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

DESIGNING PRODUCT FAMILIES: EXPERIENCES OF FOUR NORWEGIAN MANUFACTURING COMPANIES

Tormod Jensen, and Cristian Nilsson

Keywords: Product families, Product platform, Platform description, Design for variety

1 Introduction

Highly competitive global markets force companies to change their way of doing business. A major trend when designing product families is an increased interest in using product platforms. The large automotive companies where early in adopting platform and modular strategies to improve the economies of scale, but now also smaller companies and suppliers with less complex products find interest in this way of designing products. A constant focus on cost reduction and increased global competition leads the way to designing the products in a smarter way. The purpose of using product platforms is to increase variety for the customers and simultaneously improve the internal re-use from components to peoples know-how.

Definitions of product families and product platforms have been presented in the literature of the last few decades. Sanderson and Uzumeri [1] define a "*product family as a set of models that a given manufacturer makes and consider to be related"*. This is a very broad definition, but by adding the need to have a high degree of reuse in creating the product variants, Maier and Fadel [2] define a product family as *"... a group of products that shares some common technology"*. This family may be designed with modularity and product platform approach. Modularity is defined by Ulrich and Eppinger [3] "*as chunks (subassemblies) that implement one or a few functional elements. The interactions between the chunks are well defined and are general fundamental to the primary function of the product"*. A well designed modular structure can allow changes to one chunk without affecting the rest of the design. Product platform is by Meyer and Dalal [4] defined as "*a common subsystem or subsystem interfaces that is leveraged across a series of individual products by means of shared product architecture"*.

The definition of product platform that is used in this article has been proposed by Robertson D. [5], "*the collection of assets that are shared by a set of products*." These assets can be divided into four categories:

- Components - part design of the product, tools and fixtures
- Processes - the equipment used to make or assemble components into products, the design associated production process and supply chain
- Knowledge – design know-how, technology, applications and limitation, mathematical models and testing method
- People and relationships – teams, relationships between team members, relationships between the organization, customers, suppliers and the design team

A more comprehensive discussion about platform definitions is presented by Kristjansson et.al. [6]

Much has happened since the mid- nineties regarding product design strategies. Establishing the correct product architecture for the product family is a difficult task, and different approaches have been presented to create the architecture using modularity [7], [8] and platform [9], [10]. Several authors have looked at how the industry implement and use these design concepts, among them Tatikonda [12] and Muffatto [13]. They have examined the planning and execution of different types of projects within a product family platform series, from a strategic viewpoint. Juuti [14] takes a broader view; including the whole value chain and look at how capable and mature the organization is to utilize the concept of platform. Other authors like Halman [15] have looked at how the development organization implements platform thinking and the risk they encounter in the process. Most of this work is related to industries that mainly consider the platform to be an aspect of the product architecture, and ignore many of the other possible aspects of platform strategies referred to in literature. The product architectures referred to are also often of the type aimed at the end customer and were the companies decide most of the product requirements themselves.

The objective of this article is to explore how consumer-sale companies and OEM-suppliers (original equipment manufacturer) use the concept of platform in their product portfolio. The focus is on how the companies use and structure their know-how in order to establish a productive product portfolio. The following two research questions are explored; how can the concept of platform be applied in different industries and products? This is an attempt to investigate if there are different ways of utilising the concept of platform, depending on the type of industry, if they are a consumer-sale- or OEM-supplier company and if the complexity of their products varies. The second research question; how is the platform knowledge communicated in the companies? This question tries to sort out how the communication and understanding of the platform is done internally in the companies, among designers, and between designers and manufacturing, managers, suppliers and so on.

2 The study

The study is based on a series of interviews. Four companies are analysed: two OEM-suppliers, Hydro Automotive Structures and Kongsberg Automotive, and two Consumer-sale companies, Ekornes and Stokke, which produce relaxing furnishes. All of these companies are located in Norway, a country with high labour salaries and relatively long distances to the global customers. The customers are mainly in the European Union, but also in the USA and Asia. They all have a long logistic chain in order to reach the market.

2.1 The methodology

The research methodology was chosen to include both consumer-sale companies and OEM-supplier organisations, in order to highlight possible differences in the use of platforms and in the role of platform design.

2.2 Data gathering

The study is based upon 9 interviews, in Hydro Automotive Structures, a business unit within Hydro, Kongsberg Automotive, Ekornes and Stokke. The interviewed persons where partly selected by our contact person with the company or by direct contact by us. The interviewed persons were primarily managers and senior engineers all working with product development or in R & D departments. Most of the interviews were performed individually and in their working environment. All the persons were males and were either with a doctor's degree in engineering, graduated engineers or engineers that had worked their way up from apprenticeships. All of them have been working in the company for many years. Each

interview lasted from 1.5 to 3 hours. The interviews were focused around one of each company's products, in order to be able to dive deeper into the development process and the companies' overall way of doing things.

2.3 Data analysis

All the interviews were transcribed in order to perform a detail analyse. The questions and responses were classified and grouped by topics, based on Robertson's [5] lists of core assets (components, process, knowledge and people & relationships).

3 The studied companies

All the studied companies have long tradition in making their products and all have long time market experience. For the moment all of them are doing well and seem to have good profitability.

3.1 OEM-suppliers to the automotive industry

Hydro is a large oil and aluminium company, with activities in all parts of the world. Within the aluminium business they are a manufacturer of aluminium as a material, semi finished products (sheets and extruded profiles) and final products. The business unit in the study is Hydro Aluminium Structure (HAST), which manufactures automotive crash management structures such as bumpers, sub-frames, and whole space frames. The production volume varies from low to high production, were bumper structures are in the upper end. It is the bumper structure design and production that will be discussed further in the article and this is HAST's main product, fig 1. A bumper system is placed in the front and rear of the car, and consists of a cross beam and crash boxes at each connection points to the chassis. The system is designed to absorb the energy from a 16km/h offset crash, without damaging other parts of the car structure. The products consist of few, but highly formed parts. The main technology in these products is in the material properties, the forming ability, the lightweight design and the integration of these into products with high energy absorbing capabilities. HAST delivers these types of structures to a majority of the European car makers. These structures can be found in all from low-cost- to premium-brand cars. Each product is customised for the customer, leading to a large number of product variants, approximately 70 new variants pr. year. The customisation of the products is a must to be able to be in business, and is not seen as a problem. All products have in common that they must fulfil the same government and insurance tests.

Figure 1: Bumper system and position in the car

Kongsberg Automotive (KA) is also a global first-tier supplier, which manufactures gear shift systems, seat comfort systems and commercial vehicle systems for the majority of the car and truck producers in the world. Commercial vehicles systems include, among other products, the clutch operation system, fig 2. The clutch servo reduces the pedal force needed to activate the clutch, making it more comfortable for the driver to change gears. It is the servo unit that will be presented further in the article. The servo uses pressure air to boost the

hydraulic pressure from the clutch pedal. KA manufactures this product in many variants, fitting all from small to large trucks and busses.

Figure 2: The clutch operating system and the clutch servo

3.2 Consumer-sale companies

Ekornes ASA is the largest furniture manufacturer in the Nordic countries and owns, several brands among them Stressless®. Stressless is one of the world's most famous furniture brands. Ekornes is located in an outskirts part of Norway, with fjords and high mountains, putting an extra demand on transports. Their main product the Stressless, fig. 3, is a collection of chairs and sofas with multiple functions as tilting back rest and adjustable head rest. The Stressless products are produced with a relatively high variety for the customer, while keeping a strict control over how these variants are created. The production volume of the Stressless is around 1100 chairs per day and 100-200 sitting units of sofas per day. The development and management of Stressless furniture will be discussed further and this is also their main product. The company designed their first reclining chairs in 1971. It was delivered in few variants and the production volume was high. The sales and profits were good, but as time passed a more modern look was needed. The chair went through some changes, without adding too many variants, until the mid 80-ies. Releasing new and exciting products to the market was seen as a way to improve the sales. Highly skilled industrial designers created many new products. Unfortunately most products were created with individual industrialising terms, resulting in an inefficient production. Six different manufacturing processes were handled which dispersed the product portfolio. Time spent at production on ramping up for new models and changes between them, was becoming a problem. The volume manufactured on each component fell and the cost of producing a chair rose. Ekornes was technically bankrupt in 1990, and some major changes were needed to save the company

Figure 3: Stressless® chair and sofas, all seats have tilting back rest.

Stokke is also in the furniture business, located close to Ekornes. They are smaller than Ekornes and focus their products towards a different customer group. They have two product assortments, one for children (chairs and beds) and one for adults called the Movement collection. The Movement collection focuses on allowing the user to always to find a new sitting position. The form and colour of these chairs appeal to a narrower customer group willing to have something special, while not compromising on correct sitting. Stokke launched Europe's first adjustable recliner and have continued to develop functional and modern chairs, fig. 4.

Figure 4: A reclining chair, model peel™

To get an overview of the key values for the four companies, table 1 present the operating revenues, net profit and number of employees.

Table 1. Key values for the companies in 2004, * = HAST is a sub units within these numbers, ** = 2002, based upon 1€=8,47NOK

	Hydro, extrusion and automotive*	Kongsberg Automotive	Ekornes	Stokke
Operating revenues (€, million)	3258	261	267	84**
Net profit (€, million)	32.7	31	40.5	-
Number of employees	-	2265	1546	460**

4 Platform interpretation

The purpose of product platforms is to create variety for the customers while keeping a minimum of in-house variety. Increasing the reuse in as many assets as possible is important to improve the company's ability to perform well on the global market. Regarding product platform design, Robertson [5] defines assets in platform design to be more than standardisation of components, as mentioned before. He includes components, processes, knowledge and people & relationships. The analysed companies do the reuse within these four assets in very different ways.

Their own perception about how they design and manage their product portfolio is partly the same as found in literature, although the term "platform" is not widely used. Ekornes focuses on standardisation and establishing industrialised conditions for the products. Stokke have

their attention on creating attractive and functional products that fit within their supply chain. Stokke has a well-functioning network of suppliers of competence and components. KA uses the concept of platform, as KA has positive experiences from designing the servo product around a platform. The term "platform" was however not used until recently, when a new family of products was designed. This product family was designed with a variation strategy from the beginning. HAST has a strong focus on optimal use of the production lines. Products as the bumper beam are therefore designed to fill the production lines. HAST also has a new product family, crash box, which is included in the bumper system. For this product, HAST is in the process of designing a product platform architecture.

4.1 Components assets

Ekornes is a company that has first hand experience with both loose and strict control over the product variants. In 1992 they restructured their product portfolio and a standardisation process was started. In 1993 this process had removed 75 % of the components, meaning higher volumes for each component. The focus went then from removing components to optimising them for manufacturing and focusing the variants to different customer groups. The product platform was based upon components standardisation and postponed differentiation in how the variants were created. A central technical aspect of the platform is how the design of the undercarriages, steel frames and foaming of the seat is tuned to fit the automated production line. The chairs are created in three different sizes, were the width is the variable parameter. This parameter can easily be varied without having too many adjustments to the production line, since all the interfaces between the components are kept constant. The main differentiation of the product portfolio happens when the final foam and leather/textile is assembled, but even here Ekornes is strict about standardisation, as the development manager says:

A new colour is a variant and we must also at this point think standardisation. The standardisation must not slip at the last segment. If we can remove more variants than we replace, that is desirable.

Ekornes is in a position to have full control over their product portfolio. They can decide when a new product is to be released or taken out of the market. The customers are not interested in an excessively fast turnover of new variants, so only a limited number of variants are changed each year. This, combined with the high level of component standardisation has reduced the production cost so much that the high employee salary in Norway has little influence on the final product cost. Ekornes has also arranged so that most of the manufacturing is in-house. Because of the high volume of products Ekornes produce, it can arrange an efficient logistic chain to the customers.

Stokke has a different strategy for running their business. Stokke does not have a product portfolio based on reuse of high volume production. The products are produced in low volumes and target a niche in the furniture market. They have strong focus on creating chairs that allow multiple sitting positions. By having special competence around the critical parts that allow the movement, Stokke can use external consultants in the design process, which give the chairs a very unique form and identity. The use of external consultants helps Stokke to push the chair design front. One very vital part of their way of doing business is a lean supply chain and manufacturing on-demand. Transport is done by road, and although delivery can take several weeks, the supply chain is considered sufficiently fast by the customers.

Kongsberg Automotive is also a company that has a long tradition of making their products, like the clutch servo. The design of the servo first appeared in the 70-ties and has evolved since then. The product is built around a scalable platform, with approximately 200 variants, partly illustrated in fig. 5. The high number of variants is needed to satisfy the different customers and their truck models. The customization is mostly related to the response the truck driver wants to feel, the servo force needed on the clutch and the servos interconnection points (fluid-, pressurized air connections and mounting connections) to the gear box. The product is built around a large cast component, fig. 2, which is customized with minor changes to meet the customer requirements. This is also the most costly component in the product, since it requires an expensive die-cast tool. Adapting the most complex component each time might seem unwise to an outsider, but the main technology in the product is actually related to some interfaces within the product. Although these interfaces connect relatively inexpensive components, they have very strong links to the overall functionality and quality of the product. The products have long lifetime, approximately 7-8 years before a mid life update and another 6-7 years after that. In addition KA must often supply spare parts for up to 10-20 more years.

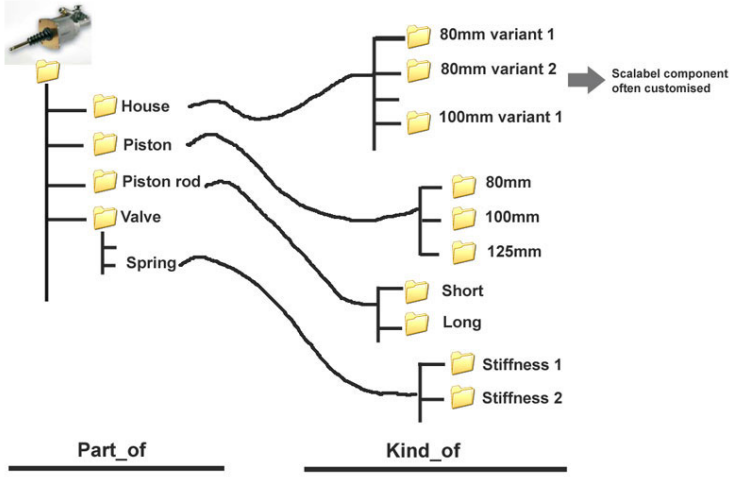

Figure 5: Part of the product architecture to the servo, illustrated with the Product Family Master Plan [17]

Hydro Aluminium Structures has a different approach to the use of their product platform than the other companies have. Their products have a very high degree of customization, more than all the other companies in this study. The customisation is also of the character that it is not easy to accommodate in the final assembly step. So the customization is performed early in the design process, with close contact with the customer. As the customers develop each new car, for example over a 4 years period, there is a lot of parallel design of components and therefore the customers often change the functional and packaging requirements several times after the design work has started. As early as 1969 Hydro started to manufacture the bumper beam and have now managed to gain large market shares for their product. The HAST product platform could be characterized as being several technological concepts that are adapted to the customer, but can be manufactured with minimal investment in tooling for the production line. HAST's portfolio of bumper systems is very large, both regarding the total number of product variants and their production volume. The variants vary with regard to, for example, if the product is aimed at a European or a North American car, the required energy absorption capabilities and the chosen manufacturing processes. The production volume ranges from 1000 to 800 000 units for each product variant. This type of

portfolio makes it possible to design the products to suit one of the production lines, and secure that the all lines are filled with appropriate products.

The other part of the bumper system, the pair of crash boxes, is a component that appeared in the mid 90-ties, as the focus on crash behaviour increased. HAST started the product development, from scratch. The first generation of crash boxes had good performance, but the industrialising processes chosen have proven to be too expensive. The next generation of crash boxes will have a better match between the product architecture, flexibility of design, industrial premises and cost. The portfolio is redesigned to accommodate more of the platform capabilities they have achieved in bumper design.

4.2 Process assets

Ekornes has a component-standardized product architecture that is very suitable for the production process. Production is designed around a postponed differentiation of variants and is highly automated. A new factory has been built to optimize the material flow and establish the best premises for automated production. For example, most of the work on wood and metal structures is done with robots, making an earlier expensive structure much cheaper. They also focus on having as much of the activities related to the product under their control and close to the main factory. Thus, the logistics internally in the company are reduced and the external supply chain is simplified. The supply chain uses both ship and road transport to and from the factory.

Stokke is at the opposite end than Ekornes, with the production based much on manual production. Stokke uses many specialized suppliers that do similar work for other furniture companies. The suppliers can thus have continuity in their work.

KA focuses on manufacturing the main part of the servo in–house (cast house and piston) and outsource the other components. The cast servo house has several surfaces used at manufacturing and for test set-up. These are kept constant through the product variants, making the manufacturing sequence and testing less sensitive to new variants. As the largest servo was designed, additional fixture surfaces for the manufacturing were established. This can be seen as a generation update of the platform, since the production technology also has improved over time. Several of the cast house versions have also from the beginning been designed with multiple connection possibilities for hydraulic fluid and pressure air and they are machined open according too the variant produced. KA aims at reducing the stock of semi finished products as well as cast dies to a minimum.

At **HAST** the manufacturing process is a vital part of the product platform. It starts with the material used. Since Hydro also is a primary manufacturer of aluminium, a melting factory for a special alloy is located close to the production site of both the semi-finished products and the final formed components. The bumper beam component is made of stretch formed extruded aluminium. This is an advanced method of forming semi-finished products into the final product shape. Through many years, HAST has managed to standardise several elements in the design and production of these components and related tools. Several lines have been designed, each with a different number of forming steps. The designers can chose a production sequence in the design phase, which matches the required production volume. HAST invests heavily in production equipment and can handle high volumes, provided the lines are up running most of the time. For the crash box, a good match between the design architecture and the manufacturing process (like for the bumper beam) has for the moment not been established. Another challenge that HAST has concerns the assembly of the system,

which often is done close to the car manufacturers plant. The components must thus be designed and manufactured in a way that makes it possible to assemble them after a transport and still be within the required tolerances and product performance boundaries.

4.3 Knowledge and product information

The market division at Ekornes plays an important roll in maintaining the product portfolio. The product development manager can get full access to sale statistics to each product variant, statistics about each of the 2500 Stressless shops world wide, and information on the type of marketing campaigns that have been done at each shop. Product variants with falling turnover are investigated. Action is taken with additional marketing to extend the product life or replaced with a more modern variant. New variants are specifically designed to target the same customer group as their predecessors, without affecting the sales of the other variants. The product development manager expresses the market orientation of the product design as

"We have a product development division that has an industrial anchoring, but also has a connection to the market that makes us able to create modern and timely products that can be industrialized on a rational way."

When it comes to stored product information, electronically or on paper, there is a large difference between the furniture- and the automotive industry. In the furniture industry the products are not so technically complex, so most of the documentation is sale related. They rely very much on previous experience people posses and perform only some simpler tests to verify the product. Ekornes has in the group objective and values written down a product strategy emphasize designing with product platform. The technical product information to both Ekornes and Stokke comes from CAD systems and outside that little information related to product platform is stored. A product developer at Stokke said

"To find an appropriate level of documentation, we have to weight the time spent on documenting against the risk of having too little documentation."

In the automotive industry the product knowledge goes much more in depth than in the furnish industry, meaning there is a bigger need for technical documentation. Furthermore, the automotive customers have requirements in how products should be documented and quality guaranteed.

At **KA** the product platform of the servo is based upon an old concept. Through the years they have gained knowledge from their own tests and customer's feedback, refining the technology within the product. A lot of development and tests, both simplified tests and on years-long road tests make the foundation for the technology. Even minor changes to the design, can trigger the need for new testing. Testing is time consuming and very expensive, so keeping it at a minimum is much more important for the platform cost than strictly focusing on components reuse. The database with test results has become very large and to extract the correct information for reuse in new projects is sometimes found to be difficult. For the earlier product versions the test information may not be stored with sufficient product data to be fully reused as documentation for new variants, since testing has become more demanding over the years. The customer usually requires that the product goes through a long run test that last years before it enters the market. Changes during this period are usually not allowed. KA has also tried several methods to secure that the platform is used as best as possible, in addition to the existing quality systems. One method tried during the 90-ies was to write down why changes were made, on detailed level. This should then simplify the design work next time,

but it became quite time consuming and it was found difficult to retrieve the wanted information from the database later on due to difficulties in organizing the information in a good seek able manner. Nowadays the most important information from the development projects are stored in a "Book of experience", which is a few pages with relevant information which the project leader for a new project shall read prior to starting up similar projects. To stay in the upper front of servo design, KA's products are constantly benchmarked against competitors'.

HAST products are designed to have excellent performance in both low and high speed crash, yet having a very low price. The complexity in design is to control every aspect of the aluminium's temperature- and forming history far down into the micro scale, through the whole process. Simulation is therefore done among in the manufacturing forming steps, assembly (welding) and on the product level, so that the final crash behaviour and the product cost are optimal. The high number of projects per year makes it important to routinize parts of the design process. For example, for the design of a new bumper beam variant, several starting models (CAD models), from previous projects are used in the early design phases. They give valuable information about crash performance, mass of material used, manufacturing steps needed and cost. Several systems assist the communication between departments and disciplines. One of them is a detailed description of all the production lines aimed at having designers as users. These descriptions go in depth around the manufacturing possibilities and limits. This system is maintained by the manufacturing process departments. To further improve the reuse of experience and knowledge, a "design portal" is under development. This is a place for the designers to get ideas and use previous experiences to avoid pitfalls, etc. Behind this portal there is large amount of data from many projects down to a very detailed level, for example related to simulations, physical tests, and production experiences and so on. This design portal is seen as a tool to secure correct reuse of product and process experience. HAST's primary reason for a detailed documentation is that they are a large product development organization, spread around in different countries and wants to avoid doing the same mistakes several times.

For the crash box component the experience is far lesser. A concept that can function as a design platform has not been established and the structuring of design knowledge is only just began. Even if these two components (beam and crash box) use much of the same basic technologies, they are implemented differently and this causes challenges. The crash box interaction with the manufacturing is very different, due to how the assembly is done and the design of the very complex stamping tools.

4.4 People and relationships

Ekornes and the Stressless product is a good example, in how to see that industrializing the product is one of the key areas in product platform design. For a period the industrial designers had a lot of influence and they did not understand the mechanisms that provide efficient production. But after that the organization structure was changed to match the product platform developed. The product development organization was organized as a factory within the factory, with all phases of the production represented. Skilled persons from the production were transferred to the development organization. The use of external consultants was abandoned and the internal designers focused on matching the design to the production line and securing that all the people within the product development factory knew the company's industrial premises. As the platform was introduced there was a change in the decision structure. All new product variants must be accepted by the product development

manager as the first step. Then a product council decides which variants to display on a furniture exhibition and with the response from customer a new collection is chosen. The council consists of people from the marketing, production, product development and executive directors. There are no other people from the financial departments other than the executive director of the company in the product council. This composition of the organization and council is done to secure that new product variants fits within their industrialized processes and secure the future.

At **Stokke** the product development group is small (9 people) so the internal communication of knowledge and experience float easily. Since they use consultants to design the form of the chairs, they have established a very efficient contact network of people who are expert in different engineering and manufacturing fields. People from the product development team train also the sales people so they get in-depth knowledge about the products.

KA has from their early day's had a fluent contact with their customers. As the product is tested and verified by the customer, a change is only done if highly needed. It would increase risk which can only be reduced by new testing. This is mutually understood by both parties. The platform technology and associated processes is developed primarily in cooperation between R&D and the model factory ("Center of Excellence") in Hvittingfoss. Then this technology and associated processes are emulated in the KA factories outside Norway.

In **HAST** the product platform is strongly linked to the management of the knowledge and experience people possess. HAST is an organization that has a lot of engineers and special competence on material (aluminum) property and manufacturing processes. Each new project is always manned with people from different disciplines. If projects run into design difficulties, people from other design teams are brought into the project to help, but in spite of this sometimes the designers miss a better flow of information across the design teams. To find new projects, the market department traces the market and contacts the potential customers who they know well. HAST is usually involved in new projects in their early stages. A car is developed through several years (cars around 4 years) and through this time the car design is very dynamic. The packaging and functional requirements change constantly as the development of the car progresses. Hydro must be able to customize their product platform to the initial requirements and to the changes that appear. They must be able to quickly change the design without altering the industrial premises. This process demands a close contact between people but also intensive exchange of product data. The customers to HAST usually conduct their own tests, both virtually and in physical models. HAST links their product models directly into the customers' systems.

Table 2 summarises the findings of how the concepts of platform can be applied to the studied companies.

Table 2. Summarise of the main characteristic of the companies platforms

	Ekornes	Stokke	HAST	KA
Components	High standardisation High tool re-use	Low standardisation	Low components and tool re-use	Medium re-use of components and tools
Process	Routines design process Vertical supply chain integration (in house) Factory adapted to platform	More flexible and informal design process High focus on supply chain	High re-use of design concepts / technology High re-use of manufacturing principles and infrastructure	High re-use of design concept / technology High re-use of manufacturing
Knowledge & information	"Culture" for industrialisation	Informal channels of knowledge communication Innovation intensive	Highly specialised know-how around material and product performance Much design data is stored	High re-use of product history experience
People & relationships	Strong link between product development and retailers	Strong network of suppliers	Dynamic and intensive communication with customers	Strong internal relationships also between global units

5 Discussion

All the companies in this study use the concept of product platform differently. Ekornes has adapted the principles of product platform for the whole company and use it to achieve a very high commonality internally and variations for the customers. The way Ekornes use product platform and organize their product portfolio is closely related to differentiating the product portfolio and remove components from the portfolio as found in articles from Meyer [11] and Mortensen [17]. They have the opportunities to utilize product optimization in depth, due to the full control over the product portfolio, when to release or remove products from the market. In addition the technology in their products is far less complex than found in the studied automotive companies. Stokke has a smaller product portfolio and manufacture their products in small volumes. They focus on designing and reuse key elements in the chairs, supply chain and then use externally industrial designers to create the form of the chair. They use a strategy that failed for Ekornes, but a success for them. Due to targeting product to a customer niche and how the product variants are developed.

The automotive industries are in a different position than the consumer-sale companies. Their control over the products, release of new variants is strongly related to the release of new car and truck models. The product platform is therefore used as a way to reduce the complexity, by increase reuse in the design process and reuse of production principles and equipment. Looking at relevant literature for utilising the product platform this way, Meyer [4] and Jiao & Tseng [18] discuss the use of platforms in industries that manufacture nonassembled products, as film and semiconductors. Their focus is mostly on establishing product and process efficient indexes. The author [19] discuss the designs variability and the belonging

manufacturing flexibility for process intensive products, but still the amount of product platform research done for this type of industries is far less than for consumer-sale related companies. In fig. 6 modified version of Riitahutha [16] figure. The architecture is connect to three elements, increase variety, increase commonality and reduce complexity. In this study the consumer-sale companies seems to be most positioned between increase variety and increase commonality The OEM-suppliers more complex products (technology) work more on reducing design complexity and being able to do quick redesigns. There are always some requirements that will change with time and evaluated the product architecture solution space for such change, seams to be very important for the OEM-suppliers. The future is not easy to predict, but some requirements related to vital performance seems to follow certain trends. Doing reflections around the future is important. The invested capital in design, knowledge and production equipment is large and a long lifespan for the platform is preferred.

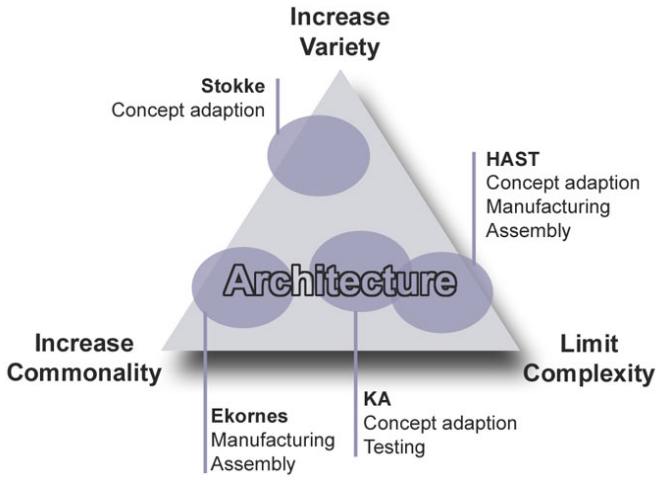

Figure 6: Dimensions in product platform development and the main focus areas for the companies in this study [16]

When it comes to communicate the platforms commonalities and distinctiveness, Ekornes has a strong culture driving for standardisation in all part of the organisation. The product complexity and turn over speed of new variants at Ekornes is thus limited, so the need for a large information flow is not as great. The product development management has good ability to control when new variants are released and old removed. All the other analysed companies the drive for standardisation is not as strong as Ekornes, but both at KA and HAST it are increasing. HAST who have so many projects each year, can not channel all information through a few key persons. They need to spread the knowledge and ability to decide on reuse issues to several persons. HAST and KA are both manufacturing on demand and having a system that supplies the designers with red (bad), yellow and green information from the existing variants, could be a way to improve knowledge reuse. Both have lot of detail information about each variant and on each component, but have improvement potential regarding the information flow.

6 Conclusion

This study has investigated how two different industries organizing their product portfolio to easy generate product variants based on platform. The term platform was found not to be so widely used, but more the concept of re-use of assets. One customer-sale company used the platform in a more concrete manner, with high focus on standardization. The automotive companies focused more to find reuse within other assets as knowledge, due to their high technological products. None of the studied companies had a complete description of their platform, but information was communicated on demand. The informants acknowledge the important and the challenge of manage product platform information, so that it easily can be stored and retrieved.

References

[1] Sanderson, Susan W. and Uzumeri, Mustafa, "Managing product families", Irwin, USA, 1997, ISBN 0-256-22897-3

[2] Maier J.R.A and Fadel, Georges M., "Strategic decisions in the early stages of product family design". ASME 2001 Design Engineering Technical Conference and Computers and Information in Engineering Conference. Pittsburg, PA, Sept. 2001, 9-12

[3] Ulrich K.T., Eppinger S.D. "Product Design and Development", McGraw-Hill, Inc 1995

[4] Meyer M.H., Dalal D. "Managing platform architectures and manufacturing processes for nonassembled products". The Journal of Product Innovation Management 19, 2002, 277-293

[5] Robertson, David and Ulrich, Karl 1998 "Planning for product platform", Sloan Management Review; Summer 1998; 39, 4, 19-31

[6] Kristjansson A., Jensen T., Hildre H.P. "The term platform in the context of a product development company" Proceedings of the 8th internationale design conference (Design 2004), Dubrovnik, 2004

[7] Dahmus, Jeffrey B., Gonzalez-Zugasti, Javier P. and Otto, Kevin N., "Modular product architecture" Design studies, 22, 2001, 409-424

[8] Ericsson, Anna and Erixon, Gunnar, "Controlling design variants: modular product platforms" Society of manufacturing engineers, Michigan, 1999, ISBN 0-87263-514-7

[9] Simpson, Timothy W., Maier, Jonathan R.A and Mistree, Farrokh, "product platform design: method and application" Research in engineering design, 13, 2001, 2-22

[10] Martin M.V., Ishii, K. "Design for variety: developing standardized and modularised product platform architectures". Research in Engineering Design, 13. 2002, 213-235

[11] Meyer, Marc H. "Revitalize your product lines through continuous platform renewal", Research Technology Management, v40, n.2, Mar-Apr, 1997, p 17-28

[12] Tatikonda, Mohan V. "An empirical study of platform and derivative product development projects" Journal of product innovation management, 16, 1999, 3-26

[13] Muffatto, Moreno and Roveda Marco, "Developing product platforms: analysis of the development process", Technovation, 20, 2000, 617-630

[14] Juuti, Tero, Lehtonene, Timo, Pulkkinen, Antti and Riitahuhta, Asko, "Requirements for efficient platform utilisation with configurable products" 7th workshop on product structuring – product platform development, Chalmers university of technology, Gothenburg, March 24-25, 2004

[15] Halman, Johannes I.M., Hofer, Adrian, P. and van Vuren, Wim, "Platform-driven development of product families: linking theory with practice" Journal of product innovation management, 20, 2003, 149-162

[16] Riitahuhta A., Andreasen M.M "Configuration by modularisation" proceedings of NordDesign 98, KTH, Stockholm, 1998

[17] Mortensen N.H., Skovgaard H.J., Skovsen F., Vølund L. " Improving business by conceptual modeling", Booklet from DTU, Department of Mechanical engineering, 2001.

[18] Jiao J., Tseng M.M. "Customizability analysis in design for mass customization" Computer-Aided Design 36, 2004, p 745-757

[19] Jensen T., Hildre H.P. "Product platform performance in meeting with the manufacturing" Proceedings of the 8th international design conference (Design 2004), Dubrovnik, 2004

Tormod Jensen
Norwegian University of Science and Technology
Department of Engineering Design and Materials
Richard Birkelandsvei 2B
No-7033 Trondheim
Norway
Phone: +47 73590933
Fax: +47 73594129
E-mail: Tormod.jensen@ntnu.no