Abstract: Product development is one of the most creative manufacturing processes. Furthermore, it is highly relevant in product price formation. The process is not predictable and the success of the creative work is evaluated only later – from market reaction. In the main position of this process is human – (engineer, inventor, developer etc). One may ask how we can optimize or be leaner in such processes. Late researches have investigated many similar “leans”, for example Lean Manufacturing, Lean Office, Lean Enterprise, Lean Supply Chain, Lean Six Sigma, Lean Thinking and now Lean Product Development. This shows us that everything could be leaner. In this paper, the product development processes of both small and medium size Estonian engineering enterprises are under investigation. Relations between PLM (Product Lifecycle Management) and LPD (Lean Product Development) are described. Future trends and needs in LPD field are discussed and analyzed as well. Key words: Lean Product Development, Product Lifecycle Management.

1. INTRODUCTION

In the production and product development phase advanced CAD/CAE/CAM/PLM tools are becoming more effective and useful in small and medium sized companies. The computer-based methods are used to support engineering decision making processes. They allow the integrated use of information about different aspects, such as geometry and functionality of product, manufacturing and development processes, available resources, pricing processes, supplier data etc. Progress in design search and optimization (DSO) has continued steadily in recent years and formidable range of optimization methods is available to the engineers. In general, design optimization may be defined as the search for a set of inputs that minimizes (or maximizes) objective function under given constraints. The objective function may be expressed as cost, product lead time, product efficiency, and return on investment. It is subject to constraints in accordance with given relationships among variables and parameters and constraints of manufacturing system parameters and resources [1, 2]. Lean is the search for perfection through the elimination of waste and the insertion of practices that contribute to reduction in cost and schedule while improving performance of products [3]. Product development as an activity is not the most expensive one among the whole production chain. But as it can be seen from Fig 1, it has a strong influence on the price of the product and faults made during this stage are very costly. One can understand from Fig 1. right side why lean production was the most effective and first in the line to be used. Most Estonian SME-s have cultivated a personal approach to the product development process. Each company, even each individual product development team member has their own methods [4, 5]. This fact shows that there is huge potential for accelerating time-to-market through aggressive waste elimination in planning, design control, and interdisciplinary communication. The interest to be more
competitive is more critical in bigger production units while smaller production units may count more in flexibility. It is shown in [6,7], that is important to follow certain rules, even in cases where the product development team is small. Radeka. K and Sutton. T [8] believe that there are five particularly important questions in Lean Product Development (LPD).

First, get a good handle on customer value. How well do you know your end users? Next, take a good, hard look at your product development process. Then think about program leadership: Who in your organization makes the major decisions about product development? Then take a close look at how much effort you exert at the end of the process versus how much you spend at the beginning, when exploration is relatively cheap. Finally, what organizational barriers foster the waste of reinvention?

Those five questions are the best to describe the meaning of LPD and it is clearly understandable that those five questions have importance in both – large and small-medium enterprises. Of course some of those questions have higher importance when integrated product team (IPT), as a development unit, is used. IPT's are the basis of organizing development personnel to enable Concurrent Engineering, Integrated Product Development (IPD), or Lean Product Development. Such a team is usually empowered to make critical life cycle decisions for the development of a product or system. Because the product or system development activities are changing and evolving constantly, team membership is changing and evolving as well.

Product Lifecycle management (PLM) as a tool is strongly connected and usually integrated into the Integrated Product Team toolbox. To avoid mistakes made in the past, and to take more advantages from successful products, PLM gives us great possibility to copy useful parts and save a remarkable amount of time. The aim of this paper is to store the current situation of the product development styles and levels of Estonian SME’s based on a survey on a selection of SME-s. In addition, a roadmap for Estonian SME’s to choose an optimal toolbox for LPD is shown.

In the next part of the paper the current situation of product development level is investigated. It is based on IMECC (Innovative Manufacturing Engineering Systems Competence Centre) group production units. Those production units are categorized and their product development process descriptions are displayed. It is pointed out that a systematic approach to problem solving and Product Development helps to control expenses in this early step of pre-production process.

2. PRODUCT DEVELOPMENT IN ESTONIAN SME’S

Five years ago held a seminar called “Modern Product Development in SME-s – problems and possibilities” was held in Tartu Science Park. In those days, LPD was not discussed a as term. However, many tools used in LPD were often mentioned. Lean Production was already acknowledged at that time but “Modern product development” had meaning that specific process steps in product
development just should be passed. The reason for this fact is educational on the one hand. On the other hand, it was caused by high levels of subcontract work, where product development had no meaning. Agility in pricing and low cost equipment from the Soviet time, were the basic reasons against “lean” type of thinking.

Based on the data from a research carried out in 2009 about manufacturing SMEs, only a few Estonian production units had their own independent product development team. In most places the “brainwork” was made abroad or leaded from abroad. Large companies represented in Estonia had only a few engineers in Estonian factories and their task was simply to translate orders to the production unit and send feedback to the opposite direction – back to the head office.

One of the tasks of IMECC is to create a set of SAS (Software as Service) tools for SME cluster, for better and leaner product development.

For the evaluation of product development levels in SME’s, product development toolbox consistence was investigated. Required variety of SME input data is described below.

- From the point of view of the number of employers – the almost full range of SME group was presented;
- From the point of view of location – different regions were covered;
- From the point of view of the two sectors of production profile– subcontractors and enterprises with their own product development departments were involved.

In our case those requirements were fulfilled, (20...150 employers, SME-s situated all over the Estonia and both, subcontractors and enterprises with development department are represented). As it was shown in Fig 2, 78% among SMEs are not using the possibilities offered by the modern product development tools. Drawings are still archived in papers, versioning is mostly manually driven and unsystematic. Feedback information, for example VOC and reclamations are not available to the product development team.

As a result of non-systemized archives and an unclear version handling, a lot of time is wasted for the searching of suitable examples from archive. Also product data collecting and systemizing is difficult.

A personal approach to product development process is cultivated in Estonian SMEs and each company and even each product development team member has their own ways to manage. Smallest Product development teams may consist of only one person. Such one-man teams are quite lean by their nature, because there is no need for internal communication. On the other hand, there is a huge risk to lose everything in case of key person’s disappearance. Companies with bigger product development teams may have already encountered a full variety of problems, Radeka. K and Sutton. T [8]. But mostly they suffer due to the lack of systematic approach.

Larger companies with their sub-production units in Estonia (counted also as Estonian SME) have normally very well organized structures and workflow, but they mostly suffer at communication speed and accuracy.

PLM (PDM) level is in correlation with the employers’ amount but not correlated with the production profile. We can also see that the PLM curve’s highest point in Fig. 3 is only slightly over 50%, which means a
little more than a half of PLM offered modularity is currently used by larger SMEs and only a few modules (mostly CAD and CAM, as it was pointed out in Fig. 2) are currently used in smaller SMEs. As example, one anonymous SME-s (120 workers in whole) product development team and their work process is shortly described. The design department consists of two types of engineers: electronic engineers and design engineers.

Fig. 3. Correlation between employer’s amount and PLM systems functionality

The tasks of an electronic engineer are:
1. They start with preparing an electrical scheme according to the client design brief;
2. The Second step is to prepare a list of electronic components;
3. The Third step is to write a program code for frequency converters;
4. The Fourth step is to prepare a testing program;
5. The Fifth step is to write a technical regulation;
6. Finally, when the product is produced, engineers provide the client with exploitation extractions and make the last testing with the client.

The tasks of a designer engineer are:
1. Firstly, the engineer reads the electro scheme and makes clear all the connections and components;
2. The second step is to prepare the main specifications;
3. The Third step is to find a suitable enclosure;
4. The Fourth step is to prepare technical calculations (cooling, ventilation, stress analysis, etc.);
5. The Fifth step is to do a 3D model of enclosure with all electrical components and details;
6. The Sixth step is to make technical documentation (drawings, specifications, etc.);
7. The Final step is the assembly stage, when engineers control the assembly stage and make corrections in documentation.

In the beginning when new project starts, the manager of design department prepares a plan for future work, in which he mentions designing a team structure. During the project, all serious problems which appear should be solved inside the team. Usually a team consists of 4-5 engineers. The Manager of a design department always controls all of the documentation which has been produced for a project and after corrections, approves it. When the documentation is finished, the design engineer prepares a note, where he/she describes the kind of work should be done next. For example, which drawings should go into work.

There are no any helpful technical tools supporting PLM data collecting and handling. That is why the bureaucracy is very developed there.

In conclusion, it is clear that a roadmap for future activities is more case by case type of instruction than universal rule for all size of organizations.

3. TOOLS AND STYLES IN PRODUCT DEVELOPMENT

For the first step, situation analysis is needed. As every product development team is used to work in their own style and according to their own needs, it would be necessary to find out which tools are already in use and what is needed to add urgently. Lean product development means different things to different organizations. Some
organizations are “design-to-order”, where each customer order requires some amount of design effort. In such companies, customer requirements tend to be well defined, and the design effort typically involves the reuse of existing technologies that will be adapted to meet the needs of specific customers. Other companies engage in longer term “research and development”. New technologies must be developed, requiring greater study, testing and time, perhaps years to bring to market. And there are companies that lie somewhere in between.

Regardless, all organizations need to be familiar with the “Lean Development Toolbox”. There are numerous tools in the “toolbox”. Companies must determine which ones will be most helpful in their particular applications.

Voice of the Customer tools such as Quality Function Deployment (QFD) can help companies get off on the right track at the start of the development process. Target Costing is a concept that should be initiated at the beginning of a project and followed throughout. Costing models must be developed to monitor projected costs to verify that target costs can be met.

Set Based Concurrent Engineering (SBCE) is a concept that should be put into practice early during the “study” phase of the development process. It is during this phase that different design alternatives are identified and studied.

Design of Experiments (DOE) can help developers learn in more efficient ways during the "study" phase. Methods to help select a “solution” among the alternatives under consideration must be available. Trade-off curves and the Pugh Matrix are two such techniques.

Developers should be familiar with techniques that result in “robust” designs that will be more assured to meet customer expectations. These include Taguchi techniques, including System Design, Parameter Design, Tolerance Design, and Taguchi’s Loss Function. Design Failure Mode Effect & Analysis (DFMEA) can help to insure robustness as well. Here possible failures are considered and countermeasures are proactively included in the design.

Design for Manufacturing & Assembly (DFMA) can insure that manufacturing capabilities are considered while the product is still being designed, as can 3P events. A 3P (Production Preparation Process) event is a kaizen event where a cross-functional team works to develop the details of a design while simultaneously developing the production process. The result is a design that is producible and will be more cost effective when transferred to production.

Project Management techniques are required to manage development projects over time. These techniques go beyond scheduling systems, and establishing “milestones”. Effective and efficient communication techniques can be put into practice that will insure success. These include visual management techniques, and methods to capture and share knowledge [9].

One team works for one company, but there are more styles to follow, such as lean product development team for cluster of production organizations or independent product development team working as subcontractor in worldwide on demand style. This could be even leaner, because sometimes when the production is already running, product development team is underserved. This type of “travelling teams” can do their work in a good lean way in subsystem level and usually in specific fields only (like developing welded frames or molded housings, electronic control systems or power supply units).

There an additional delicate issue – production volumes. It is completely different if in one case one plans production in small numbers or in the other for a long period and mass production. In the first case, it is not so risky to assume to
the design phase at once, because of smaller losses of money in the future. But in case of mass production, the product development calculations and DFMA stages should be extremely exhaustive. As mass production is quite rare in Estonia (Norma, Favor, ABB, Ensto, etc) and those factories have high competence levels in product development field, we concentrate more on smaller production volumes.

4. CONCLUSION

The paper demonstrates that the gap between Estonian SME product development level and widely known lean product development methods still exists. It is obvious that a small local market does not generate a large enough pressure to start lean product development activities in SMEs without the help of supporting organizations like IMECC. From a wider perspective, the deeper experience exchange and wisely organised cooperation in small enterprises product development level improves the overall productivity and Estonia’s worldwide competition level. High price level and good quality/functionality relationship of larger PLM and PDM software systems could be an indirect engine for further cluster formation and cooperation.

5. ACKNOWLEDGEMENTS

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