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EXPLORING THE POTENTIAL OF APPLYING A PLATFORM FORMULATION AT SUPPLIER LEVEL – THE CASE OF VOLVO AERO CORPORATION

Ulf Högman[1], Dag Bergsjö[1], Marcus Anemo[1] and Henric Persson[1]
(1) Chalmers University of Technology, S

ABSTRACT
The utilization of a platform strategy has become a competitive priority in many industries, enhancing 'economies of scale' [1]. However, few studies have investigated the applicability of platform strategies at supplier level characterized by small batch production.

The aim of this study is to investigate the potential for implementing a platform formulation in a company characterized by low volume products designed for functional optimization, usually leading to tailored products. The study is descriptive and exploratory, and has studied the reuse of elements between six different product developments at Volvo Aero Corporation. Four different reuse dimensions were investigated: reuse between different product families, reuse over product generations, reuse between customer products and reuse over product size.

The study has shown that reusability exists mostly over generations within the product family. However, it also exists between products in different sizes and between similar components offered to different customers. Some reuse exists between products with different applications, primarily regarding methods and technologies, but only to a limited extent.

Implementing a modularized product platform is not seen as feasible, since most reuse is found at higher abstraction levels. Instead, a technology or knowledge platform is seen as more interesting for leveraging corporate assets, both internally and on the market.

Keywords: Platform, small batch production, and reuse.

1 INTRODUCTION
The utilization of a platform strategy has become a competitive priority in many industries, most notably in the automotive industry. Many firms in other industries are adopting this strategy, with different modifications and degrees of implementation. This adaptation is the focal point of this paper. Key factors for utilizing platforms in a global organization include: the economies of scale gained by reusing design solutions and minimizing bill-of-materials; customer-oriented offers with high degrees of variety; the responsiveness in time-to-market; and the flexible utilization of design and manufacturing resources. The implementation of a platform strategy within an organization has been identified by researchers as enhancing 'economies of scale' [1]. However, few studies have investigated the applicability of platform strategies in a supplier and/or small batch production environment.

The aim of this study is to investigate the potential for the reuse of elements over product generations and across product families in a supplier company, and to discuss the potential of implementing a platform strategy. The research questions this study aims to address in the chosen case company are:

- What is possible to reuse between similar products in different sizes?
- What is possible to reuse between different generations of the same product?
- What is possible to reuse from similar components offered to different customers?
- What is possible to reuse between products with different applications?

When we say “reuse”, we mean this in a broad sense. It is an exploratory study, and we do not limit ourselves to, for example, design solutions or modules; rather, we are interested to map a broad picture of reuse. This may later translate into a more narrow definition of reuse, but that step will be taken as a result of this study.

The study is descriptive, aiming at contributing with insights regarding the potential for implementing a platform strategy at supplier level working with complex products, characterized by low production volumes and where the products are designed for functional optimization, usually leading to tailored products.

2 LITERATURE REVIEW

It is essential for an enterprise to deliver a stream of new products in order to be successful in the long run [2]. However, the business climate in most sectors is highly changeable, and sometimes companies fail to deliver in the long run. One reason for these failures is that companies typically design new products one at a time, having the consequence that each product must compete for resources against other products in the companies’ portfolios [3]. Two problems occur when focusing on developing single products as rapidly as possible with no long-term thought behind the process: redundancy of both technical and marketing effort and lack of long-term consistency and focus [4].

The implementation of a platform strategy within an organization has been identified by researchers as enhancing ‘economies of scale’ [1]. These enhanced economies of scale result from component/module standardization and design reuse. In this regard, the most detailed account of component standardization in literature to date is that by Black and Decker.

Black and Decker, a consumer power tool company, redesigned its basic universal motor such that a range of power options were available by varying one design parameter – stack length [2, 5]. This new design with standardization across other major subsystems in their product offerings led to 85% savings in labor costs per unit [2]. These savings may tend to be magnified (or some might argue justified) due to the inherent large demand (in millions) for consumer products. On the other hand, the aircraft engine industry is characterized by volumes that are several orders fewer in magnitude (in hundreds) and products that have a high degree of engineering complexity. Even so, Rolls Royce RTM 322 aircraft engine is widely cited as an example for internal leveraging [6]. In the 1970s, Rolls Royce simplified the design of the complex aircraft engine through the use of modularity. They did so for a number of reasons, including realizing economies of scale.

Partitioning the engine into seven basic modules (fan (or low pressure compressor), high pressure compressor, combustion chamber, high pressure turbine, low pressure turbine, exhaust nozzle and control system) enabled Rolls Royce to exploit economies of scale across engines and over time, as well as to facilitate the ease of maintenance [7]. Scaling an existing engine design to new thrust ranges, and thus other aircraft applications, is commonly done by the system integrators through re-design of the in- and outlet modules while maintaining the high cost modules of the engine core unchanged. In recent years, not only mass-producers of consumer goods, but also other types of companies (e.g. suppliers) have identified platforms as a fruitful approach to creating competitive advantages [8]. Examples include, as presented in research, the usage of market segmentation grids for developing a product platform for yokes used to mount valve actuators in the nuclear power industry [9], the examination of how a robust standardization of components could be implemented during the design of an absorber-evaporator module for a family of absorption chillers [10], and various other implementations in industrial settings [11, 12].

New technologies can provide opportunities to exploit new markets and create a foundation for a firm’s success, thereby creating a platform for a firm’s business. Kim and Kogut [13] argue that a platform technology represents the coincidence of market and technological opportunities and that this usually happens when markets are not yet well-defined. As technologies age, they argue, market opportunities are filled. In the sense of platform thinking, the knowledge of a firm can be considered as owning a portfolio of options, or platforms, on future developments [14]. The knowledge of the firm can be seen as relatively observable. Examples of tangible representations of this knowledge include operating rules, manufacturing technologies, and customer data banks. Know-how in turn is more intangible and is the accumulated practical skill or expertise that allows one to do something smoothly and efficiently [15]. Knowledge can also be intangible in the sense that it is embedded in the organisation's structure, its systems and procedures, the work place organisation and tools, the working traditions and practices, the management style and philosophy and in the decision-making, planning and control procedures [16].

Patriotta [17] presents the knowledge-based view of the firm, and emphasises firm-specific, difficult to imitate assets as a source of sustainable competitive advantage. Some of the most valuable assets of an organisation are often hidden and invisible to its owners, managers and other stakeholders. These assets are the knowledge possessed by individuals, as well as the organisation's knowledge assets, which include its technology assets [16]. This knowledge needs to be managed and can be a foundation or a platform for building new knowledge and creating value. The knowledge needs to be managed, and, in order to identify opportunities for doing that, critical knowledge functions that contribute most significantly to the success factors of the business must be identified [16].

However, little research covers the application of platform development strategies when it comes to specialized small batch production (as opposed to off-the-shelf components) in business-to-business relations. This paper will analyze the advantages and hindrances for the implementation of a platform strategy in such a situation. This will be done from the perspective of a supplier in the aircraft engine industry.

3 METHODOLOGY

3.1 Research strategy

This study has been conducted as a qualitative case study at one particular company, Volvo Aero Corporation (VAC). Volvo Aero is a wholly-owned subsidiary of AB Volvo. Its main operations are located in Sweden, but it has subsidiaries in Norway and the USA. VAC develops and produces components for aircraft, rocket and stationary gas turbine engines that possess high-technology content, in cooperation with the world's leading manufacturers, and it acts on the global market. Its main operations are as a subcontractor supplying its customers with specialist components, as shown in Figure 1, in business-to-business relationships [18]. The industry consists of a limited number of actors that act either as system architects and integrators, sub-system suppliers or component suppliers. They cooperate in joint ventures when developing new products, all contributing with their own funding as risk-and-revenue sharing partners and with specialist capabilities. See, for example, Prencipe [19] for a closer description of the industry.

The focus in this article is primarily to provide description. However, it is also to use as input for the modification of a hypothetical platform formulated in an earlier study in the same company [18]. As is common in case studies [20], different sources of data have been used, such as company documentation, unstructured interviews, and workshops. Still, the primary method has been semi-structured interviews.

Initially, a pre-study was conducted where four people were interviewed through semi-structured interviews. These people were chosen to represent each of the four dimensions of the research questions. However, all of them also provided their opinion of the other dimensions that were not directly related to them. This first step resulted in 11 main categories of areas of reusability. Different aspects of enhancing and hindering factors that could arise when applying a platform strategy were identified and several elements of reusability were found (although at a fairly abstract level).
To increase concretisation, a retrospective longitudinal research approach was selected. In it, six different product developments conducted during the time period 1995-2008, within a particular product family, were mapped. The product family chosen was a jet engine component that for many years has been a company specialisation, the turbine exhaust case (TEC) / turbine rear frame (TRF), a static structure located at the rear of the engine (see Figure 1). The reason for selecting this component was that extensive experience exists from different developments, in different engine sizes and with different customers. This made it suitable for answering the research question.

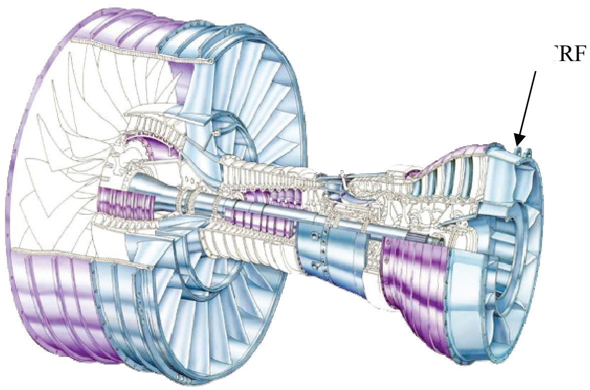

Figure 1 Civil aircraft engine structure. Coloured components are typically designed and produced by VAC, with the TEC/TRF component indicated.

Initially, a workshop was held with three key individuals chosen who had participated in most of the six developments. A discussion was held around a matrix that had been drawn on a whiteboard. This allowed each participant to see the 11 different reuse categories, which was the outcome of the initial four interviews, and come up with suggestions for reusability and to challenge this matrix. The workshop was followed by 12 in-depth, semi-structured interviews where complementary questions were posed. The questions, formulated in an interview guide and based on the results from the pre-study and the workshop, were asked to ensure that five basic things were known: what was reused, how it was reused, where it was reused, why it was reused and where it came from. All participants were contacted and informed of the purpose of the interview beforehand. A qualitative approach, where semi-structured interviews are the chosen research method, is appropriate when “how” and “why” questions should be answered [21].

3.2 Sampling strategy and data analysis

This study used a form of purposive snowball sampling [21]. This meant it started with the initial contact with a small group of people and then used these to establish contact with other people relevant for the study. The people interviewed were selected based on their expected ability to contribute to the different aspects and dimensions explored in the different steps of the study.

The transcribed interviews from the pre-study were analysed by each author individually and important and interesting ideas and information were written down on Post-it notes. The notes were then grouped with notes containing similar information. This enabled us to distinguish different categories of interest. Those categories could then be used to present the findings from the pre-study. The procedure of discerning the interesting findings from the interviews has been inspired by the concept of grounded theory [22]. There, key points in the data collected are to be marked with a series of codes, which are extracted from the text. The codes are then grouped into similar concepts, in order to make them more workable. From these concepts categories are formed, which then are the basis for the creation of a theory.

The transcribed in-depth interviews were used to give a deeper understanding of each category of reusability in the matrix. These interviews were analysed differently from those in the pre-study. The important findings in each transcribed document were marked with a certain colour and thereafter grouped together with other related findings. The grouping was based on the reusability matrix developed in the pre-study and workshop, and focus lay on giving as much information as possible on the reusability situation in each category in the matrix. The workshop, together with the complementary interviews, is believed to give a truthful picture of reusability between the different projects over time.

3.3 Reliability and validity

External reliability [21], meaning the possibility to repeat the same study in the same context and reach the same results, may prove difficult. This is not uncommon in qualitative research, since the individuals and organisation change over time [21]. However, the different steps in the study have been documented and saved in a study database, making it possible for another researcher to return to the material and repeat the analysis, in accordance with recommendations from e.g. Yin [20]. Recommended practices for semi-structured interviews [21], i.e. recording, transcription, coding, and grouping, have been conducted and documented. This will facilitate a review of the analysis, if needed.

Internal validity [21], meaning agreement between observations and researcher interpretation, has been strengthened through respondent validation. In respondent validation, the written report has been submitted for review by all interviewees. In addition, an interviewee seminar has taken place where results were presented and discussed. Data triangulation, using different data sources, further strengthens internal validity.

As stated by Yin [20], external validity [21], or statistical generalization [20], is impossible to achieve from one single case study. This study focuses on the development of just one specific product at VAC, and the analysis reflects the situation for this specific product. The transferability of the conclusions drawn, as described by Bryman & Bell [21], is supported through “thick description” [23]. In sum, the result from this study provides a good picture of how reusability has occurred between the different versions of the TRF/TEC in Volvo Aero Corporation. It can also be seen, as stated by Yin [20], as one data point regarding the applicability of platforms.

4 RESULTS

4.1 The studied product developments

Six different TEC/TRF product developments were investigated. The TEC/TRF-component is a static, load carrying structure, located at the rear end of the engine. Its main function is to align the turbine outlet flow in the direction of the engine centre line. It usually also incorporates a mechanical interface with the airframe through which engine thrust is transferred to the aircraft. A drawing of a typical layout of this component is shown in Figure 2. VAC manufactures these components but relies on sub-suppliers to contribute, for example, materials, castings and forgings. Historically, these components have been machined from large precision castings, where VAC has relied on a limited number of competent suppliers mastering the necessary technologies to produce such complex structures. In most of the designs studied, an alternative route of manufactured structures has been chosen, where smaller individual details are welded together. One of the advantages of such a concept is avoiding the very complex castings. The castings are very expensive, due to the difficulty in the manufacturing process and the high rate of non-conformances in production.

Figure 2 The studied component, the TEC/TRF

The timeline of the initiation of these developments is given in Figure 3. Both the Antle and Clean developments were so-called technology demonstrators that ran in full-scale engine testing within two jointly EU/Industry-funded demonstrator programs. These demonstrator developments were led by Rolls-Royce in the UK and MTU in Germany, respectively. The GEnx 1B and 2B developments, led by General Electric in the USA, aimed at developing new engines for the Boeing 787 Dreamliner and a re-engined version of the Boeing 747 Jumbo-jet. The GP7000, developed under the joint leadership of Pratt & Whitney and General Electric in the USA, is an engine being developed for the Airbus 380. The PW1000G, under the leadership of Pratt & Whitney, is a new development aimed at the Mitsubishi Regional Jet (MRJ), and possibly the Bombardier Cseries. The three main engine suppliers today, General Electric, Rolls-Royce and Pratt & Whitney, are all represented in these six developments. Furthermore, different engine sizes are represented, with long-range aircraft such as Boeing 787, Boeing 747 and Airbus 380 and regional jets such as MRJ and the Bombardier Cseries.

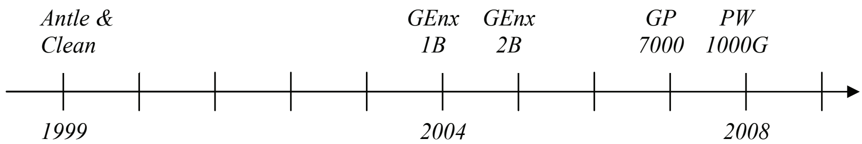

Figure 3 The year of initiation of each product development

4.2 Areas of reusability

The pre-study resulted in a list of 11 main categories in which reusability was expected to be found. These categories have been identified by analysing these four initial interviews and grouping related methods, solutions, tools, and so on together. The categories are as follows:

- Manufacturing equipment (e.g. machines and fixtures)
- Structural designs
- Design elements
- Interfaces (meaning, for example, design knowledge of managing interface issues in large industry networks and knowledge of interface influence on component design)
- Subcontractors (meaning, for example, established and known sub-contractors with relevant capabilities)
- People (meaning experienced individuals with relevant tacit and explicit knowledge, competence and capacity)
- Materials (meaning, for instance, material characterisation data, knowledge of the applicability of materials for different applications, knowledge of weaknesses of materials, and knowledge of how material are affected by manufacturing processes)
- Manufacturing methods (meaning, e.g., welding methods, machining methods, brazing, heat treatment, repair methods, non-destructive testing, and inspection methods)
- Simulation methods (for design analysis; can be, for instance, stress-strain, aerothermodynamics, performance prediction, dynamic modelling, system modelling, and manufacturing process simulation)
- Design methods (for design synthesis, product modelling, and manufacturing process modelling)
- Support systems (routines, standardised work practices, and reusable models, for example)

In the workshop and in-depth interviews, the categories were used as a framework for concretizing and clarifying the level of reuse for the six studies product developments.

4.3 Reusability in the four dimensions

In the workshop and in-depth interviews, examples of reuse, from the different projects, were listed under each of the 11 categories. Based on the number of examples listed and the level of reuse, a classification in four reuse levels could be made (None, Low, Medium and High). This classification is qualitative, not quantitative. It amounts to researcher interpretation, as well, although it is validated by the interviewees. The result of this interpretation is shown in Table 1. The different examples of reuse are not included in the table, but the empirical results are discussed below.

Table 1 Reusability in the four dimensions, N=None, L=Low, M=Medium, H=High

	Different Applications	Different Customers	Different Generations	Different Sizes
Manufacturing equipment	N	L	M	M
Structural designs	N	L	M	H
Design elements	N	L	M	H
Interfaces	N	L	H	H
Subcontractors	M	H	H	H
Employees	H	H	H	H
Materials	M	H	H	H
Manufacturing methods	M	M	H	H
Simulation methods	M	M	H	H
Design methods	L	M	H	H
Support systems	H	H	H	H

4.3.1 Reusability between products with different applications

As can be discerned from Table 1, the reusability between different product applications is low. There are just a few categories in which elements have been found to exist in different products. Those elements that have been reused are not very product specific; instead, they lie on a higher level of abstractions and are a part of the product realisation rather than product specific elements. It is mainly the knowledge embedded in people coming from other areas that can be applied to and reused for the product in question. Those few elements that have been reused from other areas or products are mainly generic technologies, such as support systems and basic welding technologies possible to use on all products.

The hampering factors for reusability between different areas and products identified in the case study are similar to the hindering factors identified in the pre-study. Naturally, the difference in topology between the TRF and other products precludes product specific elements from being reused. Most importantly, however, the structural changes made for the TRF and TEC, going from casted to fabricated components, have forced VAC to develop new methods to comply with these changes. This, in turn, has impeded the reusability of methods used by other projects. Also, the difference in customer requirements for civilian and other components and the difference in complexity between the different areas have prevented some methods from being used. In sum, it is the uniqueness of this concept and its need for specially designed methods, technologies and design elements that constituted the biggest hinder for reusability between other areas and products. Therefore, only generic technologies, knowledge and competence from all parts of the company have been possible to reuse in the projects included in the study.

4.3.2 Reusability between different generations of the same product

Most reusability can be found by looking at the projects over time, from generation to generation. This is not very surprising since much had to be developed for these projects specifically, allowing few elements to be taken from other areas or products. Here, it is the development made in each project and the experiences gained in each project that has been reused. For example, welding simulation has been under constant development, and much has been improved between each generation. The lessons learned in one project have influenced the way the method was used in forthcoming projects and what improvements it needed in order to avoid experiencing the same problems it went through earlier. Naturally, people play an important role here since the knowledge gained in each project has the biggest chance of being transferred to forthcoming projects if the people who obtained the new knowledge are transferred, too. If the same people are allowed to work with the same method for several generations, a deeper understanding of the product can be obtained. This enables the method to be improved accordingly.

The similarities between each generation of the TRF and TEC have allowed some product specific elements to be reused. Some of the basic structural design ideas developed for Antle have been used for all projects. However, some projects have been influenced by the customer, and different designs have been used according to their demands. Therefore, even though some product-specific elements have been possible to reuse, most reusability can be found in the underlying knowledge, technologies and methods used to design the product.

4.3.3 Reusability between similar products in different sizes

The reusability between products in different sizes (in other words, the scalability of products) exists mainly in the underlying knowledge and core technologies possessed by the company. It is not the products themselves that have been possible to scale to different sizes by increasing or decreasing the shape of the product; it is the knowledge of how to design the product in the first place that has been reused for scalability. For example, the knowledge gained from GEnx 1B facilitated the design of GEnx 2B and allowed VAC to create a product in a different size and shape much easier than what would have been possible without the experience from GEnx 1B. Even though the products have not been possible to scale themselves, it has still been possible to reduce the amount of work needed for derivative products, in accordance with the goal of applying a platform strategy. One example mentioned in the case study is the dimensioning to the load case of fan-blade-out for GEnx 2B, which was greatly facilitated due to the similarities to GEnx 1B.

4.3.4 Reusability between similar components offered to different customers

Table 1 shows that reusability exists in different dimensions of the company and that several elements have been possible to use in all projects. However, in the end, VAC depends so much on the requirements and solutions enforced by its customers that the full potential of reusability is impossible to reach. Even though many of the technologies and methods of VAC can be used repeatedly for different customers, it is still the customers who have the final say regarding many of the methods, designs or technologies used. This limits VAC from using the method, design or technology that suits them best. Instead VAC has to do what it is told by its customer. Not even the same basic machine elements such as nuts and bolts can be used for different customers. Furthermore, contractual restrictions exist that limit the possibility of transferring, for example, design solutions, or design data, between different customer products. Even though VAC is an independent component supplier to the "big three", these companies are in direct competition with each other. This has to be respected by VAC in order to maintain customer trust.

In conclusion, the high customer dependency and the fact that most elements have been developed for these projects have hampered the reusability in VAC. Even though much is similar between the different projects, it still seems that much has been developed specifically for each individual project and the potential for reusability has been low. The developments made in each project derive from a need for that specific project, and much focus has been given to the optimisation of each specific product (rather than the optimisation of the product family as a whole). One example is the small change in size between GEnx 1B and 2B, which hindered the reuse of product specific elements. Such hindrance contradicts the goal of reaching economies of scale. The reason for this change derived from the customer who demanded this change, and it is a typical illustration of the customer dependency that exists in VAC. This might have been the best decision from the product performance optimisation perspective. However, from a reusability point of view, it impeded the reuse of much of the structural design and design elements. One could therefore question the possibilities of creating a platform strategy before the product has matured more and the improvements made for each product have not affected the reusability to such a great extent.

5 DISCUSSION

Depending on how generic VAC wants its platform to be, different types of platforms are applicable. The more company wide the platform aims to be, the harder it is to find recurring elements possible to include. In fact, based on the result from this study, it is most suitable to create a platform for the product in focus alone, although a broader platform strategy with wider synergies is probably more desirable from a company perspective. When looking at the six concepts of platforms identified in this study, it is clear that some are more preferable than others depending on how generalisable the platform needs to be.

A product platform [4, 25] that reuses product-specific elements is hindered by the limited number of recurring elements between the different products. This is because of the topological differences and different customer requirements, where weight is one of the dominant design drivers. Hölttä et al. [24] concluded that “if technical constraints, such as power consumption or weight, are the main drivers of design, an integral system will provide more suitable architecture than a modular system.”. This conclusion supports our finding.

The possibilities of applying a customer or brand platform [25] is limited by the high customer dependency at VAC. If VAC could take on more design responsibility, more knowledge could be allowed to be transferred between different customers and applied on different products. Preferably, VAC should have its own set of core capabilities that match the needs of the customers and that may be used regardless of project or buyer. This increases the possibility of using one customer as a beachhead [25] for one product, developing the core technologies needed to design this product, and thereafter growing more business in this segment by using these capabilities for other customers.

It is difficult to discern an entirely generic technology platform VAC can emanate from, when engaging in new product development projects. If a technology platform is created, it would be desirable to have a more comprehensive focus and search for common needs of products with different applications when developing new technologies. However, technology is often tailored to the particular product, which could be seen from the empirical data. A technology platform at different levels, incorporating both product specific technologies and more generic technologies, is foreseen as a way of obtaining both product line advantages and corporate-wide advantages.

The corporate knowledge base has been found to be applicable across product families. It is the employees who possess the knowledge, and it is the support systems that help to coordinate activities and facilitate knowledge transfer and the creation of best practise routines. Thus, it is important for VAC to encourage individuals to make use of their knowledge, making information about who knows what available and creating contact surfaces for the employees to exchange experience. Support systems can facilitate the contact between individuals and ease collaboration as methods and routines are created to locate and utilise knowledge.

5.1 Level of concretization in a technology platform

There is a need to differentiate knowledge so that it becomes easily accessible to the employees working in product development. Some knowledge is very abstract and applicable to almost everything. Other knowledge is specific and applicable only to a few products or processes. The empiric research found that it is suitable to define three different layers of abstractions. These are presented in Figure 4.

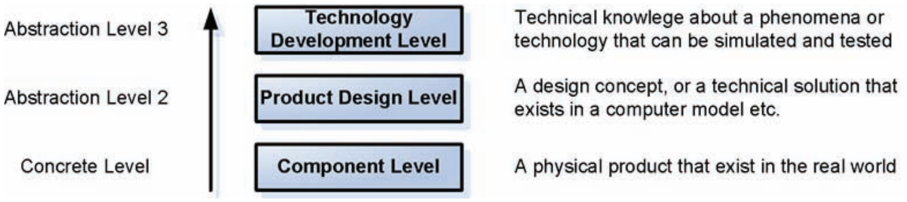

Figure 4 Levels of abstraction

These three levels of abstraction can also be utilised to analyse the current product and technology development at the company. The concrete level refers to the components manufactured in the factory. The second abstraction level refers to concepts in product development. Finally, the third level refers to the technology development and is also the most general and abstract level. In order to test the platform approach, the empirical data was applied to these abstraction levels. They are presented in Table 2.

Table 2 shows that most reusable knowledge in product development is found on abstraction levels 2 and 3. The only components that can be reused on a concrete level are design elements, and there are not many exactly the same in reality. The focus on the platform to be used in product development must therefore be on abstraction level 2.

These results indicate that a standard component based platform, or modularization, is not usable for a company such as VAC. The focus on knowledge and reuse of knowledge at higher abstraction levels is therefore suggested as a base for a future platform.

Table 2 Reusability in three abstraction levels, X=major reuse, x=some reuse

	Component level	Product design level	Technology level
Manufacturing equipment		X	
Structural designs		X	
Design elements	x (few cases)	X (most cases)	
Interfaces		X	
Subcontractors		X	
Employees			X
Materials		X	X
Manufacturing methods			X
Simulation methods		X	X
Design methods		X	x
Support systems		x	X

A limitation in the design of the study, which may influence the conclusions drawn, is that the studied company has not implemented a platform formulation to date. This means that when the six product developments that were included in the study took place, reuse was not systematically considered in the design activities. This also means that reuse potential may have existed but had not been realised. However, this aspect has been considered in the interviews and discussed. Additionally, the results reached in this study are confirmed by another study [18] that resulted in similar conclusions. That study was more forward looking, where a working group involving company designers and researchers explored the potential of applying a modular product platform in future developments, however unsuccessfully. This strengthens the validity of the results reached in this study.

5.2 Platform formulation and follow up

In an earlier study, Berglund et al. [18] presented an initial model for platform formulation based on the levels of abstraction as presented above. This platform model further separated the knowledge regarding design and knowledge regarding the manufacturing. On the highest level, the platform model concerned abstraction level 3 (that is, technologies). The platform model is presented in Figure 5.

When investigating Table 2 and the formulated platform principle from previous research, it is found that most reuse for VAC can be found on abstraction levels 2 and 3. Only in a few cases is it going to be possible to reuse components directly, as for example in the automotive industry.

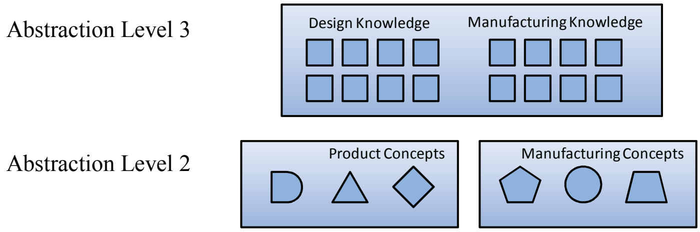

Figure 5 Platform model for VAC [18].

6 CONCLUSIONS

The purpose of this study was to investigate what types of elements are reused at Volvo Aero Corporation, a component supplier in the aero engine industry, and to discuss how a potential platform strategy might look. The study has shown that reusability, in the case of TRFs and TECs, exists mostly between different generations of these products. However, it also exists between products in different sizes and between similar components offered to different customers. When discussing abstraction levels, the reuse is mostly found at higher abstraction levels. It has also been discerned that some reusability exists between products with different applications, as some methods and technologies come from other parts of the company and/or are applied on other types of products. However, the recurring elements have almost always been modified or altered along the way and the solutions, methods and technologies used for previous projects do not look completely the same in the next coming projects. There are two main reasons for this. First, the people involved in the projects gain more experience and are able to use their knowledge for the next project. Second, different customer requirements force VAC to change its methods or solutions.

The constant development and improvement of methods and solutions has impeded the reuse of product specific components. Instead, most reusability has occurred in the form of experience and lessons learned. The experience lies in the realisation of the product and how to optimise it and obtain better quality. As such, much of the reusability can be found on a product design level. This has implications for the reusability between business areas and products with other applications, as many of the methods and solutions developed are specific for the TRF and TEC.

In summary, in a company like VAC, with low batch production and product designs driven by technical constraints (like weight and performance) and product characteristics optimisation, a technology platform appears most promising.

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Contact: Ulf Högman
Chalmers University of Technology
Department of Product and Production Development
412 96 Göteborg
Sweden
Tel: Int +46-70-5482877
Fax: Int +46-520-94007
Email: Ulf.Hogman@volvo.com
URL: http://www.chalmers.se/ppd/SV/organisation/avdelningar/produktutveckling/personal

Ulf is an Industrial PhD candidate from Volvo Aero Corporation and Chalmers University of Technology. His research interest is primarily in processes and methods for technology development.