiencies to deliver them effectively. This will be achieved, as any engineering decisions taken will be based on proven knowledge and experience, to reduce risk and maximise utilisation of resources of both the enterprise and its supply chain.

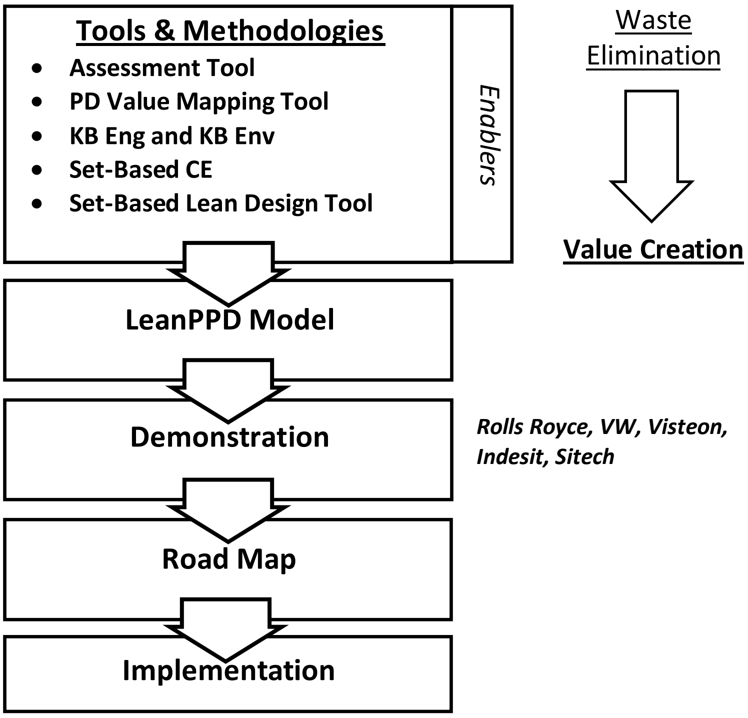

Figure 1: The LeanPPD Paradigm

The aim of the LeanPPD project is to develop a new model and its associate tools based on lean thinking that will consider entire product life cycle. Providing knowledge based user centric design and development environment to support value creation to the customers in term of innovation and customisation, quality as well as sustainable and affordable products. This is the new **LeanPPD paradigm** which is the result of the application of lean thinking in product design and development. Figure 1 illustrates the LeanPPD paradigm which consists of several enables namely: lean assessment tool, product development value mapping tool, the knowledge-based engineering and environment as well as set-based CE and set-based lean design tool. These enables are the building block of the LeanPPD model that will be demonstrated using several business cases from three different sectors; aerospace, automotive and home appliances. A route map for the incorporation of the model into organisations at different levels of development will lead to the full implementation of the LeanPPD model. The following section is presenting the conceptual LeanPPD model and explains the rational and the role of its elements.

4 The Conceptual LeanPPD Model

The conceptual LeanPPD model is illustrated in figure 2. The main features of the model that are in the progress of definition and development are; value creation, knowledge-based environment and the Set-Based CE (SBCE). In applying lean concepts, a major objective is to identify value and non-value added activities. In product development, any activity that would result in customer requirements being met could be considered as value adding activity. Notions of 'value' are relatively straightforward to apply in a manufacturing context but need to be further developed to be truly applicable in the product design and development arena. For example, iterations in manufacturing are usually seen as non-value adding, but iterations that are used to explore a design space are an essential part of delivering an optimal product solution to the customer. The model is developing tools and approaches to identify opportunities for value creation from a customer viewpoint, as well as a tool to help in representing them in the design of the product and product development process. A novel (Set-based design lean tool (SBLDT) is being developed to generate a set of lean designs based on definition of design and manufacturing features that are affected by lean principles. These lean features would be identified, extracted and inspired from lean tools, e.g. Poka-Yoke, Single Minute Exchange Die (SMED) and Quick Change Over (QCO).

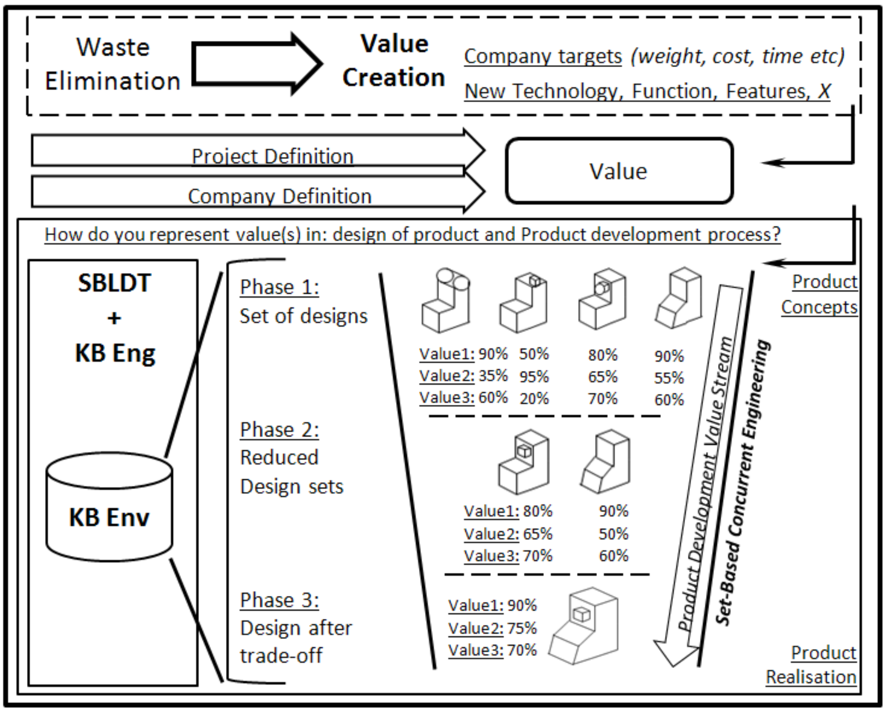

Figure 2: The Conceptual LeanPPD Model

The project is adopting the hypothesis that lean product development is product development in a knowledge-based environment. Hence, one of the main features of the conceptual LeanPPD model is knowledge provision. A knowledge-based engineering architecture will be designed to support the development of two knowledge-based systems, these are Knowledge-based engineering (KB Eng) and Knowledge-based environment (KB Env). The KB Eng will capture several domain knowledge (e.g. injection moulding and stamping to support a range of product life cycle engineering applications such as costing and DFMA. The KB Env will capture the previous projects to be one of the main sources of knowledge to define a set of conceptual designs of a new product. The authors believe the knowledge environment will enable manufacturing companies to balance the need to react to value creation opportunities against the efficiency to deliver them effectively. This will be achieved, as any engineering decisions taken will be based on proven knowledge and experience to reduce risks and maximise utilisation of resources of both the enterprise and its supply chain. The project is developing a new lean knowledge life cycle to support the systematic methods for knowledge capture, re-use and creation to enable a knowledge-based environment for LeanPPD.

SBCE principles are going to be used in order to trade-off among the different concept designs based on the value of the lean features that will be measured in terms of function, cost, ease of manufacture, and quality as well as the smooth transformation to a lean manufacturing system for the physical realisation of the product. This will results in the definition of one final lean design

5 Conclusion

The related literature of lean product development research has indicated that the research community has made a small progress in addressing lean aspects of product and process development. In addition, the previous research into lean has not addressed the applications of knowledge-based engineering, nor provides solutions on the evolving issue of product development value mapping to highlight value creation throughout the development process. Therefore, a significant lack of techniques could be used to provide a route by which lean thinking could be incorporated into existing product design and development in different sectors. The proposed conceptual LeanPPD model intends to resolve these gaps by merging the latest in knowledge-based system architecture with value-based model for LeanPPD.

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