INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN
ICED 05 MELBOURNE, AUGUST 15 – 18, 2005

ORIGINS AND PROSPECTS OF PLATFORM BASED PRODUCT PARADIGM

Timo Lehtonen, Tero Juuti, Antti Pulkkinen, Anna-Maria Roikola, Asko Riitahuhta

Keywords: Product structuring, Modularisation, Platforms, Historical perspective.

Abstract

In this study, the essence and the context of platforms as an industrial practise are examined using historical perspective. This kind of approach is seldom used, but similar ideas have been presented earlier, for example in references [1] and [2]. The hypothesis of this paper is that there exists a sequence of development stages in the history of product structuring. According to the hypothesis innovations and events like the introduction of standard screw thread are not only seen as a step forward in production technology. Moreover, it is an early case on product structuring as standardisation of connecting elements. This did not only enhance production, but also enabled reuse of a small item of design.

According to this hypothesis, we can find the precedent, evolving development stages of the platform based product paradigm. By documenting the characteristics of these stages, we can find what is actually new in product platforms. We can also make extrapolation and have justified foresight on what there will be after the platforms.

1. Introduction

In the area of product structuring and modularisation, product platforms are now among the most interesting topics. In addition of being a matter of academic interest, the term "platform" has become a part of language also in industry. The state-of-the-art solution is a platform-based modular structure, where the product is divided in standard sections and customer variable sections. The variable sections should have function-based modular structures, but the standard section could have an assembly-based modular or even an integral structure. There are also platforms established on other basis than functional modules. As said earlier, the topic of product platforms is now very current. Often platforms are supposed to be a solution to many problems, which are confronted with globalisation.

In lesser extend it has been examined, what is the new content in platform based product development paradigm. It is justified to raise this question because the main elements of this paradigm have been known long before the word "product platform" was used at the first time. The objective of this study is to examine the basis of the platform based product paradigm. The focus is on platforms, which make use of modular structures. Other types of platforms are also discussed. The approach is to view the product platforms as a one step of historical development of product structuring. By using the historical perspective we can reveal the actual advances and also figure out future development possibilities.

2. Product platforms

There exist different definitions for a platform. For example Meyer and Lehnerd [3] define a product platform as a set of subsystems and interfaces that form a common structure from which a stream of derivative products can be efficiently developed and produced. Muffato and Roveda [4] use the same definition but make addition that a platform should be a set that is intentionally planned. Robertson and Ulrich [5] see product platform to be a collection of assets that are shared by a set of products. These assets can be components, processes, knowledge or even people and relationships. Kristjansson has studied different definitions of platforms [6] and he has found that in 14 well known sources there are 15 different topics that are addressed. By defining the lowest common denominator he concluded a universal definition of platform, which was “platform is a collection of core assets that are reused to achieve a competitive advantage”.

There are many viewpoints to platforms in academia and the situation is similar in industry. The simplest way of forming platform is a set based approach, where selected component sets are used as a backbone for product palette. The motivation of utilising product platform is achieving the economics of scale in component production and standard procedures in assembly line. In recent years car manufacturer VAG AG has tried to utilise such a platform. In so-called technology platform product there exists a technological subsystem, which forms the core of all products in product palette. [7] The most well known example of such platform is tape transport mechanism in the Sony Walkman personal stereo. The idea of using technology platform is the allocation of investments made in developing the core technical system. As sets of components can establish a basis for platforms, modules could be used too. If the modules used are assembly based, the platform supports procurement, production and logistics. However, the more interesting type of a product platform is formed of function-based modules. In customer variant product, the variation often is connected to functionalities of the product. Thus, this kind of platform supports customer variation, which is an essential theme in business today. It is important to note that only a fragment of product platforms used in industry is based on functional modules. In a following illustration the possibilities to form a platform are shown. The technology platform could be assembly or modular based.

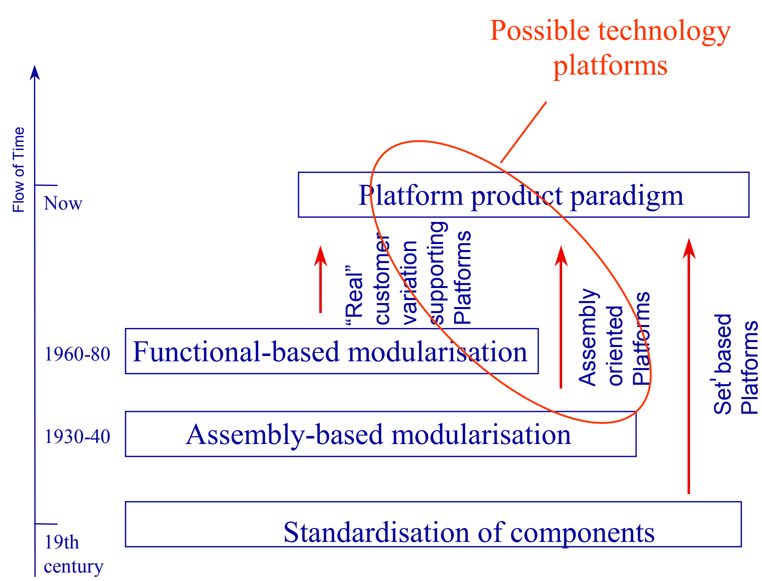

Figure 1: Different approaches to form product platforms (Revised picture according to Juuti&al [8]).

Now we can look at the paradigm called ”platform based product” and try to figure out how this differs from standardisation and design reuse. Using historical perspective we can see when product platform way of working has started in industry. According to Aasland et al. [9] the platforms have been introduced in 1950, when big American automobile manufacturers co-ordinated their different brands so that to large extent there came virtually identical models under different brands. This “platform” consisted of a physical building group: engines, suspensions and transmissions. So it seems that here we had a set based product platform that was supposed to benefit from economies of scale in production lines.

However, if we go deeper to examine the prime goals of designing new cars for example at General Motors, we see a slightly different picture. In 50’s the importance of car styling became the most important factor when launching new car models. Rob Leicester Wagner writes about the priorities in GM where the emphasis was put on styling. GM considered industrial design as the most important element of the car, with the automatic transmission being to second in priority because of the comfort factor. Engineering was a distant third. It is difficult to believe that engineering would rank so low on the list, but GM knew that the consumers wouldn’t buy what they couldn’t see [10]. Take into account that it seems that the same motors were not used from model to model because of their importance but because it doesn’t matter what the technology inside the car was. So we can’t truly talk about a set based platform using the technical part, because the emphasis was not put on technical matters.

Developing a platform is typically dedicated to product engineering. However, related issues like production processes and systems have to be taken into consideration as well. Group Technology (GT) is a structured method, which was traditionally aimed at rationalizing the production process in the area of small and medium batch size [11]. In a nutshell, the method is targeted towards of arranging the parts spectrum and manufacturing processes according to design and machining similarities. When the arrangement has been attained, GT makes use of the production engineering techniques that are applied for mass production. Eventually, the effect of economies of scale is pursued.

The diverse effects of GT are mainly related to the properties of manufacturing system. According to Arn [11] a company can have an effect on internal issues like…

…increased

- effective machine operation
- productivity
- costing accuracy
- reliability of estimates

…decreased

- planning effort
- paper work
- setting time
- down time

- work in progress and work movement
- finished parts in stock

Also, effects that have external importance like increased customer service and order potential as well as decreased overall production time and cost, may be achieved with GT. A traditional GT manufacturing system can be regarded as combinations of set-based product platform and re-engineered production system that are tuned up for the flow of production as shown in figure 2.

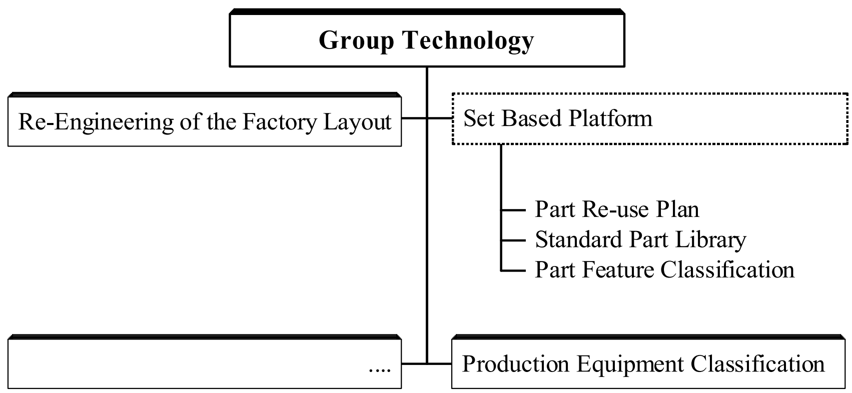

Figure 2: Some properties of set based platforms appear with Group Technology

The objectives of GT are quite alike to set base platforms, since they both are aimed for increasing the productivity and managing complexity in production. Their purpose is to bundle new features or parts in a production context as well as to re-use parts. Also the means to attain the objectives are quite similar with GT and set based platforms.

As a conclusion from the above, it is evident that there are not many new ideas in set based platforms nor simple assembly based platforms either. So, the novel thing with product platforms is connected to modular structures and further on function-based modular structures. Hence, understanding the platforms requires thorough understanding of product modularity. Thus, it is not possible to examine them without an attempt to define product modularity.

3. Product modularity

Term "module" comes from Latin word "modulus". Architect Marcus Vitruvius Pollio used it for first time in written literature in his book “De arhitectura libri decem”. "Modulus" was a standard unit of measure, which was used in architectural planning. However the product modularity as we know it, is an invention of later times. The utilisation of modularity in larger extent started in industry during the 20th century. The fact that there does not exist any common definition for module in industry, makes it open to various interpretations; which products should be consider modular and which should not. According to the "industrial thinking" a product is modular *if it includes an internal division in part structure that is made according more abstract reasons than assembly.* These reasons called here "abstract" are abstract only in the context of part structure. The reasons for having modular structure could be connected to organising the production, managing the life cycle of a product or managing the variants in product palette.

Reasons connected to organising the production are for example the assembling of main components and auxiliary devices to separately manufactured machine units for example in diesel locomotive manufacturing. Another example is partitioning ship hull to sections, which are small enough to be lifted with hoisting equipment available. An example related to the life-cycle partition is for instance to group the components, which have shorter lifespan than the whole life of the product, for replaceable maintenance elements. An example related to variation is encapsulating subassemblies due to the technical development to one block. Modularising products in order to cope with variants is usual and a manageable solution to this is gathering up a tailoring package that contains the special expectations of the one customer's order.

In research field the fundamentals of product modularity can be traced back to Borowski (1961) and the "baukastensystem" that he defined [12]. Borowski defines that general building block system should be called special "baukastensystem" only if there is principles and plans how it is possible to build restricted or unrestricted amount of variations to specific application area of standardized building blocks. The original definition was following:

"Das Baukastensystem ist ein Ordnungsprinzip, das den Aufbau einer begrenzten oder unbegrenzten Zahl verschiedener Dinge, aus einer Sammling genormter Bausteine auf Grund eines Programmes oder Baumusterplanes in einem bestimmen Anwendungsbereich darstellt."

The building blocks interact with each other only thru interfaces and there were no internal variations in building blocks. In this extent all classical prerequisites for modular system were met. In addition to this, Borowski required that there should also be variation in the system.

"Das Baukastensystem tritt erst in dem Augenblick auf, wo das Vorhandensein der Baugruppen zur Fertigung verschiedener Dinge durch verschiedene Kompination der Baugruppen ausgenutzt wird".

According to this a single product cannot be a "baukastensystem". This makes sense also with modularity, although it is sometimes forgotten among the researchers and industrial consultants.

Far from history one can find products, which contain at least ideas of Borowski´s definition based on the "baukastensystem". Thus, it seems to be impossible to firmly show, what is the first modular product of the world history. An Early example of using word "module" can be found at late stages of the Second World War, from German shipyards. Shipyards re-arranged their submarine production by starting to build the hulls of submarines of lengthwise divided blocks, which they called "modules". These could be considered as assembly-based modules although no re-use or variation was utilised. This is a classical example why to separate the product into parts according to reasons for organising the production. One can discover that this approach, which was new in those days in the marine industry, serves as a standard solution in the shipbuilding nowadays. However, the assembling of the blocks was not invented in 1943. Bridges, for instance, have been made in the similar way already for a long time before, but German shipyards are the first who called their product "modular".

Evidence on the maintenance and life-cycle oriented modules can be found from year 1972, when GM subsidiary Electro-Motive Division (EMD) introduced it's GP38-2 and SD40-2 diesel locomotives, which were first in the new "dash-2" series. In those locomotives electrical control system comprised largely of plug-in modules. The structure of the system had been rationalized and control components had been gathered to compressed cubicles. In addition, the whole control system had been built of removable modules and when the defect was faced the faulty module was changeable without having to let the whole locomotive stand while repairing. Better protection of the system improved the reliability of the locomotives, the modular structure eased the service and what was most important, raised the usability level of the locomotives. Dash 2 –locomotives proved to be very reliable and they were a success in the market. EMD SD40-2 became the most successful model of General Motors so far. No less than 3945 locomotives were sold in 1972-1986. [13].

The next step in history was the function-based modularity. This type of a structure can be derived for example from the Theory of Technical Systems by Hubka and the systematic approach of Pahl and Beitz. There also exists an abstraction of the designed artefacts, which supports this kind of structure. For example the Domain Theory [14] points out the existence of an Organ-domain between the Function-domain and the Part-domain. This approach supports designing assemblies that are actually function carriers, corresponding to modules.

To realize the variation in product palette by modular means has raised its head in the 80´s. Swedish truck and coach manufacturer Scania presented new models called “second series” in 1980. A step ahead, compared with the previous models was an advanced standardisation of components. That created a precondition for the implementation of the modular solutions in the third series in 1987 [15]. By the fourth series ten years later the modular structure was finished and the benefits gained by that were taken to selling arguments in the marketing. Thus the modular structure was no longer an internal matter of Scania. According to Scania´s own announcement, the number of in product palette decreased from 20 000 pieces to 12 000 pieces, when moving from the third series to the fourth. The number of truck variants offered to customers was kept on at the same level. Scania offered 360 different truck models and in addition, thousands of different versions of those.

In mass-customisation a matter of great importance is to have control over variety. The function-based modularity does not address whether modules are standard modules to whole product family or are they (customer) variant modules. One solution is a platform-based structure, where the product is divided to standard sections and customer variable sections. The variable sections should have function-based modular structure, but the standard section could have assembly-based modular or even an integral structure.

The industrial importance of modularity has grown in the 80´s and in the 90´s, when mass customization has more and more replaced the traditional mass production. The change has reached the traditional project delivery companies, when the demands of being effective have increased due to the globalisation development. The development mentioned has made it more tempting to assemble a customer specific delivery out of ready-made modules. This business paradigm is called configuration. The configuration is defined as delivering customised products by means of mass/serial production, which is achieved by designing a configurable product, whose variants cover the needed variation. In this sense a configurable product can be seen as a product family based on same sets of modules / building blocks.

As earlier defined [16] [17], a configurable product has the following properties.

- Each delivered product individual is adapted to the needs of an individual customer and is made for order.
- Each product individual is specified as a combination of pre-designed components or modules. Thus, there is no need to design new components as a part of the sales-delivery process.
- The product has a pre-designed general structure and has been pre-designed to meet a given range of different customer requirements.
- The sales-delivery process requires only systematic variant design, not adaptive or original design in the sense of Pahl and Beitz [18].

Configurable product is defined in *configuration model*. The configuration model represents the available components or modules, rules of their correct combinations, and rules on how to achieve the desired product properties for a customer.

When more closely examined, we found that configurable product (family) and function-based product platforms could in many cases be identical solutions.

Victor and Boynton introduced the co-configuration on late nineties [19] as a next natural step from mass customisation. The mode of operation sets even more challenges on the product modularity. In the co-configuration the important aspects are:

- The whole lifecycle of the product
- All the stakeholders and their contribution to the co-configuration during the lifecycle
- The viewpoints needed by different stakeholders

As described before there are several viewpoints to the product modularity. When the modules are described from assembly point of view versus functionality point of view the results differ considerably. At the first glance it seems that the representations are not even about the same product. When we consider this and the fact that various other viewpoints are needed for successful co-configuration we are able to conclude some challenges for the product modularity.

In the co-configuration the modularity needs to adapt on the changes e.g. in the technologies used, and it needs to enable product reconfiguration. The product evolution during its lifecycle can lead to situations where the amount of modularity and integration is remarkably altered. We are aware that the lifecycle aspect has been in investment products for a long time already and e.g. the maintenance viewpoint is nothing new. However, if we follow the ideas of Victor and Boynton the product could also adapt itself to new needs along the lifecycle and would learn how the customer wants to use it. In such case it is not enough to upgrade parts of the product and the maintenance with spare parts does not bring any relief on the demand of product intelligence. The design challenge is how to plan the product modularity enabling the co-configuration of the product in such manner it is profitable for the company.

4. Development of product structures

In the previous chapter the industrial history and the demands of modern times of modularisation has been observed. If this is reflected against the theories of modularity presented, we can discover a systematic development in utilizing the modular structures. By increasing the internal structuralism of product, more and more wide benefits are sought. When different steps are arranged according to the timeline, we see that order of appearance is also order of complexness of used structuralism. Thus there is a proper reason to assume that there exists evolution. Idea about evolution of modular product structures was first presented in 2003 [20]. The development of deployment of modular product structures is presented in figure 3.

At the very bottom of the array, there is standardization of building blocks, which forms the actual basis of any type of modularity. The first known type of modularity – the assembly based modularisation – is above it. The modules in this type of modular product are physical assemblies. The modular architecture is often made from viewpoint of production and/or service. This type of modular division is natural to almost all products. It is thus easy to achieve and it is the longest known form of modularity. If it can fulfill the business needs of a company, there is no point of using more complex modular structures.

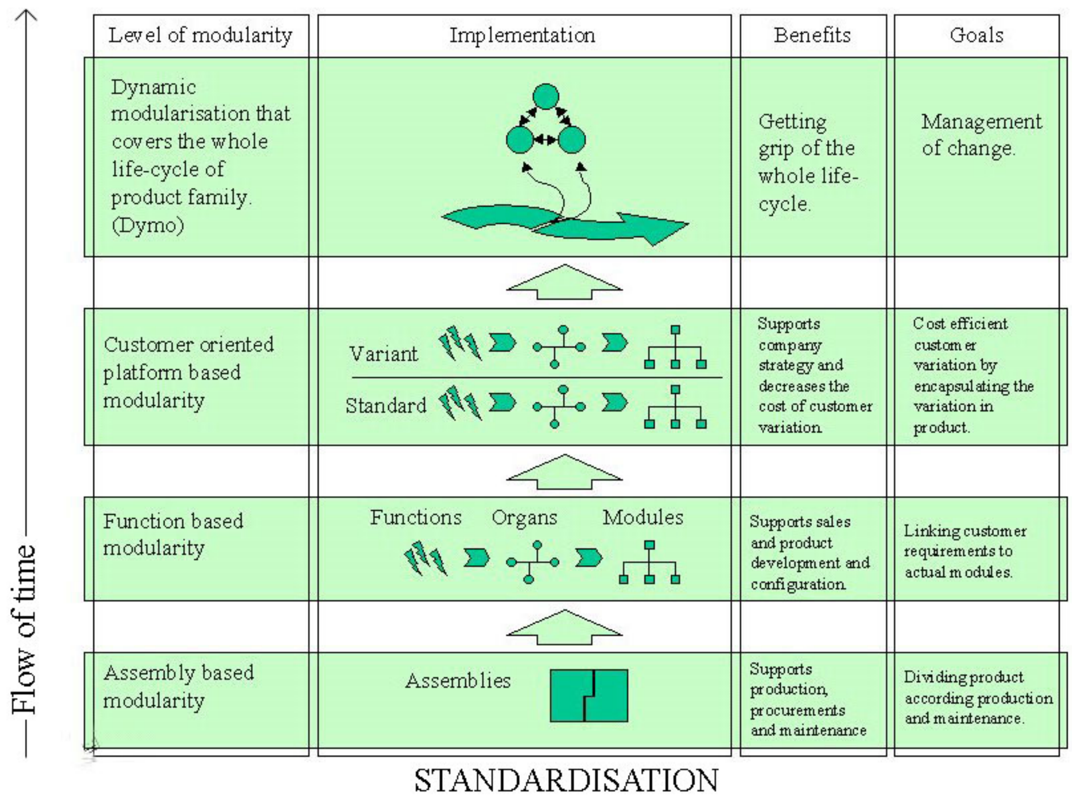

Figure 3. The development of modular product structures

Next step above is the function-based modularity. The design process most used among the Design Society emphasizes using the functions as starting point of the design (e.g. [18], VDI-richtlinie 2221). The function-based modularity includes this approach. However the function-based modularity can be found useful often from starting business aspects. The variant features in mass-customized products are often linked to functionalities. So the functional division in module structure can support very well of selling and designing such products. This type of modular structure also strongly supports the business paradigm "delivering configurable products" [14]. This division also gives support to product family life cycle. The functionalities are more easily changed, when modular structure is made according the functional structure. There should be fewer relations, which are not related to main functionalities. The old prejudice associated to this type of modularisation, is that the product will become extra heavy and under optimized when every function is made as a physical element. However it is not said that modules should be physical assemblies. The problem included in this approach is, that this increases the challenges in production and requires more advanced product data management than assembly-based modularisation.

The next step after the function-based modularity is function-based product platform concept. This differs from pure function-based modularity by dividing the product to variant and non-variant part. In companies this division is strategic and cannot be made only according to technical reasons. Defining the non-variant part defines also greatly the product palette. The relative size of the non-variant part must be remarkable in the product or the term platforms should not be used. If very small non-variant portions would be accepted, all products including bus modular structure (according to Ulrich [21]) would be platforms by nature.

The adjectives of “openness” and “flexibility” are often linked to the idea of product platforms. The “openness” in this sense means that there is a possibility to add modules to the module system after the platform architecture is defined. The “flexibility” means about the same added with some undefined idea of possibility to alter the platform architecture “on the fly”. Unfortunately normally neither of these is reality outside very limited possibilities often inbuilt at the very definition stage of the platform architecture. However there would no doubt be strong demand for modular system, which would be both “open” and flexible. Some ideas of how this could be achieved have been presented. In 1998 professors Riitahuhta and Andreasen defined Dynamic Modularisation [22]. The definition was the following:

”Dynamic modularisation is the novel Modular Engineering process, which allows bringing in a dynamic way new more merited modules to the system and leaving out the old ones. This process is based on the definition of the encapsulation, similarities and the description of interfaces as well as modular management system. All different stakeholders’ views should be taken into account; other dimensions will be very similar to those defined for modularisation.”

The idea of Dynamic Modularisation has been developed since and the first industrial application has been presented in 2003 [20]. The main idea of process presented is division of development work on two levels. At the upper level there is defining *business needs* in various forms such as product categories, feature roadmaps, product roadmaps or product portfolios. According this knowledge a general architecture is defined. The aim is to fulfil the need, which can be seen and which qualify the business criterions. The dynamism demands that during the development process all above mentioned should been validated. The general architecture of product family set interfaces and outlines modules, which can be used. This is highly strategic work. All requirements could not often be covered by one architecture, but decisions must be made of to start different product lines for different market segments.

The ability to fulfil needs is called platform capability. Features, functions of the product, product cost etc. are subset of capabilities. At the start the capability is as planned. When new requirements appear later in product family life cycle, it will be seen whether the platform capability is enough to cope with them.

Most of the conventional design work is made inside the module development project streams. The streams are sequential development projects, which are made according to roadmap. This roadmap includes the planned features and desired moments when modules having these features should be available. Product programs provide the releases of products. A product program integrates needed modules into final product and selects suitable configuration of released modules to meet their customer expectations. In ideal situation there is no actual planning, but only selecting and integrating the modules. The optimisation between the release schedule and the amount of features is often needed.

The business goals are shortening the development time of single products as well as increasing the productivity in product development by making design reuse compulsory in the process. The elimination of actual design work in product projects however makes it essential to keep the platform and roadmaps up to date. Main pressure for changes can be allocated to the module properties and to its behaviour. Key issue is the lifecycle of the module; when is it available and for how long it is used. New technology as a strategic or competitive reason also imposes changes to the module and occasionally to the module structure, too.

5. Key conclusions

From academic point of view there are few new ideas in platforms, especially in engineering point of view. In some known platform-cases there is actually nothing new. Some of them are examples of using the ideas of group technology years before. The new thinking with platforms is to a lesser extent in connection with product itself or production.

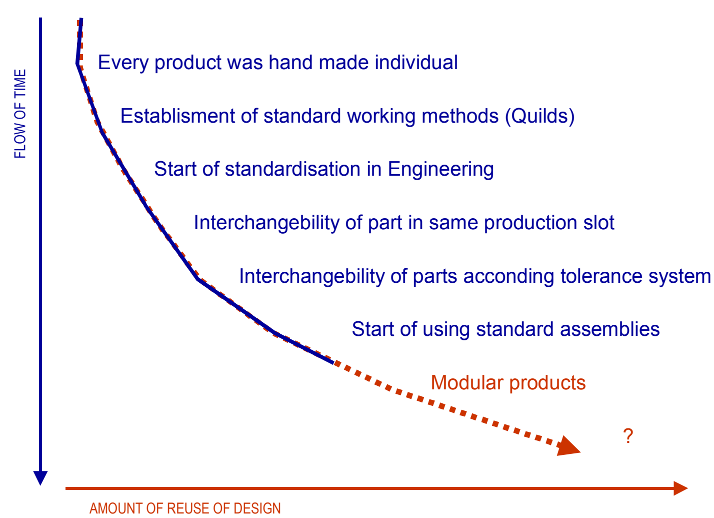

Figure 4: Simplified view on evolution of design re-use in industrial history.

The great importance of platforms is that it is a thinking model through the whole company. It gives a common understanding for all stakeholders inside a company and its network. The area of progress seem to be process related matters (like design re-use) and advances in product and design data management. The introduction of screw thread is not only seen as a step forward in production technology. It is seen as an early case on product structuring as the standardisation of connecting elements. This did not only enhance production engineering, but also enabled re-use of a small item of design as shown in the figure 4. According to this, we can found the previous, evolving development stages of the platform based product paradigm. Having found these stages, we can also make extrapolation and have justified foresight on what might be the Dynamic Modularisation. At the moment there is research work under way to make Dynamic Modularisation to enable co-configuration in the future. Today we take standardisation of screw thread as granted. Will there be similar standards for design processes or product structures in the future?

References:

[1] Cantamessa, Marco, "Investigating Productivity in Engineering Design: a Theoretical and Empirical Perspective", in "The Design Productivity Debate" ed. Alex H. B. Duffy, ISBN 3-540-76195-0, Springer-Verlag, London 1998, pp 13-31.

[2] Otto, Kevin N., Wood,Kristin L.,"Product Design", ISBN 0-13-021271-7, Prentice Hall, New Jersey, 2001, pp. 41-48.

[3] Meyer M., Lehnerd A., 1997. The Power of Product Platforms – Building Value and Cost Leadership. The Free Press, New York.

[4] Muffato, M., Roveda M., 2000. Developing product platforms: analysis of the development process. Technovation 20 (2000). pp. 617-630.

[5] Robertson, D., Ulrich, K., 1998. Platform Product Development. Sloan Management Review, summer 1998.

[6] Kristjansson A. H., Jensen T., Hildre H. P., "The term platform in the context of a product developing company", Proceedings of International Design Conference – Design 2004, Dubrovnik, 2004.

[7] Ulrich K., Eppinger S. "Product Design and development", McGraw Hill, ISBN: 0070658110, 1995.

[8] Juuti T., Lehtonen T. "Facilitating Change towards Platforms with Simulation Game", Proceedings of NordDesign 2002, NTNU, Trondheim, 2002.

[9] Aasland K., Reitan J., Blankenburg D., "Even Modular Products can be Inmanageable" in Riitahuhta A., Pulkinen A, (eds.) "Design for Configuration – a Debate based on the 5th WDK Workshop on Product Structuring", ISBN 3-540-67739-9, Springer, 2001, pp. 41-48.

[10] Wagner R. L., "Fabulous fins of the fifties", ISBN 1-56799-480-6, Michael Friedman Poblishing Group, New York, 1997.

[11] Arn, Ernst, "A. Group Technology – An Integrated Planning and Implementation Concept for Small and Medium Batch Production.", Springer-Verlag. Berlin.Heidelberg.New York. 1975.

[12] Borowsky, K-H., "Das Baukastensystem in der Technik", Springer-Verlag. Berlin, Göttingen, Heidelberg. 1961.

[13] Salomon B., "The American Diesel Locomotive", ISBN 0-7603-0666-4, NBI Publishing Company, Osceola WI, 2000.

[14] Andreasen, Mogens Myrup, Hansen, Claus Thorp, Mortensen, Niels Henrik, "On the identification of Product Structure Laws", Proceedings of 3rd WDK workshop on Product Structuring, Delft University of Technology, 1997, pp.1-13.

[15] Lindh B-E. "Scania and its vehicles, 1891-1991", ISBN 91-7886-075-X, Streiffert&Co, Stockholm, 1992.

[16] Tiihonen, J., Soininen, T., Männistö, T. and Sulonen, R. Configurable products - Lessons learned from the Finnish industry. In Proceedings of 2nd International Conference on Engineering Design and Automation (ED&A '98), Integrated Technology Systems, Inc., 1998.

[17] Pulkkinen, A., Lehtonen, T., Riitahuhta, A., "Design for Configuration – Methodology for Product Family development", proceedings of ICED99, Munich, 1999

[18] Pahl, G., Beitz, W., "Engineering Design: A Systematic Approach", Springer Verlag, 1996.

[19] Victor B., Boynton A. C., "Invented here", ISBN 0-87584-798-6, Harvard Business School Press, Boston, 1998.

[20] Lehtonen T., Juuti T., Pulkkinen A., Riitahuhta A., "Dynamic Modularisation – a challenge for design process and product architecture", Proceedings of ICED03, Stockholm, 2003.

[21] Ulrich, K., Tung, K., "Fundamentals of product modularity", DE-Vol. 39, Issues in Design/manufacture Integration, ASME, New York, 1991.

[22] Riitahuhta, Asko, Andreasen, Mogens Myrup, "Configuration by Modularisation", Proceedings of NordDesign 98, KTH, Stockholm, 1998, pp 167-176.

Timo Lehtonen
Tampere University of Technology
Product and production laboratory
P.O. BOX 589
33101 Tampere, Finland
phone +358 3 3115 2627, E-mail: timo.lehtonen@tut.fi