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The Corporate Platform – a model to create a product program

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Abstract
Product platform and modular design methods have been used to efficiently create product variants. Modular methods have primarily been use to ease product variant configuration. Platform methods have been successfully used reusing assets among a predefined family of products. Design methods for non-configurable products that can not be defined in a predefined family have not been focused. This article presents a model framework of how companies can manage and structure their core assets needed to efficiently customize new successive non-configurable variants. Because variants are customized in a successive manner the company is continuously adding new competence that will be used designing new variants. This modelling frame is called Corporate Platform. The model includes alignment of four main aspects; Market, Product Platform, Manufacturing and Product Development into the specific product variants. By having a broader view and structured approach to product and product platform development increased reuse can be achieved.

Keywords: Product platform, Product variation, Design for manufacturing

1 Introduction
Highly competitive global markets force companies to change their way of doing business. A major trend designing product families is an increased interest in using product platforms. The major automotive companies have already adopted platform and modular strategies, in order to improve the efficiency. Now, also sub-suppliers and smaller companies with less complex products find interest in this strategy of designing products. The purpose of using product platforms is to increase variety for the customers and simultaneously improve the internal re-use, within the company. There are several definitions of a product platform in the literature. The definition used in this paper is proposed by Robertson & Ulrich [1] and is: "*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

When it comes understand the complexity of product variants, regarding the product structure, several authors have proposed design methods. Sanderson and Uzumeri [2] talk about product variety and the change process of both the individual product variants and whole product families. They characterise products based on the customer type. Meyer and Lehnerd [3] present a model for how to target the different product platform and variants for different market segments as well as avoiding cannibalism. Mortensen et al. [4] have developed the Product Family Master Plan (PFMP) method, a method suitable to take "the big picture" of today's product family. The master plan gives both overview of the possible variation and commonalities. The mentioned methods do not include manufacturing aspects. Meyer & Dalal [5] and Jiao & Tseng [6] underline the importance of focusing on the manufacturing processes as an important aspect in platform design. For a modular design approach Ericsson & Erixon [7] have developed a method suitable of taking a broad view on the product variants and find the appropriate way of making the product family modular. The existing literature has though little or non-focus on how to create the product variation in a structured way for products not capable of being configured or modularised.

2 The study

The study was conducted in close relationships with Hydro Aluminium Structures (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 (->2 000 000 units), with bumper structures in the upper range. These products are characterised as being non configurable. Each product variant is customised, in order to fit the different car models. A very strict focus on satisfying the customers needs, have resulted in a product family that is based on many different industrial processes and is too costly to operate. The intention with the study is to develop a model, making it possible in a structured way to convert a product family over to a leaner product program. This by focusing on increased reuse of the assets the company possess, in a broader sense than only component reuse. These assets are based on the definition to Robertson and Ulrich [1].

2.1 Data gathering

The study is based upon workshops and a communication with the company for several years. It consists of 4 in-depth interviews, a case study and several earlier studies [8], [9] & [10]. The persons interviewed were primarily managers and senior engineers, working with product development or research. All of the in-depth interviews were performed individually and in their working environment. The same people also participated in the workshops. All the persons had either a doctor's degree in engineering or were graduated engineers all of them have been working in HAST for many years. All the interviews were transcribed in order to perform a detailed analysis. The questions and responses were classified and grouped by topics, based on Robertson's [1] lists of core assets (components, process, knowledge and people & relationships). Ideas and work were discussed and changed during the workshops. A close interaction with HAST was present at all time.

2.2 The product

The bumper structure with the crash box and respective production will be discussed further in the article, fig 1. A bumper system is placed in the front and rear of the car, and consists of a cross beam and the crash boxes at each connection point to the chassis. The system is designed primarily for two different requirements, a Danner test for the European car models and CMVSS requirements for the North American car models. Of these requirements the Danner is the most demanding requirements and is used for models operating on both the

European and North American market. This test requires that the bumper structure absorb the energy from a 16km/h offset crash and leave the car's chassis structure undamaged. The core assets in these products is control of material properties, the knowledge of forming ability, the lightweight design and the integration of these into products with high energy absorbing capabilities Together these technologies allows HAST to make products that consist of very few, highly formed parts. HAST delivers these types of structures to the majority of the European car models. These structures can be found in the range from low-cost to premium-brand cars. Each product is customised for the car makers, leading to a large number of product variants. The customisation of the products is necessary to be able to be in business, and is not seen as a problem. All products have in common that they must fulfil similar regulation and insurance tests.

Figure 1: Bumper system consisting of a beam, two crash boxes and a tow nut.

3 The Corporate Platform model

The Corporate Platform model developed consists of four major elements related to the, Market, Product Platform, Manufacturing and the Product development. The product development represents the final customisation into the specific product variants, fig. 2. The model uses existing design methods in a new context, in order to improve the reuse of more than the components in a product family. All elements, except the final customisation are divided in two levels, a detail level and a more general level. Within each of these boxes there are several processes that should be carried out, and between them a flow of information. To visualise all the complex relationships that exist between the dynamic customer interaction and to the more static corporate knowledge this Corporate Platform model describes the major interactions. By understanding the interaction and what processes to go through the different elements can be mapped out. This should result in a more controlled product development, where there are clearer separations between research and development projects, resulting in lower risk and cost. The user of this model is the design teams and the managers affecting the structure of the product portfolio. The elements in the Corporate Platform model will be thoroughly described in the coming chapters with an example and below is an overview presented:

- *Market*; the market element is where the interaction with the customer appears. The customers have a request of getting a product that fulfils a certain set of functions. The model is based on structuring the product according to some vital product performances, lining up the market segmentation [11]. The customer and trends analysis provide data on the differentiations that the market segmentation should be built upon. All these anticipated demands on variation must be analysed, and a selection of functions should be targeted to fulfil. All this information is the fundamental for developing the product platform.
- *Product platform*; the market information is combined with manufacturing knowledge and the creation of a product platform and product variants is started. The first step is to establish the few basic features that can characterise the products and the ranges they must vary within. Closely related to these features are also the belonging production processes. This synthesising process is more like finding the best

alignment of all the elements in the Corporate Platform. The result is one or several product structures that form the base for further detail engineering, and become the customised products. The reason for splitting up the product platform into a product and production section is the relationships the crash box has towards the production line. A specific product line can have several solutions of product structures that fit within the lines. The opposite situation can also happen with the crash box where one product structure can be realised through several different production lines.

- *Manufacturing*; is the knowledge base that exist within the company. The knowledge is something people possess and improved through experience and learning. It is shared as an information flow on different media as conversation and written information. In a large and global organisation as HAST the sharing of information between peoples is not always so easy, so written information must in a large extend be used. Structuring the stored information is one important factor.
- *Product development*; the product structure and product line is further engineered to become specific product variants.

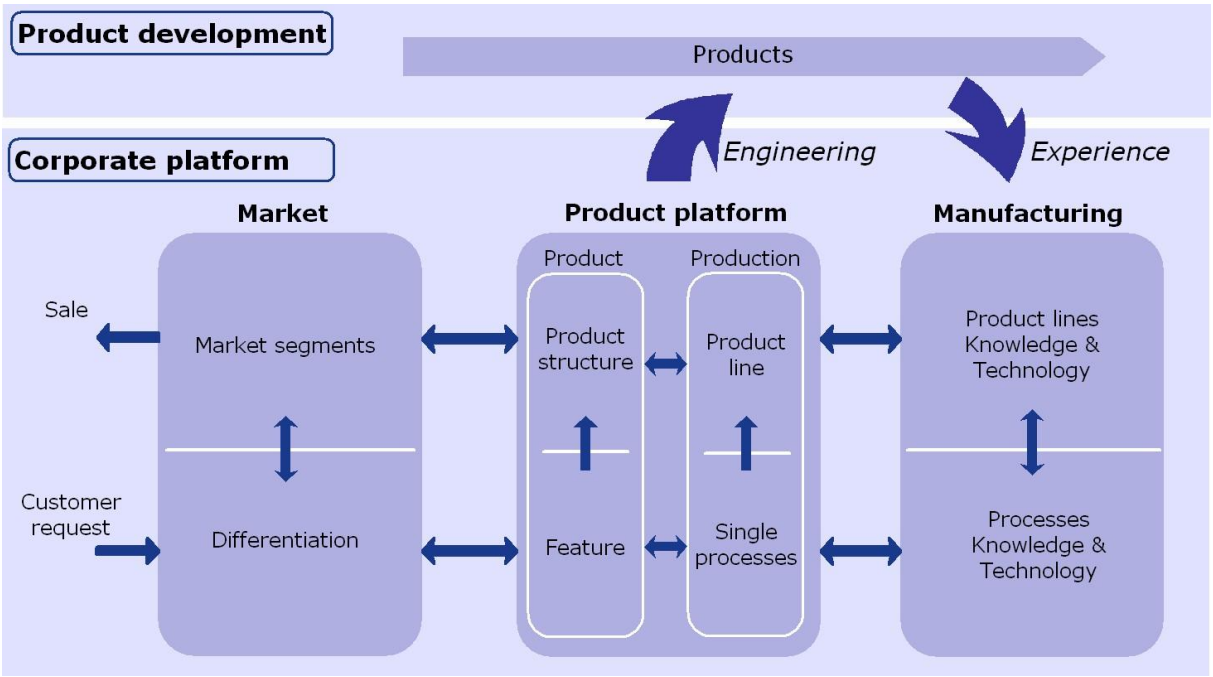


Figure 2: The Corporate Platform model with the four major elements and the sub topics

3.1 Market relationships for the crash box

The product development process is very dependent on gathering and understanding the needs that the product must fulfil. This gathering of data from a range of customer is related to identifying the product differentiation that must be part of the product platform. Presenting the variation should be done with care. In a product program one want to have a certain control over where the variation should be. There might be so many parameters that can be manipulated and including the customer with all can be to confusing [12]. A market segmentation grid [11] can sort this out and improve the communication.

3.1.1 Product differentiation

The driver for the shaping of the product program is the customer's need. These needs must be understood and translated into product characteristics that can form the base for developing

product. This is just according to traditional product development, but not only a single project / product can be used to shape this foundation. This can be done with:

- The Kano models [13] three customer satisfaction lines. For the crash box it could give; Attractive: crash performance on the tougher tests, One-dimensional: price, weight, mounting/replacing easiness on car, Must-be: crash performance on legal tests, corrosion resistance
- Future needs and trend scenarios [14], [15] the changes that the stakeholders may change in the coming years that affect the design of the platform. For the crash box this might be change in crash tests.
- Mapping out the dimension variation. In order to understand the required variation needed, the majority of the dimension, surface, material, etc. variations should be mapped out.

3.1.2 Market segments

For mature businesses it is rare not to find products where a step-up functions exists in its products. Businesses in the same category as HAST should have interest in distinguish its products. Too little focus on product features may change the customer's view on the products and it becomes more a commodity rather than something special. If it becomes a commodity the only thing for the business to compete on is cost. This alone, may in many cases be difficult to do business on. Platform strategies and product program aims to simplify the portfolio by adapting the product structure in a smart way to the segments (horizontal, vertical, beach head), as discussed by Meyer [3]. In today's crash box portfolio HAST has no segmentation of the products, they do however have products that can utilise different performance to meet the different customers. Fig. 3 shows a proposal for how to transform today's crash box portfolio over to a market segments that emphasize the products distinctiveness characteristics. This is done through an alignment process of all the elements in the model a will be further discussed in the coming chapters.

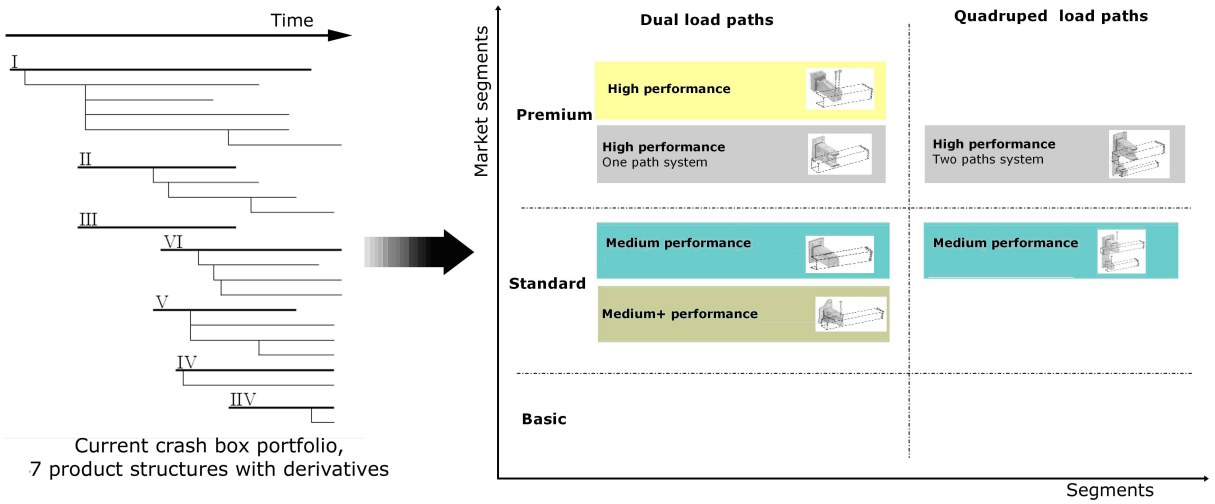


Figure 3: The proposed change in the crash box portefolio over to a layout with a distinctiveness plan for the product program. Segmented in a premium, standard segments with options for different load paths. Today there are no segments and a unstructured product portfolio

3.2 Product platforms for the crash box

The product platform section of the Corporate Platform is divided into two parts; designing the product structure and the design of the production processes. Both parts have two levels; one where the focus is on the product and production features, the second where the features are combined into a product structure and production line.

3.2.1 Product

To establish the product program that might consist of several product platforms needs a systematic approach to develop a distinctiveness plan and commonality plan. To open up the solution space and align it with the market segments one should start modelling with features and not directly on the product concepts.

The product feature can be derived from the customer's request of product functionality and future trend scenarios. Usually a few product features are capable of describing the whole range of products as the crash boxes, manipulating with feature seams to be easier to use for a range of product variants than listing all the requirements for the family. To these features there is a set of options of the variants provided. A combination of each feature options, describes one product variant. By taking this matrix and combining it with a restriction matrix, the product program starts to be formed. This gives the possibility to model with the features of product variants before a concept is made, fig. 4 shows a portion of the three structure of the crash box. By making all the possible combinations of the options in this matrix, all possible product variants can be listed. Even a small feature matrix results in a large number of options combinations. Of the option combinations made there may be some that are not allowed, physically impossible or not wanted. The restriction matrix implements such restrictions. The combination of these matrixes can be handled in the software as the Complexity Manager [16]. The product feature tree structure gives information about feature combinations that is most likely in the customer's interest. The tree structure must then be aligned so that groups of feature combinations most likely can be developed into as few product concepts as possible as well as matching it to the market segments.

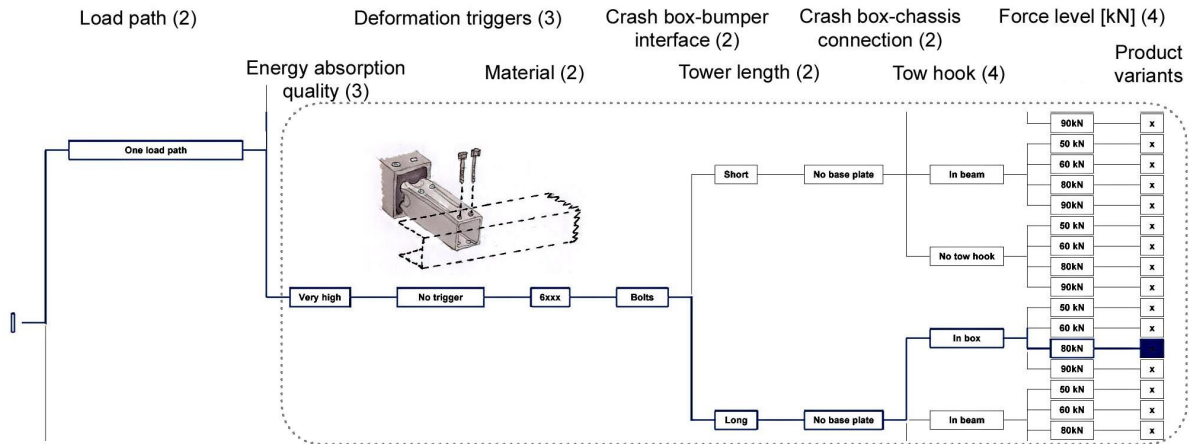


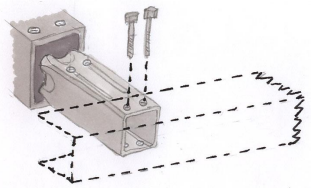
Figure 4: Part of the feature tree structure for the crash box. The bold line illustrates one set of features representing one product variant. The dashed box represent a group of features that form one product structure

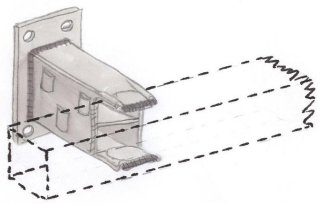
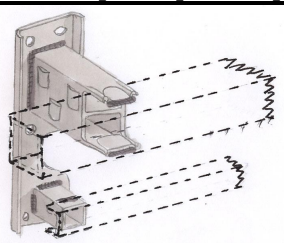
The product structure describes what should be the predefined product platform concept, from which the specific product variant can be engineered. The different in developing a product program compared to the traditional product development is the increased complexity in inputs and demands on the design results. The feature tree gives a very good starting point for concept modelling.

The synthesis process of developing product platform concepts for the established feature combinations follows the traditional product development methods. Suitable synthesis methods in this process are especially the morphology diagram [14], principle and quantitative structures [17] as well as similarity laws useful [14]. Finding a mach between the

required feature groups and a or several product structure is a complicated alignment process. There might not be only one product structure combination that gives the optimum result. There is though one very important aspect regarding this design process, the extra input induces several discussions on topics that might never been rose. These extra discussions add valuable information to the outcome of the designed products. For the crash box product inputs from the features, market segments, product line and crash box experience have resulted in 4 product structure concepts, table 1. These are primarily based on existing solutions, which are slightly changed. The change corresponds to an adaptation to the product program and implementing of the market trends. Each of the 4 different product structures is a product platform, together they can be derived into 15 major branches of product variants.

Table 1: The product structures description for the product program with the distinctiveness (2 of 4 structure groups are shown)

High performance

The product structure is based on a bolted assembly to the chassis and bumper. The bumper beam is of an open profile in the attachment to the crash box.

High performance, dual load path system	**High performance quadruple load paths system**
	
The product structure is based on complete welded systems. All the welds are made in the same fixture, since the product structures have gliding planes to secure the required tolerances. The welding cell should be flexible enough to weld both dual and quadrupled load paths systems. The lower load path consists of an open profile beam.	

3.2.2 Product platform production

Behind this distinctiveness plan and market segmentation the products have to have some commonality that can provide a boost for the company economy. In the case of HAST's crash boxes the commonality can not be focused around components reuse, but must be found in the industrial processes and the engineering processes.

The single processes represent the production technology at a detail level. For the crash box product to achieve the required properties many single processes are stacked together to form the product line. It is in the layout and stacking of these single processes that standardisation can be done. The single processes represent a major part of the technology and core competence the company possess. It was found that an uncoupled parallel development of the single processes technology and the product concept development could cause problem in achieving a stabile manufacturing. Therefore if too many special technologies are developed and not introduced in a planed manner, it can be very harmful for the flexibility of the product program. The development within these single processes must also be seen as research projects. Product behaviour can most likely be created by several methods and represent a parallel development to the product it self. If new single processes are introduced each time a new product variant is developed, the risk of failure gets to high. It will introduce production

elements with little history related to them and make the daily production more unstable. This is not wanted when using product platforms. Therefore launching new single processes should be considered as important actions in the renewal process of the product platforms.

- *The product line* is the stage where the final products are made. The product line provides the description of an industrial process that is the base of each product platform. It should be easily adapted to each engineered product variant. In the Corporate Platform this is where one of the strongest drivers for reuse and standardisation should be found. It is here that the companies and especially HAST can gain much by standardisation.

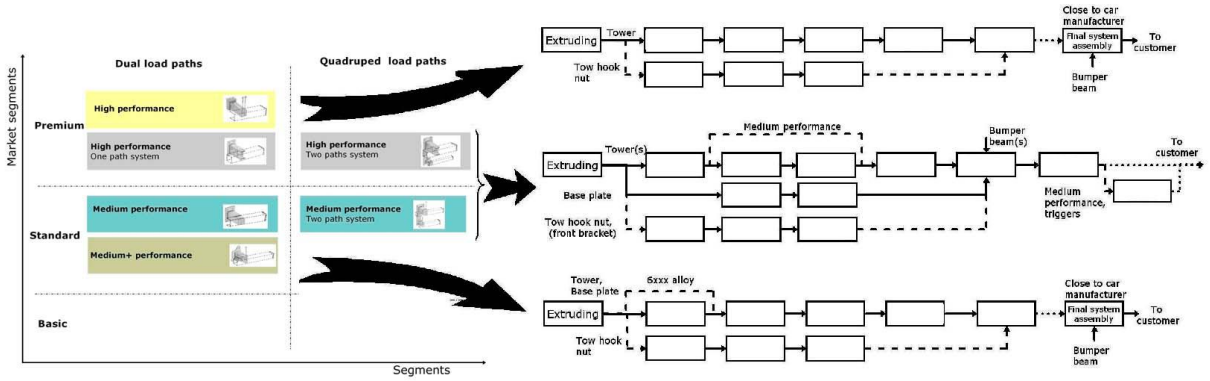


Figure 5: The market segments with product groups and the belonging industrial process. Dashed lines in the processes flow diagram indicate alternative paths, depending on material and product structure that pass through the industrial process

With the proposed product program layout the commonality is found in using fewer industrialising processes and making them so flexible that they provide the required variation. Fig. 5 shows the market segmentation and the proposed industrial processes to these product structures. Reducing process steps is historically seen as a way of making the manufacturing processes leaner, but for the crash box product this might not be the case. Reducing the number of process steps to a minimum, for a product structure, may narrow down the lines flexibility so much that no other product can be made there. This is sub-optimising and is efficient for one product variant, but not for the product program as a whole. Originally HAST's portfolio had seven different industrial processes that with this product program can be reduced down to three. With fewer than three industrial processes the product characteristics covered is narrowed too much. The proposed set of industrial processes is therefore three and the product program consists primarily of horizontal product platforms as Meyer [3] discuss.

3.3 Manufacturing

In the Corporate Platform model the section with manufacturing represent the base of core assets in the company; the knowledge and people & relationships. It is from these elements that guide and drive the product development. It should provide a boost in reuse of experience from past products and production processes.

One thing is to focus around the physical product, but as Robertson and Ulrich [1] state, that also knowledge and people and relationships plays an important role. It was found in HAST, that there was lack of a system securing an optimal information flow between the projects, the globally distributed design team and the manufacturing sites. This resulted in first-class

technical solutions did not be transferred over to new product variants, and bad solutions where not excluded in new products. The flow of information is one of the critical elements in the change over to product platforms, both regarding the derivation of new product variants and the synthesising of new product platforms. Since a product platform differs from a one-at-a-time product development in that it is intended for a range of product, the information management is far more complex. When the organisation is run with development of one-at-a-time product, the sharing of information is very much related too a flow between two points. While in a product platform context the information flow must also go in other directions to secure relationships between different projects. A large part of the information flow between design teams is to be found in the reading of stored data. The structuring of the information becomes then very important. In the study of HAST it was found that this data structure was not optimised as a information source in the product development. The possibility the engineers had to search for existing solutions and further develop them was too difficult. The data structures should be structured so that they support the reuse of first-class solutions. In small organisations and groups there is two aspects related to the information flow. People that have been part of the organisation or group from the beginning, they all have a good overview of the topics and where to find information. When a new person enters this organisation or group they have not this overview and needs much guidance in sorting things out. For larger organisation this rapidly becomes more complex, since communication networks will form partly formal paths and informal path. Managers that just anticipating that messages sent from on persons and through several others, have the same content in the end, is incorrect. A structured way of securing the information flow in all directions of the organisation is needed [18]. In the Corporate Platform model the data structured are proposed to be changed to a system that supports the design phase, by letting the information follow the product platforms and not the individual projects to each customer. This type of organising and managing the data might be possible with the new product life cycle management programs [19].

4 Discussion

The model represents a framework of describing the important elements in creating a product program. It opens up the ability to develop products in a structured approach that focus on reuse of assets in a broader sense than traditional product platform development. The model interacts with the traditional product development methods and is no contradiction to them. The existing design methods focus very much on the development of product structure and the reuse of components. Several authors among them Robertson and Ulrich [1], [5], point out the need to focus on more than only component reuse. The results from this study underline this. It was found that the organisation could achieve significant improvement in the reuse of asset in the product development phase and in the way the product information is treated. The model includes the description of both market and organisational elements, related to product variant design. These topics are large and especially the organisation elements is seen as important areas for further develop the creation process and management of product families.

5 Conclusion

Improving the company's efficiency has for a long time been very focused around single design, process improvements and component reuse. The Corporate Platform model takes this to a different level; by including the manufacturing aspects and knowledge flow in the product platform development. It makes it possible to improve the efficiency of developing and manufacturing a range of non-configurable products, but also other types of products. The model describes the product variants relationships to the company‘s assets and introduces a way of aligning the product preferences with the company's preferences. It has a strong focus

on the manufacturing aspects of developing a product program and maintains a lean manufacturing.

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