Technische Universität Graz

Doctoral Thesis

Industrial Platforms and Modular Design.
A Theoretical Consideration Verified in Praxis.

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Abstract

Industrial platform and modular design strategies were first made publicly aware and developed to their current state by the automotive industry. They were established to generate a high number of product variants and to allow quick adaptations to product changes while keeping down costs and complexity. After these strategies had been recognized as a means to success within the automotive industry, other industries have copied the concept as well.

Since industrial platform and modular design strategies bear potential risks, it is crucial for companies to consider success factors associated with these strategies before deciding on their introduction and the way to apply them. This thesis describes characteristics of industrial platforms and modular designs using the automotive industry as example.

Based on these analyses, three hypotheses about success factors are put forward:

a) a platform itself will neither guarantee a faster time to market in developing new products nor will it guarantee a higher acceptance by the customer.
b) The product life cycle heavily influences the success of a platform.
c) The level of commonality vs. modularity acts as a metric for the success of a platforming strategy.

These hypotheses are then tested retrospectively on two examples: a consumer product, and a business to business or industrial product.

The first was found to not meet the expected goals and thus considered unsuccessful. The second was found to be successful. Reasons for these outcomes are discussed and the analyses of both support the suggested success factors.

Taken together, this thesis has identified critical factors which determine the success of industrial platform and modular design concepts. Considering these factors should support companies to identify possible trap-doors, evaluate risks and help in deciding on the application of such concepts.

1 Introduction and Background

From the very first beginning of industrialization the need for effectiveness has been present and since then we have seen it growing. At all times the pressure to adapt to the various demands of changing markets has been answered by different means. Not only in times of economic turmoil as we are facing them at the moment, but also due to customers being more flexible towards swapping vendors and rapidly changing their needs, companies are confronted with permanent and large-scale changes no matter what industrial sector they might be positioned in. For this reason, it is crucial for the success of companies to take up the challenges imposed by a forever changing market and constantly act accordingly by reviewing their strategies and renewing their structures.

The automotive industry of course cannot elude itself from these circumstances. On the contrary, unlike most other industries it stands for repeated structural change and serves as an example not only for being subject of change, but also for leading change by introducing new methods and thus acting as pacemaker industry. For many years now we have seen a structural change.[1] Changing from a seller's market to a buyer's market required more than just increasing productivity for successfully holding the ground. Companies like General Motors or Chrysler give an example of that. In order to maintain the international competitiveness of their products companies have to focus on the efficiency of their supply chain management (SCM). The ability to do so is based on the development of new products.[2]

In particular it is the automotive industry that is under constant and growing pressure to differentiate its products due to the demands of customers.[3] The efforts to meet the variety of customers' demands lead to an increased number of variants while times of life cycle are decreasing. Companies react by expanding their product lines and shifting to segments of market that allow for shorter times of development. As a consequence the efficiency in development and production goes down and the operational variety goes up without adding value, because more products lead to an increased complexity of parts to be produced and processes to be coordinated. The result is an increase in costs.[4]

It can be stated that the trade off in product development between development time and costs, product and production costs and quality follows from increasing complexity.[5]

1 Kurek (2004)
2 Göpfert (2009)
3 Strassner (2005)
4 Schmieder & Thomas (2005)
5 Smith & Reinertsen (1997)

The negative consequences that derive from the above mentioned developments call for effective ways to fight back complexity and yet enhance productivity. Therefore product platforms and strategies of modularization to handle product variants have been introduced.[6] Within Europe companies from the automotive industry have been one of the first and most successful in following platform strategies traditionally.[7]

6 Schwenk (2001)

7 Klobes (2005)

1.1 Motivation

The motivation for this thesis is

a) to give an overview of the market situation as it is today and the challenges for the automotive industry that arise from it. By doing so, the key reasons for companies to introduce industrial platforms and modular designs are identified (also in industries other than the automotive).
b) To outline platform strategies and modular designs with their specific attributes and features. Thus defining success factors for creating and following platforming strategies.
c) To depict how those strategies and design concepts can be realized by analyzing examples from practice.

1.2 Structure of this Thesis

The thesis at hand is structured as follows:

- Chapter 2 treats of the situation as it is to be found at present. Using the German automotive industry as an example, the basic terms and structures of an industry utilizing platforms and modules are explained. The focal point is on finding out the root causes for complexity. This is done by shedding a light onto variety of customers, models, parts, as well as innovations of products and processes.
- Chapter 3 introduces the concept of platform strategies and modular design. After defining the terms and explaining the scopes, advantages and challenges a comparison of the different strategies is shown.
- Chapter 4 handles the question of success factors for platform strategies and modular designs by means of practical examples.
- Chapter 5 summarizes and concludes the findings.
- Chapter 6 illustrates the first example: a consumer product. It is used to show an attempt of how to introduce a product platform without taking into account different requirements and pitfalls.
- Chapter 7 gives the second example: a business to business product. Again the development of a platform is depicted and the success factors are carved out.
- Chapter 8 summarizes and reflects on the hypotheses put up int chapter 5.

2 The Market Situation and Challenges for the Automotive Industry Today

This chapter provides the basis for the following chapters. Looking back at the situation that was found in the automotive industry in the last years, it explains the situation today. It also gives an overview of operating figures and the general framework.

2.1 The Current Status and Future

The significance of the automotive industry as a pacemaker for the other industries is tremendous throughout Europe. In Germany for example in September 2009 the automotive industry is the second biggest employer (710.000 people) and is accountable for the highest turnover of all industries by far (270 billion Euro).[8] According to the German Association of the Automotive Industry (VDA), the share of export in 2008 is around 74,4%.[9]

Since an early stage this branch has had a high rate of value creation accomplished by suppliers.[10] Not only since the economic crisis in 2008 it has often been concluded that every 7th job and 25% tax revenue in Germany are dependent on the automobile.[11] Another characteristic of this industry is the fact that one of its core competencies is the ability to build up and maintain reliant and efficient supply chains between original equipment manufacturers (OEM), suppliers and subcontractors on different stages of the production process.[12]

The term “OEM” is used in different meanings. In this context it refers to a type of contract manufacturing and a form of outsourcing. An OEM manufactures products that consist of parts or assemblies that are delivered by a supplier. The product itself is then sold under the OEM company's brand name. Opel for example assembles parts produced by Siemens and whole components or modules produced and delivered by Valeo. The final product, the car, then is sold to the end customer under the name of Opel. By doing so, Opel utilizes the core competencies of its suppliers. This can be done, because mass products like cars are made out of a high number of parts in many process steps. The model of OEM production is common and state of the art within the major car companies world wide.

Besides the OEM the above mentioned suppliers and subcontractors are the main actors in the automotive industry.[13] Looking at the internal and external influencing variables, the activities and process steps necessary to produce a car are highly complex.[14] This is to be seen as one of the major issues. For that reason the following analyses consider this.

8 Statistisches Bundesamt (2009)
9 VDA (2009)
10 Meißner (2007)
11 Kurek (2004)
12 Meißner (2007)
13 Schulte (2009)
14 Wannenwetsch (2007)

It takes no wonder that the automobile industry is a role model for other industries. Concepts like lean production or total quality management (TQM) were introduced in and by car companies. They have been spreading through the supply chains into other branches.

The supplier network can be characterized by different attributes, such as:

a) A high stress of competition. While the productivity keeps growing, markets like the USA or Western Europe face saturation. On those markets the sales figures remain static.
b) A high level of division of work. Only 25% of the value creation is done within the actual car company. The rest comes from within the supply chain, from direct or indirect subcontractors, such as transportation companies. The complexity and dimension of the supply chain is not limited to certain areas of the world, but is globally outstretched. A network of seven levels (tiers) is not a rarity.[15]
c) Collaboration. Long term frame contracts, common product developments, planning of sales and demand and coordination of processes are typical for the collaboration between OEM and subcontractors in the automotive industry.[16]

In fall 2008 the world saw a financial and economic crisis. The automotive industry of course is not left untouched by it. The effects of the crisis lead to a decline in sales at almost every OEM. Due to these reasons politics react globally with different means.[17]

2.2 Driving Complexity

In the constant attempt to meet the markets' requirements, the car producing companies are trying to create demand and increase growth rates by differentiating their products through a higher number of models. By doing so they seek to evade their product range from the direct price competition at the same time. The companies are faced with a situation in which the outside pressure to develop products according to rapidly changing customer demands goes up, while at the same time the predictability for future products goes down. The complexity in product variants causes an augmentation of “inner complexity” within the companies development, production and administrative structure.

15 Alicke, Graf, & Putzlocher (2004)

16 Wagner (2006)

17 Müller & Thelen (2009) & Bartsch et al. (2009)

In the field of production for example the high complexity of variants leads to decreased production batches and increased setup costs.[18] Decreased production batches and increased setup costs have influences on the functions of an OEM. Increasing the number of models, the number of configurations, the number of parts that go along with that and the efforts necessary to control and coordinate the processes in all departments of the company of course results in a growth of complexity.[19] In addition to that, the product life time goes down as the competitive vendors act accordingly and increase their number of product variants, thus causing the customer to be stimulated towards permanently changing demands. Dealing with that and yet more, managing this complexity proves to be a difficult task for car companies.[20] To sum it up, the following elements add to the complexity of the complete value creation chain:[21]

- customer diversity,
- high number of variants,
- high number of parts,
- product- and process innovation,
- supplier diversity,
- production system.

In the following chapters the elements are discussed, beginning with customer diversity.

2.2.1 Customer Diversity

The demand for vehicles sees cyclic changes, it might be in a stalemate, going back or growing again. The worldwide competition has become stronger due to various reasons, mainly to be found in the fact that the automotive industry acts as a pacemaker for most of the world's leading industrial nations. Mobilizing the masses by means of own products is still seen as one of the first goals in an emerging industrial nation. As a matter of course those products very quickly are exported, increasing competition in other countries. We see todays ambitious Asian countries supplying the world with the products of their growing car industries.

As a result of the ongoing discussion about emissions and a growing ecological awareness, the customers have become more critical about environmental and quality related issues. Standard products often can not fulfill their demands anymore.

18 Eicke von & Fermerling (1991)
19 Kurek (2004)
20 Reppesgaard (2005)
21 Kurek (2004)

This creates a serious threat for the mass production of automobiles that has been dominating the market for decades and leads to an even higher pressure to increase the complexity in production furthermore.

Mass production as it is and it ever was has the goal of optimizing production and minimizing complexity and costs by offering a standardized and plain commodity to the majority of customers. For automobiles, the most prominent examples are the T-Model ("Tin Lizzy") Henry Ford came up in the 1920s and the Volkswagen "Käfer" that helped mobilizing the masses after the second world war in Europe.[22] With the change from seller's market to buyer's market in the 1970s and the accompanying intensification of competition to meet the customers demands, the automotive market has come to be a market of mass individualization: the cars are individualized according to the customers ideas.[23] The pattern of thought behind this is "that such a high number of inexpensive [cars] that vary in design has to be offered, to enable almost every consumer to find exactly what he needs."[24]

Diversity as it is used in this document generally refers to differences between products, processes or parts that are created on purpose. Those differences may involve specifications, features, performance or design to drive and facilitate the chosen market segmentation and positioning.

Diversity can be a combination of different executions of components (for example the same component but with different lacquering or surface finishing) only requiring a relatively small logistic change in production. Diversity also can be a combination of different components (for example differences in material, processing or shape) and can even include additional components, thus calling for a bigger change in production.

One implication of the customer diversity is the high number of variants that is dealt with in the following chapter.

22 Vahrenkamp (2007)
23 Wildemann (1997)
24 Vahrenkamp (2007)

2.2.2 High Number of Variants

The production of automobiles is often cited as the typical example for mass production. At present this still is valid for most of the vehicle categories. Nevertheless the automotive industry at the moment has to face the fact, that particular products are being produced in a high number of variants.[25] The catalog of one German car in the lower middle class for example lists around 300 million possible variants.[26] In the sector of passenger cars the European automobile producers generated the following production volumes in the last years: “Today it is seen as optimal if a manufacturing site has a capacity of around 800 to 1,200 vehicles per day.”[27]

The development from a serial producer to an international corporate group can be shown using the example of the OEM Ford. In 1903 Henry Ford founded the “Ford Motor Company” in Detroit. Beginning from 1908 Ford produced the “Model T”, commonly known as “Tin Lizzy”. In 1925 the daily production reached the all time high value of 9,109 cars. One car was a look-a-like of the others. Although Ford wasn't the inventor of the conveyor belt production as it is sometimes stated (in 1787 Oliver Evans filed for a patent to state governments in the US),[28] he had an unmistakably sense of how mass production would benefit his company: “Therefore in 1909 I announced one morning, without any previous warning, that in the future we were going to build only one model, that the model was going to be 'Model T,' and that the chassis would be exactly the same for all cars, and I remarked: 'Any customer can have a car painted any color that he wants so long as it is black."[29] Today Ford and its affiliates offer more than 60 different models of passenger cars in a vast number of variants.[30]

But not only Ford comes to offer more than just one model in one color, any other car sold in high numbers, such as the Volkswagen Golf, the Opel Astra or the Mercedes C-Class, is available in a multitude of variants to meet the customers' demand for more individuality.[31] Some experts state that there are rarely two cars produced that are completely identical.[32] The Volkswagen Golf for example can be configured in a combination of more than 1 million variants. Although the daily production nowadays is much higher than it ever was before, no car resembles another.

25 Piller & Waringer (1999)
26 Ihme (2006)
27 Ihme (2006)
28 Encyclopedia Britannica
29 Ford (1922)
30 Ford Motor Company (2009)
31 Kuß & Tomczak (2004)
32 Kurek (2004)

Basis for this is a structure of production that is specialized and adapted to fulfill the customers' demands in an adequate and efficient way. Building and upholding such a structure is made more complicated by the fact that those customer demands are subject to a rapid change. Much importance therefore is attached to innovations.[33] In the past the period an automotive generation was placed in the market was comparatively long and only minor adaptions, like brush-ups or facelifts, were applied to it. Today it is common to present a modified version of a model only 3 years after its market introduction.

"In only 2 years Ford has exchanged almost the whole model range in Europe and introduced 8 new cars. Instead of 5.4 years as before the average age of [the models] at car dealers is now 2.9 years."[34] It can be stated that rapid changes are an essential attribute of the automotive industry.[35] By increasing the number of options for motors, colors and any feature and thus enabling potential buyers to customize their mass product, car companies have to face an increase in complexity and costs. "Costs and benefits of variety have to be traded off against each other very carefully. If the variety is too low the product will not attract potential buyers. If the variety is too high the increase in complexity might influence quality and earnings in a negative way."[36]

Another driver of complexity are the high number of parts as well as product- and process innovations. Because of that they will be subject of the next chapter.

2.2.3 High Number of Parts and Product- and Process Innovations

Along with the high number of variants and models comes the high number of parts. It is easy to comprehend why this imposes a problem for the car companies, given the fact that a standard car today consists of 10,000 to 15,000 parts. For each of which several variants are existent. There are around 700 different door panels for a Porsche model for example and around 1,200 different bumpers for an Audi A4.[37]

33 General Motors Corporation (2009)

34 Grünweg (2009) & Schneider & Neßhöver (2008)

35 Cromberg (2007)

36 Piller & Waringer (1999)

37 Diehlmann (1997)

This trend is backed up by the amount of order numbers. For example at Opel it rose from 72,000 in 1990 to 170,000 in 2004. In the same time span the amount of order numbers at Volkswagen rose from 124,000 to 300,000. It is obvious that increasing the order numbers by more than 130% also calls for a higher demand of stock capacity. It adds to the efforts in logistics, such as assigning the parts in production and assembling, too. The administration and coordination have to follow suit as well.[38]

In particular the root cause for the described development of part numbers is to be seen in the lack of allocation of existing parts into automobiles that are being designed. Very often the majority of parts are developed from scratch, “although analogue parts are in use in existing models and would only need minor adaption. The amount of parts being newly developed in European cars is around 71% compared to the amount of all parts being used. […] New generations of cars are much more technology oriented than the former versions and have gained complexity in product substance.”[39]

In summary it can be stated that due to the increased complexity described above, the automotive industry has to come up with new approaches of how to structure its production. OEMs have to be able to quickly adapt to new tendencies that influence the behavior of the customers.[40] It should not be forgotten however that advantages in competition are easily undone if the efforts towards more differentiation and mass individualization cause the loss of the main business or drive up the costs in development, production and administration. The relevance of suited and expedient means to maintain the balance between mass individualization and high-volume businesses is undeniable.

Offering a best-fit number of variants for the customers while keeping the ability to innovate and reducing the complexity within the company structures itself, is a major key for success for companies.

Effective and proven approaches of reducing complexity are platform strategy and modularization. They aim to reduce complexity that is already existent by simplifying products and processes.[41] The set goal is to realize the demands of customers as good as possible while at the same time reducing costs.[42] Quality can not only be measured by means of product quality, but also has to match customer's demands.[43]

38 Vahrenkamp (2007)
39 Piller & Waringer (1999)
40 Plapper (2008)
41 Göpfert & Steinbrecher (2001)
42 Piller & Waringer (1999)
43 Cromberg (2007) & Clarke (2005)

The upcoming chapter will give an introduction to platform strategies and modularization and characterize their most prominent attributes.

3 Platform Strategies and Modularization

In the paragraphs to follow the terms “platform strategies” and “modularization” are discussed. Both are introduced separately and compared subsequently.

3.1 Platform Concepts

Characteristic for a strategy of same parts or a strategy of repeat parts is the act of consciously using parts repeatedly for the construction of different cars.[44] Those are parts “(…) of a producing system that can be used in a variety of different outputs without any change, although they were made in a standardized way.”[45] This kind of standardization leads to cost savings, without compromising too much on the ability to differentiate the car models. To break it down, the dimensions of a car that define its class and the technical features are still distinguishable. Components that are complex, but do not necessarily define the outer appearance, such as parts of the suspension or the drive train, are used in a number of different car models.[46] “By doing so the procurement costs can be reduced (economies of scale), as well as expenditures for R&D can be utilized more efficiently (economies of scope). By using proven and matured parts a higher quality can be achieved. (…) If the strategy of same parts is applied systematically to a maximized number of parts that cannot be distinguished by the customer from the outside, one can talk of a platform strategy.”[47]

The platform strategy enables companies to follow a multi-product policy, where one family of a product shares the same platform.[48] But not only do product platforms help companies in reducing parts, they also aid in streamlining production and organization, as well as in modifying product architectures.

In 1981 the Chrysler Corporation introduced a compact “K-car” platform “and invented the 'platforming'. Different concepts for cars are realized on one platform. Thus enabling diversity and individuality while creating cost-efficiency at the same time.”[49]

44 Klobes (2005)
45 Piller (2006)
46 Heitmann (2007)
47 Heitmann (2007)
48 Klobes (2005)
49 Chrysler Group (2009)

3.1.1 *Terms and Approaches in Platform Concepts*

A research of the technical literature shows that there is no general explanation or clear definition of the term “platform”.[50]

“Modular products are often based on a platform, a base module, which is not only the same for all variants of a product, but in general also is used across different products and forms the fundamental element of all members of a product family, that base on it. (…) A product platform can be seen from a general economic point of view as a combination of economic goods, that are used commonly by a product group.”[51] In addition to components or the modular assembly groups this includes

- production processes and
- know-how in development of automobiles,
- technology of production,
- planning and coordination,
- risk management and
- methods of quality control.[52]

To a large extend the know-how is with employees, who are working in R&D.[53] In principle a product platform is a set of parts or components with a common structure that belong together or complement one another. Based on this a large number of different products can be developed and produced.[54]

A platform can be comprehended as a roundup of components, interfaces and functions, that are standardized across a whole product family within a defined time period. Thus it is necessary for the practical implementation of platform strategies to consequently summarize basic functions. That means functions that are common to all variants of a product family. Normally the platform consists of an undercarriage, the drive train and the axes.[55]

50 Schmieder & Thomas (2005)
51 Piller (2006)
52 Linß (2005)
53 Draeger (2007)
54 Sawheny (1998)
55 Risse (2003)

A definition of platform strategy can be derived from a term coming from the automobile industry itself: “This means a standardization of components. The idea of producing a SEAT with the motor of a Golf and a Škoda with an Audi suspension, has helped the VW corporation in optimizing production and logistics. (…) The goal is only having to do one item of work only once and integrating it into as many products as possible by standardization.”[56]

In summary platforms can be the basis for a complex, singular module, the dash board of a car for example. They also can be the skeletal structure of the car itself.

In the following the goals, chances and main critical areas of the platform concept are discussed.

3.1.2 Goals and Chances of Platform Strategies

The main goal of having a platform lies within the wish to be able to fulfill the demands and requirements of a variety of market segments. In doing so the resources of the company are to be taken usage of in the best way possible.[57] The customer has to be presented a high number of product variants that meet his expectations and will evoke his buying interest. Within the development of the system, a cost effective architecture has to be realized for creating a basis of different models at the same time. In addition to that the number of same parts and common production technologies is to be optimized for the best usage of scale of economies possible. Herein lies one of the major problems of the platform development: on the one hand the producing companies aim towards a cost effective production, which means “producing at the lowest cost possible by standardizing the platform, because less parts mean less costs for production, assembly and logistics.”[58]

On the other hand one major goal of the manufacturer is to present the highest bandwidth of differentiators to the customer. The challenge he has to meet is in the hunt for the perfect balance between choosing the same parts of a platform and the ability to differentiate. The interest of the customer lies within buying a product that offers the best fit to his individual preferences. This of course disagrees with the manufacturer's interests of saving as much as possible by using same parts. The crux of the matter is to be found in the architecture of the particular product: it has the ability to influence the balance either to the one or the other side. The product architecture is the key when it comes to finding the right compromise between same parts and differentiation.[59]

56 Fähnrich & Grawe (2003)

57 Stürmer & King (2007)

58 Schmieder & Thomas (2005) & Stürmer & King (2007)

59 Scigliano (2003)

Compared to the singular production, platform strategies offer three fields of potential opportunities:

- reduction of product development costs,
- reduction of product development time and
- reduction of complexity.[60]

Focusing on the reduction of product development costs of an automobile for example, around 60% of the overall development costs can be allotted to the platform. If a company produces two car models based on one platform, the development costs are reduced to 50%.[61] Especially during development and design of a platform structure a shortening of development time can be realized.[62] Even "having to modify the platform for different car types and thus creating an effort for adaptation, the cost benefits of a [platform strategy] in automobile development are undeniable."[63]

Developing a platform within an existing platform strategy doesn't take less time than developing a new platform separately. Nevertheless there is an advantage in development time in developing model variants based on a platform. Those models only have to designed conceptually. The platform strategy will eventually lead to a technical standardization and thus a reduction of complexity within the value creation process. For example the number of parts can be lowered. By doing so, the assembly and also the logistics in production are easier.[64] The whole development and design process is completely restructured by following platform strategies consistently, because together with developing the platform the focus has to be set onto the conceptual design, that is geared to the customers' demands.[65]

The benefits of platforming can be summarized as follows:

- "greater ability to tailor products to the needs of different market segments or customers (…)
- reduced development cost and time (…)
- reduced manufacturing costs (…)
- reduced production investment (…)
- reduced systemic complexity (…)
- lower risk (…)

60 Proff (2007)
61 Schmieder & Thomas (2005)
62 Risse (2003)
63 Diez (2006)
64 Schulte (2008)
65 Herstatt & Lettl (2006)

- improved service."[66]

Besides the benefits and positive effects of platform strategies, that have been described so far, there also can be negative aspects that are discussed in the following.

3.1.3 Critical Issues of Platform Strategies

Connected with the platform strategy one can identify the following risks and critical issues:

- cannibalization and hyper segmentation,
- collapse of price structures,
- fading of brand values.[67]

A potential risk that is caused by the application of platforms is the hyper segmentation of the market. For each segment of the market, the profit volume is too small, i.e. there is too much, no longer profitable division of the markets. One negative effect of that can be cannibalization. This is likely to happen if the launch of a new model partly replaces another model of the same vendor that is already on the market.[68] For example the vendor could brush an existing model by applying new modules and features, that optimize the model in the direction of the customers' needs. Potential customers are pushed towards buying the new model and neglect the old one. "The new or modified product cannibalizes the already existing product."[69] The product expansion describes the spreading of the product program by differentiating existing products or models. Launching new bodyworks or motors for a car type is an example for classical product differentiation. Expansion of the product program is done by placing new models on the market. If a car company is able to position a car onto each market and customer segment, the optimal level of product expansion is reached.[70]

The higher the offer of variants based on one platform is, the lower the costs for developing a new model are. However the possible risk exists of introducing new models to the market that will compete against each other.[71]

66 Robertson & Ulrich (1998)
67 Wannenwetsch (2007)
68 Backhaus & Voeth (2007)
69 Düssel (2006)
70 Uekermann (2009)
71 Robertson & Ulrich (1998)

Another risk lies within the collapse of price structures. Normally product programs in the automotive industry are vertical.[72] Cars that are positioned vertically, but are based on the same platform, are prone to be exposed to a much higher risk of cannibalization than similar models based on different platforms.[73]

The independence and distinctiveness of brands and products can be limited by platform strategies and may eat away brand values. If that happens and to what extent is depending on the scope of the platform strategy.[74] Following the basic idea of platforming, the standardization of products should be restricted to those parts that are not visible or consciously perceivable for the customer and will not interfere with his buying decision, "while everything the customer sees and feels is differentiated. If this is not taken into consideration, the brand typicality that is uphold by the product can be lost, which will lead to product replaceability followed by brand replaceability."[75] Especially the German automotive industry seems to have accepted that the perception of how a car should look like can be copied to every model, thus often models of different classes share the same "face". Highly driven by the wishes of their Asian customers, the German car designers seem to have given up typicality for individual models already and succumbed to a certain degree of arbitrariness.[76] One should underline that by owning a car the wish to state the affinity to a specific social class does exist – not only in Europe, but to a growing degree in Asia as well. In some cases even the hidden parts of a car can already expel it from the class it wants to represent. One example is the 2001 Jaguar X-type, that was based on a version of the Ford CD132 platform, sharing around 20% of its parts with the Ford Mondeo. Not being able to attract enough new customers and being rejected by the regular Jaguar customers, sales did not meet the goals.[77] At the end the experiences with the X-type contributed to Ford selling their Jaguar division.[78] Despite all the benefits platforms have to offer – the common basis with a high number of same parts – there are drawbacks that need to be paid attention to.

Acknowledging this, the automotive industry came to realize a strategy of modularization that divides the car into discrete units according to criteria that have been defined before. According to expert opinion, the strategy of modularization offers advantages in quality, service, maintenance, differentiation of variants, reduction of complexity and cost control compared to the platform strategy.[79]

72 Arnold et al. (2008)

73 Diez (2006)

74 Kuder (2005)

75 Diez (2006)

76 Ufer (2015)

77 http://www.automotivetraveler.com/index.php?option=com_content&task=view&id=656&Itemid=336 (retrieved 30 September 2010)

78 http://www.handelsblatt.com/unternehmen/industrie/us-autokonzern-arbeitet-an-premiumstrategie-mach-es-noch-einmal-ford/11772408.html (retrieved 20 May 2016)

79 Göpfert (1998)

Modularization holds the ability to reduce respectively control complexity. The following chapters are based upon this conception.

3.2 Modularization

The concept of modularization is not new to a large number of theoretical and practical segments of economy. For theory these are mathematics, software development, biology and psychology. In praxis this holds true for industrial development and production, as well as the assembly of a product.[80]

The following paragraph defines the terms that are used in the context of modularization.

3.2.1 Terms and Definitions

Literature doesn't give any universally valid definition of the term "modularization" as it is used in many areas of economy and research.[81] From engineers, economists, scientists to people working in production and assembly – there is a vast number of definitions, each from a different perspective. To understand the context in this thesis, each of the relevant terms are defined in the next paragraphs.

Within the automotive industry a module can be regarded to as a circumscribable unit ready for built-in with respect to assembly. It consists of elements that are physically connected to each other.[82] From a technical point of view a module is to be seen as a unit that is defined by certain criteria and equipped with a decoupled interface to neighboring modules.[83]

Ideally "(...) this unit has an 'one-on-one' allocation of a function to a component."[84] Modules end at the boundaries of a car. For this reason the local seclusiveness is being pointed out. A module has to be part of an entity.

80 Junge (2005)

81 Dürmüller (2006)

82 Eger & Bergauer (1998) & Stürmer & King (2007)

83 Neuhausen (2001)

84 Schmieder & Thomas (2005)

A module is a complete unit, that can either be mounted in or to a vehicle. As an example the dashboard of a car is a system made out of different modules. E.g. the steering wheel, the meters, the entertainment system, the controls.[85] A module can also be an assembly group, "that forms a solitary unit, has defined interfaces, can be produced and mounted, is exchangeable or can be mounted in an alternative way and forms a unit that is rational in production and logistics."[86] Following this definition modules can be dashboard, door, seat, lighting, axes or steering.[87]

The breakdown of an existing product architecture by means of certain criteria into modules with defined interfaces depending on the strategy of a company is often defined as modularization.[88] Arranging functional elements in physical units, that are used as components for the car as a product or a product family is considered product architecture. The product architecture or the product structure reflects the composition of a car out of elements and their allocation.[89]

Modularity is an approach to structure complex production processes in an efficient way.[90]

To sum it up modularization respectively modular production or development is to be perceived as the breakdown of a whole product into installation specific assembly groups that belong together locally.

The components and assembly groups can be developed and assembled independently. Interdependencies with other modules that are imposed by the system have to be considered.[91] The goals and possible benefits of this concept are discussed in the next paragraph.

3.2.2 Goals of Modularization

The major goal of producing businesses is to manufacture numerous variants of models by using modularization. Thus the growing customers' demands for individuality are met. In meeting each customer's requirements in building a car, total variability is created.[92]

85 Schindele (1996)
86 Eger & Bergauer (1998)
87 Wolters (1995)
88 Schindele (1996)
89 Stürmer & King (2007)
90 Baldwin & Clark (1998)
91 Junge (2005)
92 Schmieder & Thomas (2005)

The following goals are pursued by the OEM to achieve an optimal result both in cost and revenue:

- a simple and cost effective derivation of a higher number of niche models,
- cutting on “time to market” for models,[93]
- extension of the useful lifetime of the technologies that are used,
- optimizing the model quality and
- gaining a competitive advantage.[94]

In praxis modularity is not only found on an operational level. In addition to the car as a product, also the processes in development, production, sales and marketing are split into their separate elements. Also here the aim is to avoid complexity. To achieve this the whole process is segmented into partial processes.[95]

Implementing modularization on a process level is mostly done by segmenting the production. Those production segments are independent, product oriented, self regulating units that include several levels of the automotive production process.[96] In this context modularization can be described as “(...) restructuring the organization of the company on the basis of integrated, customer oriented processes into relatively small, manageable units (modules). Those are characterized by peripheral decision-making authority and responsibility for result, while the coordination between the modules is increasingly done via non-hierarchical ways of coordination.”[97] During this process of restructuring autonomous units are formed and technical capacities are untangled. Thus the effort for coordination within product planning and product control is reduced.

Thus not only the automobile is being segmented into separate units, but also the processes that run in the background, like development, production and sales. One of the aims of avoiding complexity is to divide a task into several parts, that fulfill specific subtasks.[98]

93 Risse (2003)
94 Klobes (2005)
95 Schmieder & Thomas (2005)
96 Frese (1999)
97 Picot, Reichwald & Wigand (1998)
98 Piller (2006)

Yet another benefit in efficiency is based on the fact that "(...) the complexity of the centralized planning can be reduced, because within the separate process modules normally the complete handling of a component is striven for and the indirect and planning functions are done by the unit itself. Alas in return the number of interfaces caused by organization that have to be coordinated increases. But as value creation becomes more transparent through modularization on process level and the implementation of stable processes is made easier, one can assume a reduction of the complexity of the overall coordination."[99]

The goals of modularization in summary are:

- product and benefit optimization
- cost reduction (research & development, production, logistics)
- optimization of result through synergies
- optimization of development and throughput time

- product optimization
- reducing complexity
- increasing flexibility
- focus on core competencies

- allocation of tasks, competencies and responsibility
- clear addressing of goals (costs, quality)
- reducing interfaces
- intensification of cooperation with suppliers (outsourcing, extended workbench)

To finalize the reflections on modularization the following chapter will focus on different variants or types of this concept.

99 Piller & Waringer (1999)

3.2.3 *Differentiation of Types of Modularization*

Four types of modularization can be distinguished (see figure 1). These types can be differentiated according to their product structure.

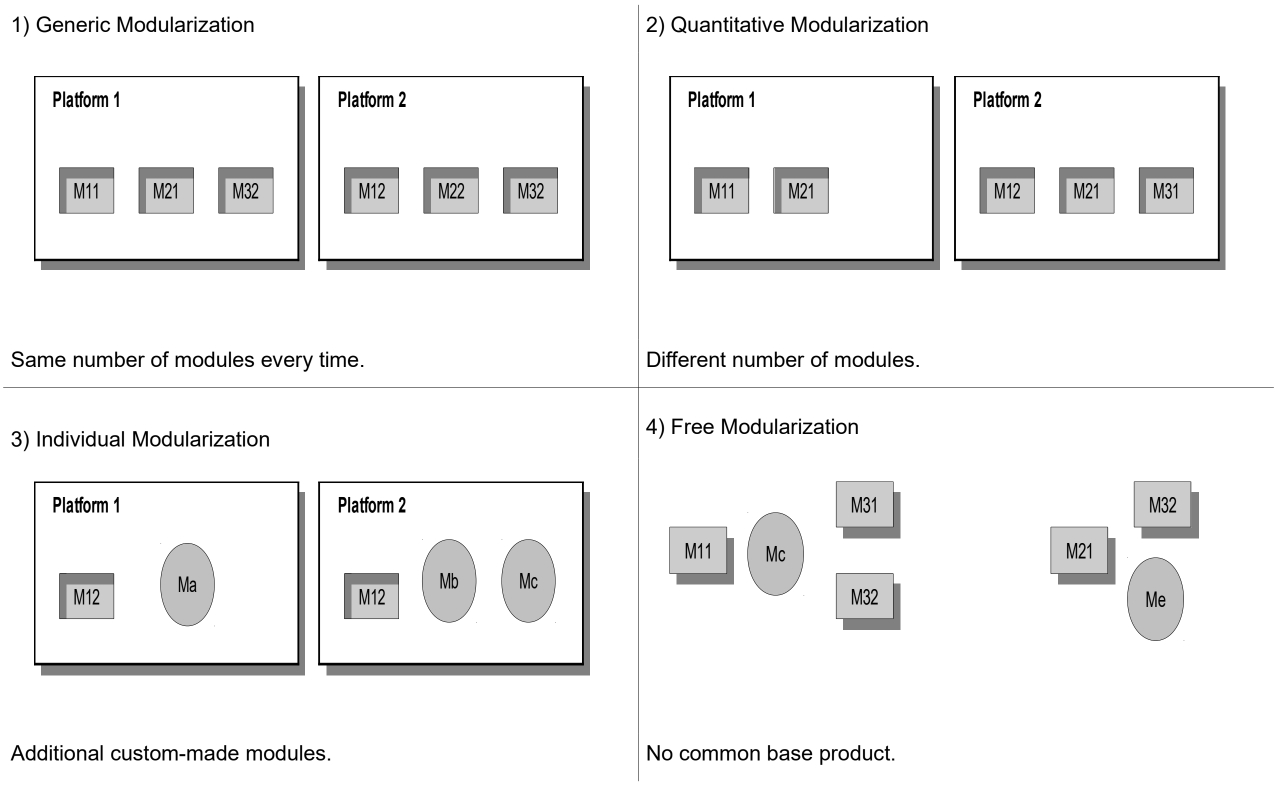


Fig. 1: Different Types of Modular Product Structures

For the generic modularization the composition of a product from the same amount of standardized modules is characteristic. An example for this are the different types of tires for the same car model.

The generic modularization can be defined as "composition of a product from the same amount of standardized parts every time, that can have different performance features, on a basis of a standardized primary product (platform)."[100] This type of modularization is to be considered as relatively rigid. For that reason it is not commonly used in the automotive industry.[101]

100 Piller & Waringer (1999)
101 Junge (2005)

Modularization by “fitting cut” is a modified version of the generic modularization. In it one or more standardized modules are connected with a platform, that is variable within certain limitations, such as length for instance. One example for the usage of this version is the development of the Audi A4. By varying width and length on several places of the platform, the A4 platform can be used for the Audi A6.[102]

Quantitative modularization is the composition of a product out of several standardized modules on a basis product. The number of modules for example can be determined by additional optional equipment. This allows the customer to personalize his product by choosing a different kind of audio system or a “rough street package”.[103] The modular product family of the car model “smart” can be taken as an example of this kind of modularization. This car, that is completely build as a modular construction, allows potential customers to buy particular standardized modules as optional equipments or accessories.[104] Within the automotive industry the “quantitative modularization” gains importance. [105]

“Individual modularization” means that “a product is built out of a given or variable number of modules, that are mounted on a base module. The attached modules can either be standardized or be individually made for the customer.”[106] This form of modularization is commonly used in the production of rail vehicles. According to the customer’s demands so called “free-for-design-areas” are produced: door modules for example.[107] Compared to the “quantitative modularization” the difference is in the integration of one or more modules made to customers’ demands into the base module. This form of modularization is an exception in the automotive industry and is rarely used. An example for it is the integration of a special on board bar into a car.[108]

“Free modularization” doesn’t need any base product. Standardized and individual models can be combined freely.[109] Among all the forms of modularization this one allows for the highest degree of differentiation and orientation towards customers’ needs. It’s the most flexible and strongest form of modularization. Due to the high level of freedom however the feasibility is difficult. Subsystems for vehicles or modular production plants can be made following this principle. Yet there is no example in automotive production.

102 Hackenberg, Hirtreiter & Rummel (1997)
103 Löwer (2008)
104 Jungmann (2003)
105 Zimmer (2001) & Tietze (2003)
106 Piller & Wagner (1999)
107 Junge (2005)
108 Mayer (1993)
109 Junge (2005)

As a summary to the different forms of modularization it can be stated that normally the basis on which modularization takes place, can be made out of several base modules.[110] Only the form "free modularization", which is not of importance in the automotive industry, is not depending on the concept of a base module involving several variants. But as it was written before, this form is just theoretical in the context of this thesis.

To conclude this chapter the following paragraphs will point out similarities and differences of the platform and modularization concepts.

3.2.4 Comparison of Both Concepts

Both, platforms and modules, can be classified as components. Modules are smaller though.[111] Figure 2 shows that modularization follows the direct way from the customer through the product variety and product architecture to the product or organization.

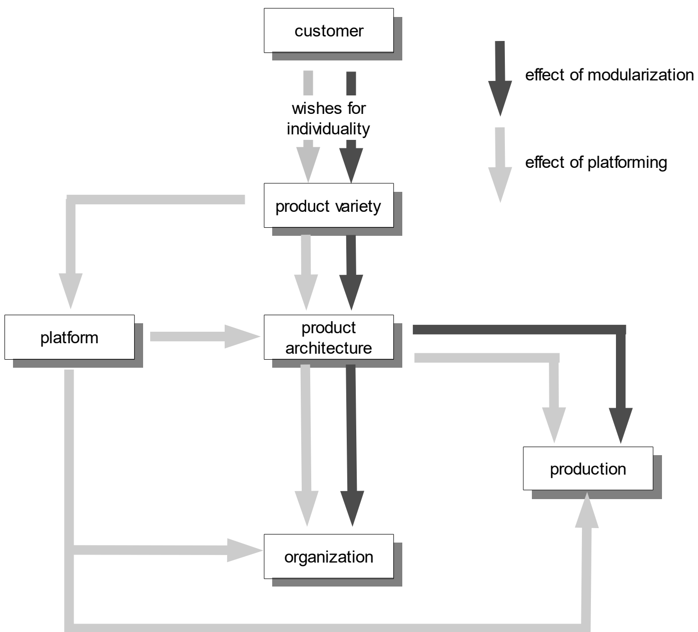


Fig. 2: Comparison of Modularization and Platforming: How the Customer's Demands are Met

110 Piller (2006)
111 Stümer & King (2007)

Platforms can be described as a sum of components and parts connected by force. “Force” already forms the first issue. A platform that has been designed and realized normally stays as it is. Technologies as well as costs are fixed and defined. This might turn into a problem if the car of a relatively cheap brand has to be developed on a platform of a car that is higher in price and market position. In the opposite, having to develop a high-priced car for the premium sector of the market on a platform that was designed for a car for the budget sector of the market might also prove difficult. This especially is the case if the technology of the platform is not apt for the task.[112]

Choosing for a modularization strategy can solve this problem. Modularization is an enhancement to platform strategies. The platform is laid out specifically for a segment and shares a high rate of same parts within a segment. By using synergies between models of different brands high savings can be achieved.

The modularization strategy benefits from a platform that is made out of several modules. An additional cost saving can be gained by reducing variants. That means using modules across different segments. For example by using low-cost-modules.[113]

The treatise on modularization has shown already that both concepts are typically used in combination. Yet there are differences that can be worked out when looking at the concepts in a non-combined state:

- platform concept as a business strategy:
  in corporate management the platform concept is regarded higher than the module concept. The short lifecycles of products and the high number of variants based on a platform are added to the strategic objectives of an OEM for example.[114] Still it has to be pointed out that a modular design principle can accomplish an equivalent number of variants.[115]
- platform concepts create a higher amount of costs:
  basically you can only speak of a platform when the share on the product in total is very high. The share of a module on the contrary is quite low usually.
- a platform only contains a few visible components:
  modules contribute for differentiation, too. A platform avoids to do so. The part that differentiates is used for distinguishing against other variants.

112 Brückner (2008)
113 Doane & Franzon (1998)
114 Robinet (2003)
115 Stürmer & King (2007)

- on a platform the variant planning is done before the development:
  using modular concepts means being able to further develop the modules, because they are more flexible. This results in not having to plan all variants in advance.[116]

The higher the share of modularity of a platform is, the more flexibility it can be credited for. Thereby the efficiency of the tradeoff between similarity and differentiation is increased.[117]

Chapter 4 will include a presentation of the shown concepts with focus on experience and tangible examples.

116 Schmieder & Thomas (2005)
117 Brückner (2008)

4 Success Factors for Platform Strategies and Modular Designs in the Automotive Industry

As an example of how platform strategies are followed in the automotive industry, the modus operandi of the company Volkswagen is shown.

4.1 Platform Strategies of Volkswagen

Car producing companies are faced with a higher and fast growing competition. Rivals from Japan have been entering the European market decades ago and since then every decade has seen new competitors from emerging markets. For this reason, Volkswagen has to shorten the times needed to introduce products, that have been functionally enhanced, are based on platforms and can be developed and produced in a fast and cost effective way. The whole picture, nevertheless, i.e. the integrity of the product itself, has to be perceived as innovative and leading in technology as well. This is made even more difficult by the customer's wishes for individual products.

Product development leads into a complex process, that is determined by the ability to handle costs and complexity in an increased extent, while at the same time quality requirements and progress in technology have to be taken care of.[118] To be able to reconcile cost effectiveness with requirements of innovation automobile manufacturers switch over to incremental changes for the introduction of new models. Existing systems are to be supplemented with innovative components and functionality. The main fields where innovation takes place in the automotive industry are

- drivetrain,
- safety,
- comfort and
- infotainment.[119]

Why and how platform strategies play a prominent role in the achievement of these objectives is shown in the following chapter using the example of the “A-platform”[120] and the models that are derived from it.

118 Piller & Waringer (1999)

119 VDA (2003)

120 the A-platform comprises the A1 to A4 platforms, it has since then been renamed to PQ3x

4.1.1 *Volkswagen's “A-platform”*

The Volkswagen A-platform was introduced as a platform for small to mid-size cars in 1974 with the “Scirocco I” (A1-platform).

The utilization of the A-platform for Volkswagen means “(...) based on a few general models and floor pan components, developing and offering a variety of car types of different brands, that stand for themselves and differ from each other due to their outward appearance.”[121]

Figure 3 shows the A4-platform and the models derived from it. Note: the full number of models and variants is not shown (i.e. the different variants of bodies, such as hatchback, sedan, convertible etc.)[122]

Fig. 3: Volkswagen's A4-platform and the models derived from it

The next chapter highlights the benefits that are achieved with the A-platform.

4.1.2 *Benefits Realised by the Platform Strategy*

In general the Volkswagen corporation is one of the most frequent users of platform strategies globally. In 2005 there are already 18 car models based on the A-platform's successors, the PQ33 to PQ36 with a total production output of almost 2.1 million cars per year (see figure 4).[123]

Platform		**Output numbers**
A2	A520 lao, Feng Yun lao, Jetta	118890
B-VX62	Alhambra, Galaxy, Sharan	34376
B2	Santana, Santana 2/3000	123235
B4/B5	Santana	5495
BUGATTI	Veyron	50
C3	Mingshi	
LAMBORGHINI	Gallardo, Murcielago, R8	2147
PL/PQ46-47	A4, A4 Cabrio, A6, Alhambra, Eos, Passat, Passat Coupe, Q6, Sharan, Superb	977284
PL/PQ48	A4, A4 Cabrio, A6, Beduin, C1, Coupe, Passat, Q5	
PL22	Gol, Parati, Saverio LB20	333472
PL45	Passat, Passat GP Lingyu, Passat NF, Superb	95904
PL62	A8, Flying Spur, GT, GTC, Phaeton	33557
PL64	A8, GT, Phaeton	
PL71	Cayenne, Q7, Touareg	159245
PQ22	Gol NF, Saveiro NF	
PQ23	Caddy, Polo Classic	26278
PQ24/PQ25	3K, Cordoba, Fabia, Fox, Fox MPV, Ibiza, Ibiza MPV, Polo, Polo Classic, Polo MPV, RoomsterRoomster Van	1071445
PQ31	Caddy, Citi, Golf	27113
PQ33/PQ34	A3, Bora, Golf, Jetta, Leon, New Beetle, New Jetta, Octavia, Santana 4000, TT	221348
PQ35/PQ36	A3, Altea, Bora, Caddy Van, Compact SUV, Golf, Golf Plus, Jetta, Jetta Wagon, Laura, Leon, Octavia, Sagitar, Scirocco, Toledo, Touran, TT	1839115
BENTLEY	Arnage	
T2	Kombi	13237
T5	Pickup, Transporter	199756
Total		**5281947**

121 Schmid & Anders (2001)

122 Dudenhöffer (1997)

123 CSM worldwide (2006)

The A-platform not only acts as base module that stays the same for every variant of a car model, but also is used across different products. Thus, the A-platform is an elementary determinate of all members of an automotive family, that base upon it. Components, production knowledge and production processes together form the particular product platform.[124]

A fundamental benefit of the A-platform is not having to start all the development steps from scratch for every model derived from the platform. Generic and specific tasks can be isolated and done separately. Systematic procedures or the whole process of information search and information processing can be combined in one central spot. By doing so the efficiency of development and production procedures can be enhanced significantly by standardizing and refining cross-project tasks. It is for example sufficient for the A-platform to define costs for certain modules only one time.[125] For any series of models that is to follow, only the information base for the costs has to be updated.

It is assumed that doubling the numbers in production output leads to a cost reduction of 6 to 10 percent.[126] Keeping in mind that the A-Platform is just one out of many within Volkswagen, the potential of savings becomes apparent.

Another example for the reduction of complexity and costs is the module strategy that has been introduced by Volkswagen in 2000.

4.1.3 Module Strategy of Volkswagen

Due to the strong increase of models and variants of the different brands of the Volkswagen group, the complexity of products and production increased as well. The diversity of parts economically was not reasonable for handling anymore. Following a platform based strategy only while introducing more models, the costs for research and development rose significantly.

Implementing the module strategy in a sustainable way can lead to remarkable cost savings and therefore also to competitive advantages. Not only can modules be found across different brands, but also across different segments. Several modules are used in several models and brands of the Volkswagen corporation. The module assembling can be practiced from the entry model to the luxury automobile. The effects of scales that unfold from that are of benefit especially for large-scale producers with a high number of brands. This is the case for the Volkswagen corporation. Moreover the shortening of the product cycle that had been sought for was not achieved.[127]

124 Haf (2001)
125 Junge (2005)
126 Stürmer & King (2007)
127 Klobes (2005)

Figure 5 shows an example of the strategies that Volkswagen is following for its modules. The upper part depicting a product outline in which each platform has its own specific modules. The lower part gives an example of how modules are shared across platforms. These strategies are derived from the critical issues discussed above.

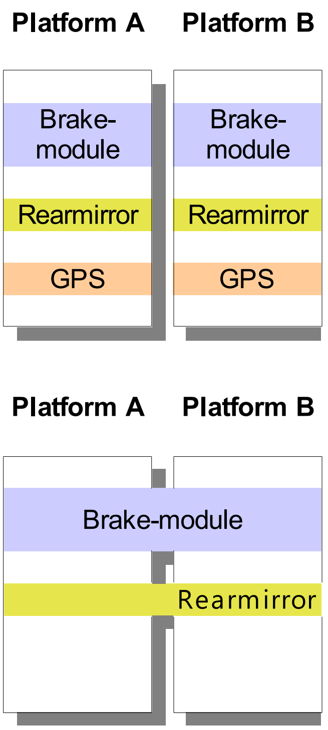


Fig. 5: Volkswagen's module strategies[128]

The life cycle of a module is approximately 12 years. Small changes however can still be done. In contrast the life cycle of a platform is around 7 years. "Following the module strategy consequently, 20 to 30 [percent] of the development costs can be saved. (…) By doing so, capacities for development can be used more efficiently and resources can be reallocated. Also the development time and costs can be reduced and adapted to the changed demands of the market (...)"[129]

In accordance with the strategy shown in figure 5 on the right side, modules have to be constructed only one time across different platforms. Before using modularization, several modules had been designed for particular platforms respectively models (as can be seen on the left side of figure 5).

128 Klobes (2005)
129 Klobes (2005)

5 *Summary and Findings*

Chapters 1 to 4 introduced the concepts and strategies underlying platforming and modularization from a theoretical point of view. Using the automotive industry as an example these chapters also defined the technical terms.

In order to provide a more fundamental understanding of the relevance and benefits of platforms, also literature findings are to be given in the following paragraphs. A lot of studies come to the conclusion that a high number of product variants is a means to better meet the customer's requirements, thus ensuring the success of the enterprise.[130] [131] [132] [133]

In the long run a company successfully managing a product platform, as well as implementing the required changes within the company's structure and processes is able to offer a high variety at comparatively low costs. [134] [135] [136] [137] [138]

Taking into account the analyzes of the automotive industry and literature findings to date, the following hypotheses on success factors of platforms and modular designs are put forward:

a) a platform itself will neither guarantee a faster time to market in developing new products nor will it guarantee a higher acceptance by the customer. The market pull has to be at a level that justifies the introduction of the platform. Especially for consumer products emotional bindings towards a product as a whole or attributes attached to that product rank above technical needs. The incentive to start building up a platform therefore has to come from outside the company. However, measuring market pull and identifying the needs of the customers remains a tremendous challenge.

b) The product life cycle heavily influences the success of a platform. While industrial goods usually show a relatively long life cycle and are less inclined to undergo constant renewal or updates, a rather short life cycle characterizes consumer products. For this reason establishing a platform for the development and production of a consumer product is much harder to accomplish as it usually calls for an already well established platform that also includes a process platform, an adapted production and supply chain configuration.

130 Dertouzos (1989)
131 Kahn (1998)
132 MacDuffie, Sethuraman, & Fisher (1996)
133 Stalk & Hout (1990)
134 Meyer, Tertzakian, & Utterback (1997)
135 Meyer & Lehnerd (1997)
136 Robertson & Ulrich (1998)
137 Sawhney (1998)
138 Ulrich (1995)

c) The level of commonality vs. modularity acts as a metric for the success of a platforming strategy. While modularity strives towards decomposition of the product and thus enabling a high number of variants, it also drives production costs. Commonality on the other hand aims towards grouping of similar modules or product variants, lowering production costs, but via clustering also lowering the number of variants, leaving less choice and attractiveness of the product for the customers. The balance between commonality and modularity is a major success factor.

The effects of the financial crises that hit the world in 2008, the growing pressure for more efficiency, the increase of complexity and differentiation, set the outline in which the producing industry has to function. If one company seeks to outrun the others, the key lies in

- the reduction of complexity for the development and production of new products,
- the unconfined orientation towards the market by following the customer's needs and
- the reduction of costs in all parts of the company.

A platform that is built from several modules can be used across different segments, giving the entrepreneur a powerful and most versatile tool for reducing complexity. It also enables him to offer products that easily adapt to the changing demands of the market. The module has to be developed one time only, taking into account the existing platforms across the OEM. Needless to say the effects of scale are utilized in a most efficient way and the number of variants is diminished.

Looking at the history of platforming and modularization, it becomes clear that the future will see a lot more of it. Nevertheless the strategies of platforms and the concepts of modules must not be regarded as a silver bullet or a guarantee for success. Without a close ear to the market and the perpetual alignment of the structures of all the processes of a company, the platform strategy and modularization is bound to come to naught.

The following chapters will test these hypotheses on two examples of industrial platforms from practical experiences.

6 Platforming for Consumer Products

Although the car industry can be regarded as the crib, the nursery ground and the pacemaker for the concept of platforms and modular production, it nevertheless is not the only branch of industry that quickly adapted the idea and fit it to its needs. Especially those industries that derive significant benefits in mass customization from platforms and modular designs can often be found in the field of consumer products.

The term ‘‘consumer product’’ refers to “any article, or component part thereof, produced or distributed (i) for sale to a consumer for use in or around a permanent or temporary household or residence, a school, in recreation, or otherwise, or (ii) for the personal use, consumption or enjoyment of a consumer in or around a permanent or temporary household or residence, a school, in recreation, or otherwise; but such term does not include— (A) any article which is not customarily produced or distributed for sale to, or use or consumption by, or enjoyment of, a consumer (...)”[139] Following this definition the example used in this thesis will be common domestic appliances intended for the personal care in private households.

6.1 Development of Domestic Appliances for Personal Care

The development of the product as an example given in this chapter takes place in the time span between 2000 and 2003. It is not the very first of its kind, but a successors of an existing product line. It however sets a milestone in product development as it represents a major innovation in the way the company tackled a challenge.

The company the development is set within is one of the major actors in the field of consumer products worldwide. Founded over 100 years ago in the middle of Europe it currently employs more than 100.000 people in more than 60 countries. It's an incorporated company with an annual turnover of 23 billion Euro in 2009. The company is active in a variety of different fields of operation. However after restructuring taking place between 2006 and 2008 now concentrates on lifestyle, lighting and healthcare products. The company does not only develop products, but also holds its own production facilities worldwide. Alas due to the process of restructuring, a growing number of products are being produced externally, mainly in Asia and Eastern Europe. In addition to that the use of suppliers also for product developments is greatly increased.

139 U.S. Consumer Product Safety Act

The company heavily relies on supply chain management and began global sourcing of modules and manufacturing services at an early stage. It is laid down within the company's philosophy to transfer other companies that are seen capable of manufacturing readily developed products ("OEM suppliers" in the terms of the company) into suppliers that are also being able to do parts or the full extent of product development ("ODM suppliers"). Candidates for this transfer are mostly found in Asia, the majority in China.

By doing so the company aims towards focusing on core competencies in product development. A majority of the end customers are still situated in Europe and the Americas. For this reason also the product development is mainly set in western countries. However with the growing needs of the Asian market, more and more product development projects are being transferred either to company-owned development centers in Asia or to Asian externals, specialized on product development. It is a common belief that by rapidly gaining access to a vast and changing field of development and production knowledge, not only will costs for development be driven down, but also time to market for new products will be decreased.

As the products still have to be sold also on the western markets, the design studio for key products remains in Europe. Consumer products more than others are sold via emotional bindings of the customers (see chapter 2.2.1). It is this insight that led automotive companies like Kia or Hyundai to put the responsibility of their cars' design into the hands of Europeans.

6.2 Coping of a Major European Consumer Produer with Low Cost Competitors Entering the Market: the Example of the Electrical Toothbrush

First to the market in the 1950s, the electrical toothbrush soon became a very common tool for the personal care every day. The company introduced above is known for its home appliance dental care products on the consumer market and is one of the major vendors of electrical toothbrushes globally.

However with the arising offers for similar products on the home appliance market especially from the Asian countries, the company saw itself faced with a growing number of competitors. Supplying a variety of easy to use, simply constructed and low priced electrical toothbrushes, those competitors were threatening the position of the company at the end of the 20th century. By that time the perception of electrical toothbrushes as semi-professional devices allowing for a higher price had vanished, thus lowering the market entry barriers significantly. This was due to the fact that a lower quality perception was accepted by the customers.

Being put under pressure from the low priced end of the market, the company was forced to come up with a strategy that would keep the low end / low price competition far away from the mid and high end sector of the market. Reflecting the behavior of the Asian newcomers to the market, the company sought for a high market penetration with a low cost product. In order to be able to do so,

- new ways of cost reduction had to be developed,
- possible new features for future markets had to be prepared and
- order-fulfillment-cycle-times had to be reduced sharply.

The ultimate goal was to come to the market very quickly, though still being able to expand horizontally, maintaining flexibility for a number of features yet unknown at the moment of launching the product. It was decided to go for a platform approach at an early stage of the project. The next chapters will show why and how this was planned for, will describe the impact onto the development of the product and which the results in numbers were.

6.2.1 Planning a Platform and Modules Approach for the Production of Electrical Toothbrushes

The terms that have been introduced in the chapters before will be used in the chapters to follow, keeping their very same meaning. However as every organization defines their own word of art, new explanations of terms will be given when necessary.

The planning of a platform approach by the company used as an example started out with setting up the goals and measures in order to be able to align the company policy across the various departments (research and development, production, logistics etc.) and keep track of the progress of restructuring. Initially two key performance indicators were chosen:

- the product renewal rate and
- the product innovation level.

As for the product renewal rate, it was analyzed that the portfolio so far had seen a renewal every three years. This rate was regarded as too low and the goal was set for a renewal every twelve to eighteen months. The definition of the renewal rate is: the time at which a particular product or range will be in the market before another actualization, upgrade or redesign occurs. New versions are seen as additions to the portfolio, while an actualization, upgrade or redesign replaces a previous product. An actualization might also be a new product or range with only small changes using an existing architecture. An upgrade consists of a new product or range with a specification improvement (higher technical specification) by the use of a new building block that fits in the existing product family architecture.

Defining a means to quantify the product innovation level and setting a specific future goal that would allow for checking on the progress, however, was not done. One can state that the level of innovation is much harder to define and convert into traceable numbers.

The company aimed at the following benefits:

- reducing the design efforts and thus
- reducing the time to market of products, to be realized within a defined architecture.

Besides these two main benefits, also smaller advantages were in focus:

- the ability to produce customer specific versions in small series,
- an improvement in quality,
- a significant cost reduction and
- the possibility to outsource the development and production of single modules.

The company sought for a best practice example suitable for guiding through the process of restructuring. "The case of the Sony Walkman" was found to be close enough to the field of products offered by the company to act as such an example. [140]

The company extracted basic rules out of the strategy that Sony had shown in the 1970s and 1980s for their "Walkman", that were considered universally fit for their own product portfolio and processes:

- how to quickly come up with a high number of variants,
- how to customize products for different local markets, without having to introduce a new design,
- how to successfully segment markets in order to achieve different pricing and
- how to build up a supply chain that is able to support all of the above mentioned.

By following the leading example of the success story of Sony, a major goal was to reach market share leadership of 45 to 50% by

- covering all price levels,
- including also relatively small niche markets and
- optimizing the portfolio for specific regions.

140 Sanderson & Uzumeri (1997)

By doing so the company expected to be able to gain a premium price, thus creating a highly profitable business and still being perceived as an innovator. The first challenge in doing so, was identified as simultaneously managing

- variety intensity (only different re-arrangement of existing features or cosmetic changes) and
- change intensity (introducing new features or improvements).

Proving to be successful in this would, so the planning was, result in being first to the market, by this setting high market entry barriers, that would be keeping the competition away. On the way to reach the set goals, the key success factors were defined as

- setting up and maintaining a fully functional product variety strategy,
- decentralize leadership globally in order to nurture a regional market pull and
- fully exploit the product designers to include them in cutting down the cost of changes and improve the designs for optimized production.

However promising the approach of an integral platform might have seemed at that moment, the management yet was aware of the fact, that a product platform is not the universal remedy for each and every challenge to come up. For this reason a decision guidance was invented to aid in approving or rejecting an architectural approach.

6.2.2 Deciding upon a Platform and Modular Design Approach for the Production of Electrical Toothbrushes

The indicators that signal the necessity for a platform approach were divided into external and internal symptoms:

- external symptoms:
  - yet unexplored markets (new areas of business)
  - high speed of technical changes
  - no predictable model for order entry (sales forecast)
  - high number of competitors
  - high wish for tailored products

- internal symptoms:
  - high number of changes in production necessary during lifetime

- cost-down processes necessary
- functional improvements or feature upgrades necessary
- rising of costs for product distribution

Unexplored markets or new fields of activities for any enterprise are challenging. If there is already a significant number of competitors on the market, the market entry barriers usually are set up high and there is no expertise within the organization of how to act on that specific market. Taking this into account, the company found the platform approach to be a helpful instrument to conquer new markets. In order not only to enter new areas of business, but also to dominate these new markets would require the company to be more innovative than the competitors and also to realize a faster innovation time.

This of course also helps in keeping up with the high speed of technical changes the market undergoes and in particular setting the pace for the competitors to follow. By being fast, innovative and flexible in adapting, the fluctuation in order entry and the wish for tailored products resulting in a growth of variants are not only met, but mastered. Thus giving an additional advantage over competitors.

It was therefore decided to step away from the innovation creation process as it had been known and practiced so far and move on towards a platform based model as a means to be able to react quicker and increase the innovation output over time.

The traditional innovation process was set up as a serial progression, where production followed product development, which followed the market requirements. Those were defined by volume, price, performance and diversity.

The new approach acknowledged the need for speed of innovation and flexibility. It also integrates the supply chain at a much earlier stage of planning and in parallel provided for the development of a platform, that the product will be based upon:

1. market requirements • volume • price • performance • diversity • flexibility	2a. development of a supply chain platform 2b. development of a product platform	3. product development	4. production

The internal symptoms calling for a platform based approach are just as important as the external symptoms, but mostly are driven by a cost point of view. If the production sees that a high number of changes is necessary, it is clear that the quick adaption will be crucial for keeping set-up costs down. A high number of cost-down processes or functional improvements as well as feature upgrades having to be done during lifetime are an unmistakable signal for a product development process, that was either not suited to meet the requirements of the market or to fit to the supply chain used by the organization. Also here the introduction of a supply chain platform and a product platform before product development serves as a means to cut down costs. How this is achieved will be shown by an example in the following chapter.

According to some authors, there are four basic strategies in product development:[141]

- global design product using newly developed platform (global standardization),
- local design product using newly developed platform,
- global design product using old platform and
- local design product using old platform.

Whatever strategy is chosen – each of them requires the presence of a functioning platform. Global design enables the company to reduce development costs and time, as the development activities can be realized once and then being rolled out globally. However it may be hard to meet the specific requirements of the local markets in some cases. Purely developing locally ("on the market, for the market") on the other hand will make it easier to meet the needs of the local market, while not granting the company to use economies of scales in development work – at least not to full extend.

Choosing a new or old platform based strategy also is of high importance for the success of the product line. While old platforms have the advantages of being proven, reliable and already introduced into production, the end-customers might not be fond of the old design or technology – especially for consumer products. In addition to that customers' usually show different likings depending on their cultural backgrounds and locations. These might require varying processes and differentiation of the product (design localizations). It has to be decided if these localization efforts are to be carried out in the centralized development facility (following a global design strategy) or in the decentralized, local facilities (following a local design strategy).

141 Sugiyama & Fujimoto (2000)

However, the company might opt for a centralized development with a local adaptation to the market. In this case, a modular design based on a platform, offers the best compromise, by helping to keep the advantages of a centrally developed, global product and at the same time meeting the requirements of the different local markets. Even more, offering the possibility of creating differentiation via the design of different modules.[142] Deciding for a modular design based on a platform makes it easier to de-concentrate if necessary even at later moments within the lifetime of a product.

For an organization operating globally also the distribution strategy naturally varies by territory. The rising of costs for shipping or generally for distribution to the end-customer markets serves as an evidence for the need for a more wide spread assembly and customization of the products. By identifying the different requirements of the customers worldwide, it is obvious that a solution tailored for each specific market also always calls for a decentralized assembly in order to cut down costs of transportation. As the company offers different products or product variants to different markets, it needs to select the appropriate distribution channel. The platform approach not only helps in realizing a tailored solution, it also enables the organization to quickly adapt to the varying demands of its different buyer markets, e.g. changes in volumes. Only with the possibility of a modular platform design and a supply chain platform that allows for flexible sourcing of parts, there is an opportunity of rapidly constructing and manufacturing products that are fit for local markets.

6.2.3 The Platform Approach: an Example of Setting up a Platform for a Consumer Product

As briefly described, the company discussed above saw itself faced with a growing number of competitors on the market of electrical toothbrushes for home users. Because of the strong growth of the market (approximately 10% per year) and the attractiveness of the business unit (high margins, already present and keeping a relevant market share), the decision was made not to pull out, but to stay, hold and extend the position within the following two years.

The move towards using a platform in order to improve the overall supply chain performance was connected with the goals to

- increase flexibility,
- amend responsiveness (the ability to quickly act on changes in needs coming from the market),
  - lower production cost,
  - reduce the logistic costs and
  - increase sales numbers.

142 Bartlett & Ghoshal (1992)

The change in the supply chain was driven not only by the wish to lower the logistic costs, but also due to the fact that the usual buyers, in particular national sales organizations, were inclined to react quicker to market responses. This meant that they would move from ordering at an earlier stage in the product development time-schedule to a later point of time, in order to be able to give a more detailed input into what the product should look like and what it should feature. By doing so, the product creation process was split into two parts: one that was the same for every variant and one that was done according to the specific order of the buyer.

This “make-to-order” or “assemble-to-order” production is described as decoupling of certain steps in product creation. Processes within the supply chain (production, assembly or development etc.) are on hold until the buyer has placed his order.[143]

The company chose the global standardization strategy using a platform that was to be newly developed and designed for the whole world. By doing so, not only the product itself could be planned and designed according to the needs of the market, but also the production site could be laid out as a greenfield project. Thus the complete development, production and logistic processes followed the recommendations and requirements derived from a holistic platform approach.

6.2.3.1 Defining the Platform

The company chose a two-dimensional model for defining the shape and coverage of the platform. Although the literature holds a vast amount of different approaches of how to define a suited platform, the rather simple approach was thought of as being robust and reliable for a first attempt. It included a segmentation of the market into different quality perceptions, which would involve look-and-feel as well as technical features, and the introduction and replacement of product lines over time (see figure 6).

As the company was striving towards creating a structure that would be robust to future design changes, the platform comprised the complete set of market segmentation. Due to the linearity and simpleness, it also allowed for easy re-use of parts and reducing the engineering efforts for follow-up or parallel designs. Thus it enabled a quick generation of new variants (derivatives, upgrades etc.).

143 Van Hoek (2001)

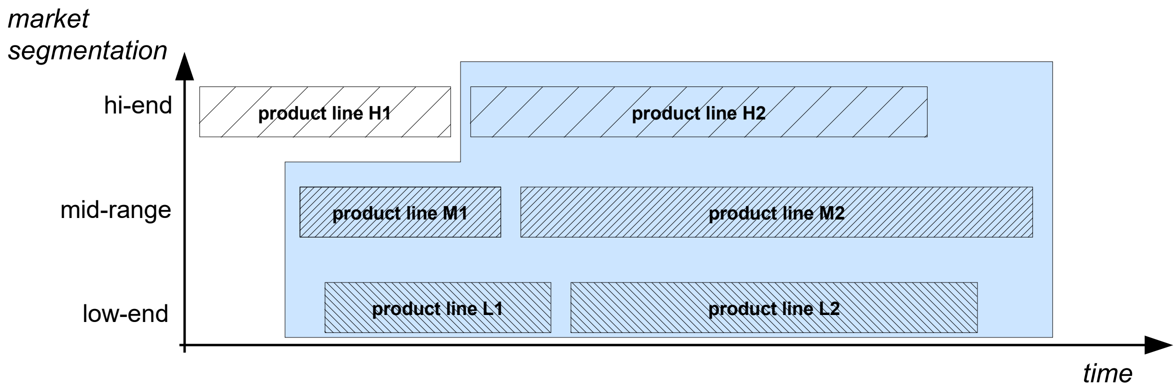


Fig. 6: Two-Dimensional Platform Outline, Basic Principle

It was determined upfront which components would need to change over time and how this would influence the connection to other components, resp. changing the other components. In order to be able to create a reliable roadmap for future developments, possible causes for necessary changes were identified.

6.2.3.2 Identifying Reasons for Change

There are various reasons why a change in components can occur during the lifetime of a product. In the case at hand, the following were identified:

- external reasons:
  - markets require a better performance (expectations have increased, pressure from competition has grown)
  - markets require a differentiation in product design (product lines, types, executions, derivatives etc.)
  - markets require lower prices (pressure from competition)
  - markets require changes due to new regulations, norms or standards
- internal reasons:
  - technological progress (new technology available)
  - costs reduction program

All of the reasons listed above were summarized in a change survey, allowing for tracking down the different directions of change resulting in updated roadmaps. Thus the company was able to categorize the expected and planned for changes and attach a time stamp to them.

6.2.3.3 *The Effect of the Chosen Platform and Module Strategy on the Product Structure*

The next step was to determine and visualize how the complete product structure was affected and highlight the impact areas of the changes. Explicit reasons why a certain component was subject to change were given and a ranking based on the degree of component redesign was done. In general the company split up the product into modules and interfaces (see chapter 3.2) and set up the product structure as well as the production and logistic site accordingly.

In this case the decomposition of the product into modules and the definition of the interfaces that determine how the modules interact within the product (see figure 7) was done by taking into account the following criteria:

- ability to generate adequate decoupling,
- robustness and
- suitability for standardization.

The interfaces then were defined according to their functional and mechanical attributes, thus enabling the development of the physical parts as well as integrating design and handling aspects that later on would be of high importance for marketing the product line.

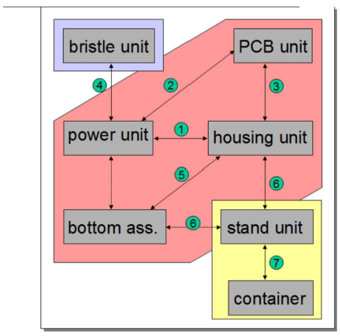


Fig. 7: Breakdown of the Product into Modules (Grey Boxes) and Interfaces (Numbers)[144]

The approach to solving the problem at hand was determined by the model the company had chosen for their product developments: the V-model. Introduced in 1992, it is quite often referred to as the standard in software development. However, there exist not only a variety of V-models, but it's also used outside of software related projects and has established itself as a standard in development projects. The type used in this example is the "German V-model".[145]

144 company internal

145 http://www.cio.bund.de/Web/DE/Architekturen-und-Standards/V-Modell-XT/vmodell_xt_node.html (13.7.2016)

Within the scope given by the model to the project team, there still was the necessity to define the modules (and their interfaces). It's evident that the quality of the work invested at this stage of the project will not determine the quality of the final result by time, cost, flexibility and other criteria. At this point an approach that would just serve technical requirements and neglect other aspects (such as the economical) is bound to put the success of the project at risk later. To ensure that no requirement is missed and the systematic approaches in problem solving and solution designing are fully applied, may seem obvious, but often proves to be a challenge.

In many cases the leading persons in development projects come from a purely technical background. Therefore they may tend to neglect other, non technical requirements. By following the rules of systematic design a “technical person”, such as an engineer, is enabled to merge his expertise with design methodology. Ideally this will ensure topics such as the general psychology of thought processes, value creation and others are covered.[146]

The number of guidelines on how to ensure a systematic approach to problem solving is too high to be included in this thesis. It should be mentioned however that every guideline – as well as the development model itself – can only serve as an auxiliary means to the people involved. There are no standard recipes that can be applied to every way of looking at a problem and that will lead to achieving the project's goal. Yet a trusted and proven methodology will help increase the repeatability and probability of a successful outcome.[147]

Choosing the right methodology and participants for a development project often enough is less complicated than answering the question if the requirements for utilizing a platform are met. This will be shown in the following text.

146 Pahl, Beitz (1993)

147 Pahl, Beitz (1993)

No.	Functional Interaction	Mechanical Interaction
1	• positioning & fixation • on/off switching • encapsulation, stability, protection • sealing	• function ◦ positioning ◦ switching ◦ sealing • geometry ◦ geometrical volume • fixation ◦ snap fits • process interface ◦ orientation for assembly, guiding / locating surfaces
2	• positioning & fixation • electrical connection	• function ◦ interconnection: pinning ◦ positioning • geometry ◦ references ◦ dimensioning • fixation ◦ position, dimensions, tolerances • process ◦ soldering process: process description
3	• alignment of LED and LED window • encapsulation	• function ◦ positioning of LED: relative dimensioning and tolerances • geometry ◦ geometrical volume as constrained by the PCB (and power unit) exterior
4	• bristle positioning & fixation • shaft rotation • bristle exchange	• function ◦ positioning ◦ fixation (holding force, forward & backward compatibility) ◦ shaft rotation movement, friction and load • geometry ◦ geometrical volume (envelope) as constrained by power unit exterior • fixation ◦ snap fit
5	• closure • sealing • battery disposal • design match	• function ◦ closure construction ◦ sealing mechanism (o-ring, hardness, tolerances) ◦ bottom assembly removal ◦ relative positioning, color match, etc. • geometry ◦ see above • fixation ◦ see above • process ◦ orientation for assembly, assembly tool, defined stop ◦ greasing (for sealing)
6	• stable positioning • energy transfer • easy in/out	• function ◦ positioning: references, support ◦ relative positioning ◦ guiding surfaces, easy in/out • geometry ◦ geometrical volume (envelope) and styling as defined by brush handle
7	• positioning & fixation • design match • removal for cleaning	• function ◦ positioning ◦ fixation incl. removal ◦ design interface description • geometry ◦ geometrical contour as constrained by the stand unit • fixation ◦ snap fits

Fig. 8: Definition of the Interfaces [148]

148 company internal

Based on the interfaces and their mechanical and functional attributes (see figure 8), the device was developed. The convertibility and multiple use or re-use of the modules, being distinguishable by their interfaces, were taken into account. Therefore the possibility to interchange and standardize the interfaces was a prerequisite. Interchanging in this context is the feasibility to insert one or more modules into a product architecture without having to touch any of the other modules in the very same product. By doing so, the development resulted in a variety of different modules, of which each could be replaced by another module, should any of the reasons listed in chapter 6.2.3.2 occur at any time. Basically, what was created not only served as a means to cut down on costs, but also offered a tool kit for the launch of a whole bundle of different toothbrushes. Segmenting the market with different product lines, each of them adapted for specific customer requirements, was significantly easier to achieve than before with classical product development the company had been practicing in this business unit so far.

In addition to that the possibility of decoupling now was fully given (see also chapter 6.2.3). The company could to react quicker and more flexible to changes from the customers' side, while having to source less parts, increasing the commonly used parts to create a higher number of variants of the end product (see figure 9).

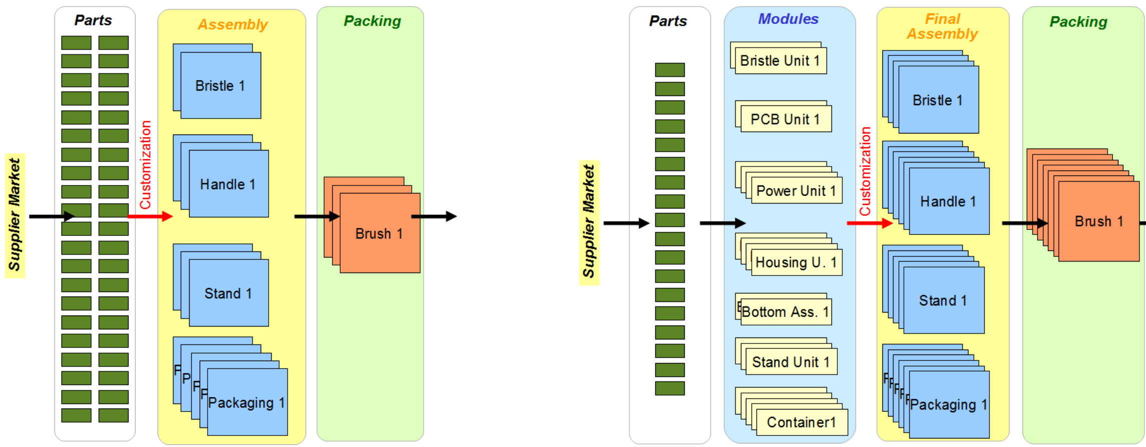


Fig. 9: Traditional SCM (left) vs. Decoupled SCM (right)[149]

149 company internal

One could of course argue that with proper planning the traditional supply chain does allow for customization as well. The main difference between the decoupled and traditional supply chain would then only be a shift of value creation from a 3 step to a 4 step supply chain. It could then be argued that the additional step might equal out the savings that are derived from decreasing the number of initial parts. However it is clearly understood that companies that have to face a market situation described before (see chapter 6.2.2), are in need of a higher flexibility and the potential to fully use that flexibility in product development to outrun the competition in time to market. The ability to quickly react to customer's needs and wishes above all is crucial for the success. By nature the size of any organization runs contrary against flexibility. The larger an organization has become, the more pressure it feels to change long time behavior and structures. The market around it is a heterogeneous mixture that doesn't usually follow a predictable pattern, leaving the company in a situation where information about future needs is limited and planning has in many cases to be done "last minute".

Within these boundaries long term planning can be accomplished in rare cases. Most often the planned product variants will be realized only partly as the changing demands of the market call for different, not foreseen, variants. The skill of efficiently and rapidly develop and create a high number of product variants out of a set of modules and standardized interfaces within a defined product architecture is the utmost goal. For this reason, the gap between planned and realized variants is one of the key characteristics of the platform approach in consumer markets. It also acts as a major criterion in evaluating and improving future product architectures.

On a sideline, a differentiation should be made in the number of product variants that were planned to be developed upfront and the number of product variants that are planned to be derived from them. Those derivative variants are product types and versions that are to be developed and marketed after the first product launch and during the product architecture's life cycle. Also for those not all of the planned variants might be realized later on and a significant number might be introduced ad-hoc, because the market calls for it.

In praxis the possibilities the decoupled supply chain offers within the architectural approach will naturally result in the ability of rapidly interchanging product attributes across variants within the same architectural generation. As a result, also the efforts to ensure backward and forward compatibility (to earlier or upcoming product generations) are greatly reduced leading to faster times to market and economies of scale.

6.3 Realizing a Platform and Modules Approach for a Consumer Product: Summary and Economical Results

The question remains: is the Platform Approach a successful means to reach the set goals? Is the overall supply chain performance improved? The metrics for the performance are:

- increase flexibility,
- amend responsiveness (the ability to quickly act on changes in needs coming from the market),
- lower production cost,
- reduce the logistic costs and
- increase sales numbers.

Answering this question will result in a simple “yes” or “no”, which by itself is of high interest. However in order to be able to repeat the success, improve the next steps or avoid mistakes being done in the process so far, getting the answer to the question “how has it been done?” is of even more interest. Therefore the key success factors have to be looked at closely:

- setting up and maintaining a fully functional product variety strategy,
- decentralize leadership globally in order to nurture a regional market pull and
- fully exploit the product designers to include them in cutting down the cost of changes and improve the designs for optimized production.

6.3.1 Increased Supply Chain and Production Flexibility

Flexibility in this context is defined as the ability to fulfill make-to-order setups within a decoupled supply chain. This means using a late configuration concept to satisfy the need of short term configuration and volume changes while ensuring that smaller minimum order quantities are still cost efficient.

Although more than 70% of the components of the products are common parts, there is a variety of 105 different models. Compared to the predecessor of the product, that still had been developed following the old non-architectural standard, the diversity is increased by factor of 20. Thus it can be stated, that the call for flexibility, the ability to react on varying needs coming from the market is met.

6.3.2 *Amend Responsiveness*

The ability to fulfill the market needs is more or less insignificant without the ability to quickly put the needs into products. In comparison to the predecessor of the product, the lead time to market was reduced to almost 50%. The company is now in the position to serve customer's needs that before were impossible to implement in development and production. By this, new customers in formerly unexplored market niches were being won, e.g. major retailers in the US.

However with the ability to offer what the market calls for comes the necessity to quickly react on any change. For this reason the ramp up time for adapted product variants was decreased from ten days to three days. This means the company was able to install an additional production of a variant in less than a third of the time as before.

6.3.3 *Lower Production Cost*

Due to the architectural approach and the modularity in configuration of the device, the company was able to source out parts of the production into regions with lower labor costs. While this requires training for new employees, the learning curves within production were improved significantly due to the modular and very structured set up of the product. Hence the learning curves decreased from several weeks to some days. As a consequence of the above mentioned, the labor costs decreased by 60%.

In addition to that, the costs for raw and wrought material were driven down by 40%. Although to a certain extent this has to be attributed to the common effects of new product development and newer production procedures, at least a significant part of it derived from the product's modular design. This allowed for effective re-use and commonality, lowering the overall parts of sourced materials.

All in all the output of products per person in production as a key performance indicator for productivity more than doubled from 600 to 1'660, while the production capacity doubled from around 50'000 to above 100'000 pieces per week.

6.3.4 *Reduced Logistic Costs*

As transportation causes the major part of logistic costs, this thesis will focus on the costs for physical movement of parts and products. Without having figures available it can be stated that by reducing the number of externally sourced parts (see figure 9), the costs for transportation to the production sites was cut down. The costs from the production sites to the distributors was cut down as well, as the outsourcing of production to decentralized sites shortened the transport distances: practicing localized production reduced the standard shipment throughput time (maritime freight) from around 9 weeks to 1 or 2 weeks.

6.3.5 *Increased Sales Numbers*

As written before (see chapter 6.2.1) the major goal was to defend and extend the own positioning on the market. In order to check on the success of the attempt, the sales numbers are the main key performance indicator.

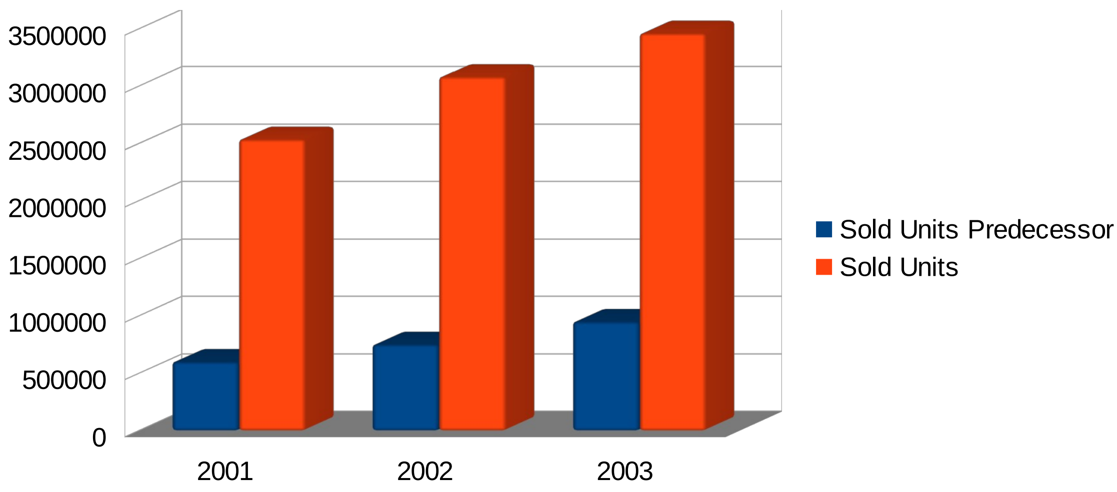


Fig. 10: Sales Numbers

It can be seen from the sales numbers that already with the introduction of the newly developed device, the sales numbers exceeded those of the predecessor by factor 3 to 4.

The set goals of

- covering all price levels,
- including also relatively small niche markets and
- optimizing the portfolio for specific regions

have been achieved partially. The product covers different price levels in the low and mid-end section of the market. The high-end section is left uncovered by this particular device due to company internal politics and the acquisition of a former competitor, whose products mainly consist of high-priced models.

At the time of product launch another competitor introduced a very low priced product (5 US$ compared to the average price of 50 US$) that did not require charging, but ran on disposable batteries. Although this competitive product neglects attributes, such as sustainability or quality perception, it turned out to be the best selling electric toothbrush of that year in the US. This mainly was credited for its comparatively good performance in combination with its low price.[150]

Optimizing the portfolio for specific regions was accomplished: the variety of over 100 different models allows for a customized portfolio that is adapted to the local needs.

The set goal to reach market share leadership of 45 to 50% was not achieved. However at present the company increased its share and now holds a stable market share in Europe of around 14%.[151] The goal of defending this share and not being driven out of the market by cheap products from emerging economies was achieved.

Comparing the set goals and the outcome on the market, the platforming approach of the company can not be regarded as a full success. The following chapter will show the reasons for this.

150 Mankin (2004)

151 company internal investigation

6.4 The Example of the Electrical Toothbrush: Conclusion and Findings

To generate a wider and more comprehensible view on the reasons, a holistic perspective is given in fig. 11.

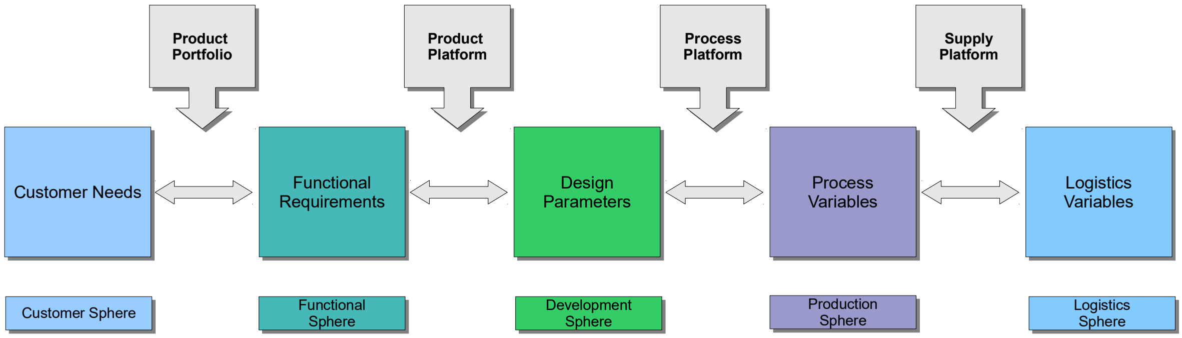


Fig. 11: Overview of Platform Design and Structure[152]

Beginning the analysis at the end, problems in solving the logistical tasks are not considered to be the root cause of not reaching the set goals. The company carries a world-wide logistical network that is more than capable of handling even more challenging tasks. The closely knit network between national sales organizations and globally spread stock keeping ensures very short delivery times. The supply platform in itself is proven to be resilient and flexible.

152 Suh (2001)

The production process within the company is characterized as explicitly laid out for the purpose of a flexible, modular configuration to fully meet the requirements of the product platform. Taking into account the commonalities of the product family and following the actual findings of modern production layout, it transfers the variety of the product structure directly into the plant configuration. After lengthy considerations the company chose to install a hybrid version of an assembly line: one part following the traditional shop layout for larger batches and moderately skilled workers and one part as an “atelier”, where smaller batches are processed and special requirements are fulfilled by higher skilled employees. As described above, this layout followed the design of the product platform: one part is set up as commonalities, the other part is more freely arranged as modules.

As shown in chapter 6.2.3.3, the development of the product family followed the findings and recommendations that are given in literature. A decoupled production enabled the company to offer a full make-to-order production. Two forms of postponement are identified by literature: time and form postponement.[153] In the first case the delivery of the products is postponed until the order of the customer arrives. In the latter, the differentiation of the product is put to a later stage of the supply chain. As explained above, the company practices form postponement, thus increasing the lead-time performance. Also here, the hybrid structure of the whole platform setup becomes visible again: form postponement usually results in a mixture of make-to-stock and make-to-order set-up of production, fit to offer common components and customized products.[154]

Also as shown above (see figure 7) the development of the platform consequently is derived from the functional requirements identified beforehand. The company is equipped with many years of product development, production and distribution of electrical toothbrushes and breaking down the functionality of these devices is done without any efforts.

According to the analyses far the company's strategy does not show any significant flaws. The four last blocks of platform can be considered to be successfully met. However, the very first block, fulfilling the customer needs obviously is neglected. This circumstance is quite clearly the reason for not reaching the set goals. A more detailed analysis will reveal the cause.

153 Zinn & Bowersox (1988)
154 Su, Chang, & Ferguson (2005)

Being faced with what is perceived as a flooding of cheaper models from various competitors, the company decided to offer a broader variety of products, letting the customer choose according to his likings. What is not seen though is the lack of market pull: the customers neither perceived the electrical toothbrush as a technologically advanced asset, nor did they feel emotionally bound to it. Not later than the mid of the 1990s the electrical toothbrush has become an instrument of personal care that is a commodity product.

The positioning of the product variety on the suitable market is not favorable. Giving the customer more choices than they really call for creates more problems and evolves in higher costs than initially expected and planned for.[155]

Another disadvantageous circumstance is the timing: at the moment of introduction to the market, another competitor offered a product that is perceived by the customers as “doing the job well” while only costing 10%. The whole set-up of the production and development process within the company does allow for a reduction of time to market – but only compared to the predecessor of the product. In comparison to the competition the companies' processes are still too lengthy and time consuming. For that reason the development of a low-cost version of the toothbrush is not possible within the very fast life cycle of this commodity product. Success is to be achieved on the long run, following a path of continuous improvement and renewals. [133]

The company is caught in the middle between having to earn the money invested into the introduction of the platform and coming up with a cheaper solution. The number of modules within the platform doesn't allow for opening a wider window of cost reduction as those have been specifically introduced and fixed within the platform as a means of driving up variety and becoming more attractive on different market. On the other hand the level of commonality is not high enough to effectively reduce the costs.

The reasons given above support the three hypotheses introduced in chapter 5:

a) The market pull is not strong enough, there are no real incentives from outside the company for a platform development.

b) The development of the first, initial platform takes more time than the development of a single, stand-alone product. Thus delaying the time-to-market for the first product.

155 Pine (1993)
133 Meyer & Lehnerd (1997)

c) The balance between the usage of common parts and modules is not ideal. While being able to offer a very high variety, the costs for producing the toothbrush remain on a relatively high level compared to competition.

Companies in the automotive or other industries for consumer products however are not the only ones utilizing platforming. As it has been shown before, the idea behind platforms was spread in the last decades to a variety of producing industries. This chapter will show a platform that evolved over several product generations and how the platform was the essential factor in the success of the products involved.

The product being examined consists of a family of process instruments. Or in other words, instrumentation that is used for the measurement of physical parameters, like pressure, temperature, flow of liquids and gases. While in all-day life most people never come across that kind of measurement, there is virtually no industry that could do without. Be it for the composition of reagents in the chemical or pharmaceutical industry, the exploitation and refining of hydrocarbons, the lacquering of a car or the production of dairy products or other food, the market for process instrumentation continues to grow tremendously every year.

There is a broad variety of ways to measure physical parameters. There are many methods on the market that have been for used for very long times and mostly are based on mechanical principles (counting of rotations, mechanical display of stress and tension etc.) or rely on standard effects (differential pressure meters etc.) Although there are still niches for those principles, there is a clear trend towards more modern and sophisticated meters. These more advanced principles come with a bundle of advantages such as non-moving parts for lesser wear and tear (and even non-contacting principles, such as the clamp-on ultrasonic meter), lower measurement uncertainties and diagnostic functions that help the users reduce process costs very effectively.[156]

The vast majority of process instruments available on the market consists of two parts:

- one part (called *sensor*) that is the interface to the process, taking up the physical measurand (pressure, temperature, flow, weight etc.) and
-
- another part (called *transmitter* or *electronics*) that is the interface to the operator and/or the process control system by transforming the analogue signals from the sensor into mostly digital signals that can be used by the process control system. This part also ensures the power supply to the sensor.

The example used in this thesis will concentrate mainly on one measurement principle.

156 Tränkler, Reindl (2014)

7.1 *The Significance of Flow Meters*

Since the introduction of the first commercial flow meters, that utilized electronic parts and algorithms, these meters have been constantly gaining market share due to their outstanding technical features. Conventional meters basically sense the movement of mechanical parts, for example counting the rotations of a gear-work, or recording the different pressures in a pipe caused by an obstruction.

In those cases, the measuring apparatus is required to move mechanical parts by direct contact with the fluid that is to be measured. This causes wear and tear and also pressure loss which calls for stronger pumps for example, which increase the costs of measurement. Modern measurement principle, such as the electromagnetic, thermal, ultrasonic principle or Coriolis, usually come without or far less than these disadvantages. Above the measurement of the flow rate, some modern variants of flow meters also can inform the operator about other parameters like temperature, pressure or density of the measurand. Thus not only is the need for additional meters reduced, but also the costs and the complexity of the plant are cut down.

In a nutshell, modern principles terminate a lot of disadvantages, while also featuring lower measurement uncertainty and higher repeatability. It doesn't surprise therefore that these principles have been on a constant march of success throughout all industries – be it in pharmaceutical applications, in waste-water treatment or in refineries.

7.2 *Introduction of the Company*

The company whose product is used as an example is part of an instrumentation and process automation enterprise founded in the 20^{th} century in Europe. It can be considered a global actor in the instrumentation market consisting of more than 80 companies.

The product basket of the whole enterprise consists of instruments measuring level, flow, pressure, temperature and other variables. The company itself produces a range of instrumentation designed for industrial flow measurement.

After substantial growth, the enterprise made its way to the position of a technological leader in the late 20^{th} century and is to be found as market leader in a number of countries and industries.

The company that belongs to the above mentioned enterprise traditionally is regarded to take the role of a technology follower – not a first-to-market.

7.3 Second to Market Development of a Flow Meter

After having produced flow meters based on the electromagnetic principle for already several years, the company identified the need for expanding their portfolio towards a more sophisticated and modern principle, because the prices for electromagnetic flow meters had been constantly dropping as more and more manufacturers worldwide started offering these, relatively easy to build, flow meters. Electromagnetic flow meters, that until then had been the backbone of the company, had begun to turn into commodity products: while still buying them in masses, customers perceived electromagnetic flow meters as not having any particular differentiation between one vendor or the other. Without the possibility to set themselves apart from any other vendor, thus creating a unique selling point, the company was forced to enter the downward spiral of prices.

7.3.1 The Introduction of a New Measurement Principle: Coriolis Flow Meter

In trying to find new markets that hadn't been covered by too many competitors already, the company came across the Coriolis principle. Introduced some years before, it hadn't been on the market for any longer than the company itself, it showed a continuous growth and there was only one major vendor on the market offering flow meters based on this principle.

In order to avoid patent infringements and to make sure that the new addition to the product portfolio would have enough attributes for differentiation, the development activities were consequently steered into a direction that ended in a completely different design of the meter. While the design of the competitor's device called for additional mechanical support of the meter and required a considerable amount of space, the new design had the advantage of being very compact.

It was the big steps in the development of modern electronics at the end of the 20^{th} century that had enabled the company to come up with a design that had been regarded as impossible before. Suddenly being seen as a serious alternative to the market leader helped gaining market share. Nevertheless for almost two decades to follow, the company grew in markets that it had been serving before, such as the chemical, pharmaceutical or foods, while the competitor kept its stronghold in the oil & gas market, that nurtured it with high growth rates and the willingness to buy high-priced products without much discounting. Other competitors that tried to enter the market around the same time, mostly didn't show the same amount of success. Many of them have vanished or have been bought by competitors. The company has established itself since then as a major player on the market for flow meters.

As much as the company's first Coriolis flow meter was novel and did not have any predecessor within the company, it already showed usage of a modular concept. The electromagnetic flow meters had been sharing certain, mainly electronics, parts and the company had been successful in cutting down development, production and stock keeping costs. Without an incentive or order to do so or goal to reach and primarily driven by the attempt to shorten development times and enter the market quickly, a variety of electronic modules of electromagnetic flow meters had been fit into other electromagnetic flow meter models. By doing so the production costs for one particular device could be reduced by more than 30%.[157]

7.3.2 Expansion of the Strategy Across Measurement Principles

Realizing that what then was called “same parts strategy” proved to be auspicious, the choice was made to expand this strategy not only within the same flow measurement principles, but also across other principles, e.g. from electromagnetic to Coriolis flow meters. In principle this decision was made and pushed forward solely by the development department. Following the definition of “platform” as given in chapter 3, these early attempts that were not driven by a holistic concept of a company-wide strategy, can not fully be regarded as part of a platform. This is also due to the fact that only the electronics or transmitter part of the meter was affected. The mechanical part or sensor, was still left untouched.

After the initial success of their meter, it was carved out that being a full supply vendor, i.e. offering a variety of different measurement principles, would be the most promising way of enabling the company to enter new markets. For that reason, other modern flow measurement principles were added to the portfolio.

Not only should the customer be able to get any modern flow metering device from the company, he should also be able to choose from a variety of different meters, each fit for his application. The company therefore came up with the concept of “flow meter families”. This concept, laid out several years ago, foresaw the need to offer the broadest variety in meters, custom fit for different applications and markets, but still sharing the same look-and-feel to help the customer in handling and thus binding him to the company. The situation up to that point had been that each vendor was following his own concept of installation requirements and a human-machine-interface. Even within the offering of one company there were several different design and operating concepts. As much as this was bemusing for the customer, it didn't create any incentive to stick with a single-vendor buying decision.

157 Own calculation

7.4 *First Steps in Modular Design*

The necessity to offer a much higher variance in flow meters and driving up diversity to the customer, resulted in the requirement to keep the diversity within development, production, stock keeping, administration etc. down (see 2.2).

Having seen that the before mentioned "same parts strategy" within one measurement principle had already proven its value, it was rolled out across all principles. Whatever parts of the electronics could be used for different meters (they may be of the same or of a different measurement principle), were used in order to reduce the variant complexity inside the development, production and logistics processes. This included:

- internal power supply modules,
- internal electronic boards used to process and transfer the primary signals into secondary signals that then could be processed by the customers' process control systems, including
  - software algorithms running on the electronic boards,
  - input/output modules that connect the measurement devices with the customers' process control systems,
- housings for the electronic parts (transmitter), including
  - human-machine-interfaces (local displays of the measurement devices).

Here for the first time in company history, the characteristics of a real platform approach were met and carried out, because not only the electronics and the software was shared across models, but also the transmitter housing – visibly making the meters match to a family of meters for the customers.

Fueled by the wide acceptance of the devices on the market and the resulting numbers of growth, more devices were introduced that were composed of the same electronics parts and electronics housings. With the introduction of the second model of a flow meter less than 10 years after the first, the platform approach made a break-through in the company. This meter not only shared the same transmitter housing and concept of a human-machine-interface as the electromagnetic (and other principles) meters, but also marked the start of a platform that has been on the market until now.

7.5 *Introduction of a Cross-Measurement Principle Flow Meter Platform*

A set of goals was put up by the project team that addressed the flaws and shortcomings identified in the portfolio until then. While some of those were of purely technical nature, the main goal was to reduce costs. This was thought to be achieved by the following means:

1. reducing the prices for the offered flow meters by more than 30% in order to compete with other vendors while still keeping an acceptable profit margin,
2. not only reduce production costs, but also costs for stock keeping, services, documentation etc. as those usually increase over proportionally with the number of variants,
3. drastically increase the number of sold devices, thus extending market share and
4. leave niche markets and enter the primary market.

At the begin of the project the project team aimed towards a decrease in prices of around 40% shortly after the planned introduction to the market. They had seen the market split into a low-cost, a standard and an "extended-features" segment for other meters and expected the same for the new meter, as the demands of future customers for new technology would quickly move from specialized applications into commodities. In order to meet those demands, it was decided to split the product range accordingly. The sensors would remain the same, but the transmitters would be offered in different variants:

- transmitter 1: an economical solution that covers the basic needs, but does not meet the highest accuracy in measurement or any additional features. It protects transmitter 1 against price aggressive flow meters based on other principles.
- transmitter 2: covering the main applications by offering high accuracy and additional features
- transmitter 3: for very special demands in custody transfer applications (this term refers to a transaction or measuring point at which the fluid is being measured for sale from one party to another). [158]

158 Rudroff (2009)

In addition to the requirements that could be linked to the device itself, the project team also came up with a strategy how to focus which markets and at which time. After listing possible target markets

- chemical,
- pharmaceutical,
- petrochemical and
- food industry

and scanning the hotspots of where those markets were situated geographically and where the main competitor had its stronghold (at the time that competitor still had a market share of more than 50%, while the company only held below 10% globally) the decision was made to focus on the

- chemical industry in Europe,
- the food industry in Europe,
- the food industry in the USA and
- the chemical industry in the USA.

The following chart (see fig. 12) shows the comparison between the preceding first generation of flow meters and the second generation in expected terms of costs, prices and profit margins.[159] As it can be seen, the production costs were planned to be cut down by half while the profit margins were to remain on the same or even higher level.

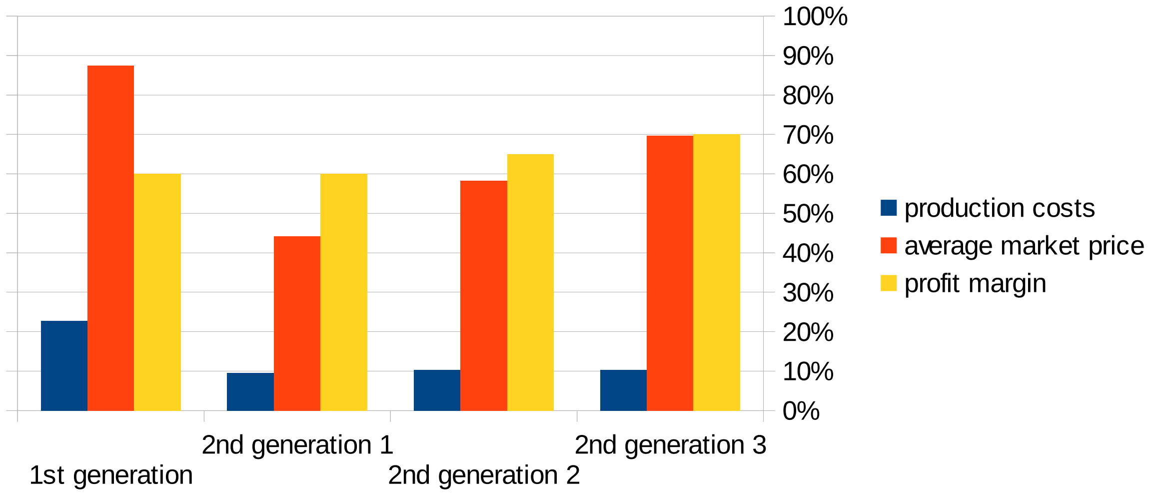


Fig. 12: Costs, Profit Margins and Prices of 1st and 2nd Generation Flow Meters[160]

159 The numbers behind the second generation indicate the transmitter model, see above.

160 Own calculation

The calculations done at that point were already of a high quality and confidence as it had been decided to utilize already existing parts of electromagnetic flow meters for the transmitter housings and also for electronic components. Therefore not only the time to market was decreased significantly, but also the planning reliability was ensured. Thus enabling the company to quickly develop a path for further growth: more than 10% per year. The steps to secure this goal were the following:

1. drive internationalization with existing and new products in Europe, North America and Asia,
2. propel diversification of the product portfolio, horizontally by filling gaps in the portfolio with other measurement principles and vertically by introducing cheaper products for low cost markets,
3. open new distribution channels by offering OEM[161] devices,
4. strictly align the offered product and services portfolio to the requirements of the industries and customers and
5. take and maintain cost leadership by reducing production and logistic costs.

The following years saw a continuous growth in numbers of sold devices and market share. For that reason, the goals to grow to a certain global market share in Coriolis flow meters were adapted several times to even higher numbers.

7.6 Elaboration of a Strategy for Segmentation within a Flow Meter Family

A survey among the sales force worldwide revealed the following factors as the main success factors for the first generation of Coriolis flow meters:

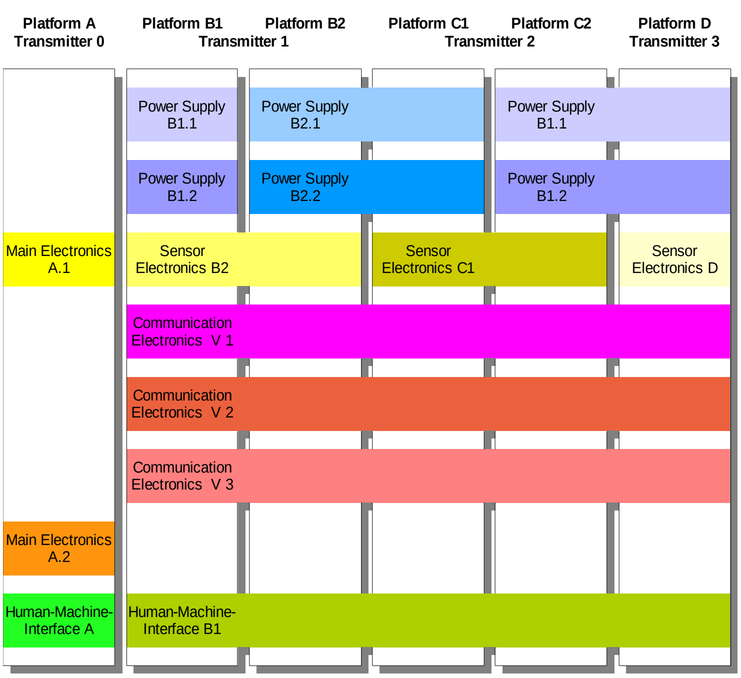
- consistent design and housing,
- consistent programming for the customer,
- good performance,
- possibilities for segmentation of the devices and
- modularity.

161 *Original Equipment Manufacturers*, here this term refers to process instruments that have been specially developed to fit into defined applications with recurring, identical requirements

Almost all of the above can be directly linked back to the introduction and consequent usage of a platform approach (with exception of “good performance”, that may also have been achieved otherwise). Accordingly for the next generations of meters the idea of a platform was yet extended. The goal was to be able to utilize segmentation and differentiation in an even higher degree. More features and more possibilities for combining features more independently were thought to offer a higher flexibility and ease of use for the customer. On the other hand the lowest-cost applications that only called for very basic functionality would be covered by the portfolio, too, by just leaving away modules that weren't needed and introducing another set of transmitters (transmitter 0), that was stripped by a majority of modules and lacked the other transmitter's major features.

7.6.1 Keeping the Amount of Parts Down

The building block model for the next platform was set up as shown in fig. 13. As it can be seen from that figure, a total of 14 modules is sufficient for the complete set of variants. Keeping in mind that a number of those modules (for example the power supplies) are also shared with other measurement principles, such as the electromagnetic, the potential of cutting down on variance and costs is evident.



As mentioned above the concept of platforming and modular design wasn't reduced to the transmitter configuration of flow meters, but also stretched across other measurement principles.

In addition to that it found it's way into the portfolio of the offered sensors, creating a diversified family of flow meters.

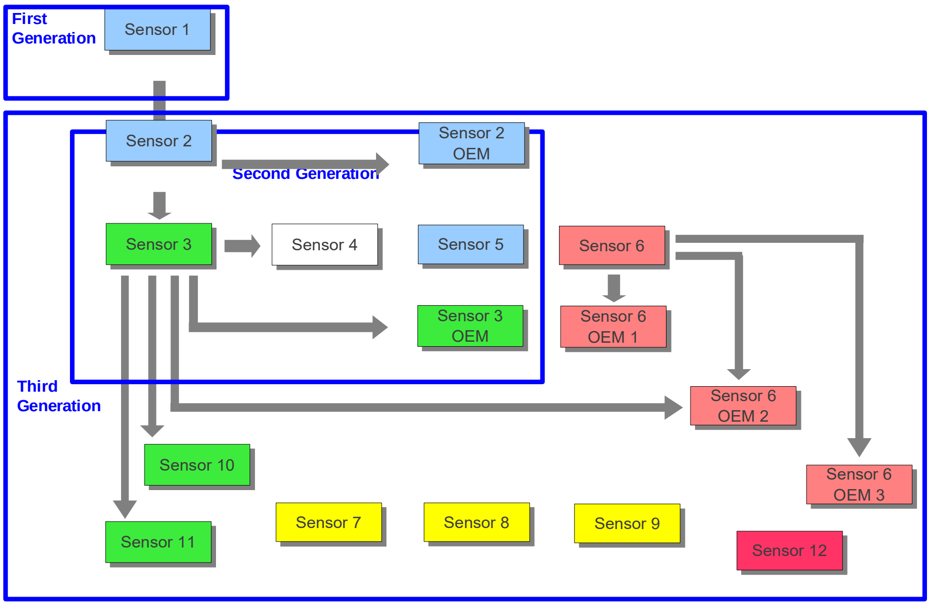


Fig. 14: Three Generations of Sensors (Colored Boxes stand for Sharing of Parts, Arrows Stand for Derivative of Design)

7.7 Coping with the Number of Variants

Comparing the first generation of flow meters (see figure 14), which featured one sensor and two transmitters, the second generation already included four sensors. Multiplied by the number of available transmitters – three standard transmitters were available plus the dedicated OEM transmitters (for specialized applications) – 12 combinations of a sensor and a transmitter were available for the customers to order (not every combination of a sensor and a transmitter was possible).

Catalogues of that time show that the total number of available variants of the second generation of flow meters was higher than 200 for standard options (special custom-fit devices excluded).[162]

The third generation of flow meters increased the number of sensors up to 14. The number of standard transmitters was raised to four, the number of OEM transmitters was raised to three. This alone caused the number of combinations of a sensor and a transmitter that the customer could choose to go from 12 up to 27. Also the number of modules was increased tremendously, because the customers called for more choices in mechanical connections for example. The standard catalogue for a sensor of the second generation had included 18 to 35 options to select from. The standard catalogue for a sensor of the third generation expanded the number of options to more than 200 for some models. All in all the amount of valid combinations for the third generation of flow meters rose to more than 50,000.

Experience would suggest that the costs for development, production and logistics as well as for administration had increased in a similar way. This of course would have called for an increase in sales prices or a decrease in margin.

7.7.1 Analysis of the Effects of Modularization and Platforming

As a complete analysis of all combinations of sensors and transmitters would go far beyond the scope of this thesis, for the following analyses the combination with the highest numbers in sales and the highest distribution rate among all industries will be used: sensor 3 (see figure 14) and transmitter 2 (see figure 13). Since its introduction as a generation 2 device, this combination has been sold more than 50,000 times – making it the companie's most successful device.

Figure 15 shows the typical product lifecycle of a Coriolis flow meter. Every decade a new generation of meters is introduced. Unlike consumer products that need to be updated quickly to follow the fast changing likings of the market, industrial products usually show much longer renewal rates. This is mostly due to the fact of regulations taking a long time until a certain type of meter has been approved for an industry and the reluctance of the customers to invest into new technologies. Nevertheless the competition on the markets is high and requires short development times. It is very hard to gain a mainstay in an industry once the approvals for a certain type have been done or a certain de-facto standard has been established by a competitor.

162 Published customer catalogue for Europe

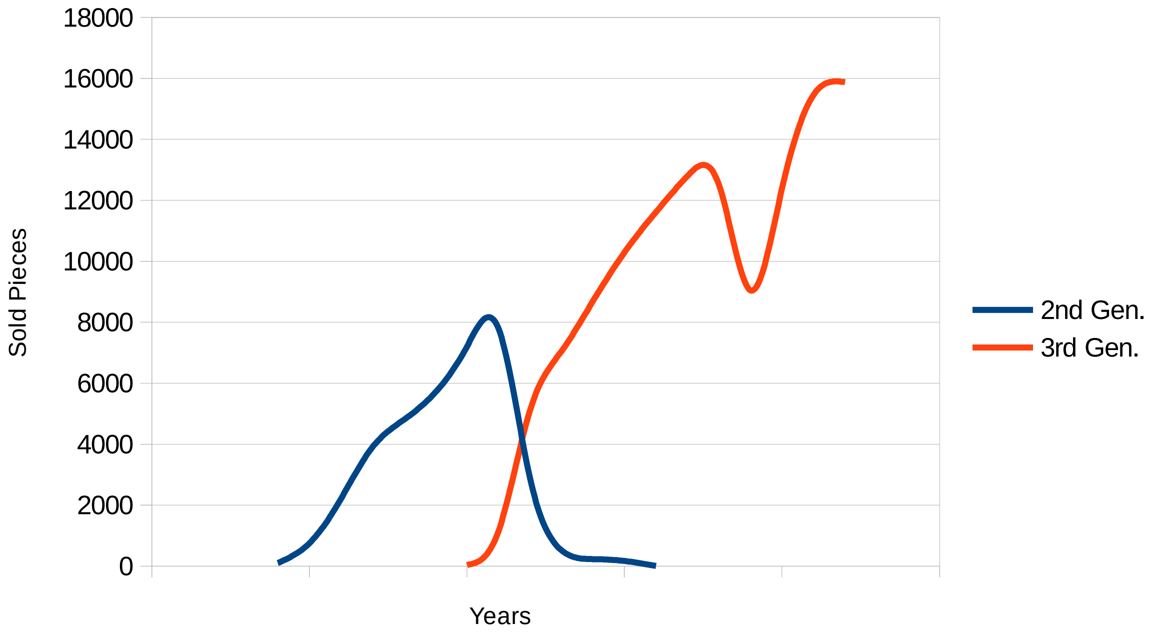


Fig. 15: Typical Lifecycle of an Industrial Flow Meter, Shown by the Example of Pieces Sold of "Sensor 3"[163]

163 Own calculation

The longer lifecycle of the devices does however foster a solid base for the usage of platforms within a company. It pays to invest into the establishment of platforms, which initially creates higher costs. During the relatively long time of production, technical and administrative updates and because of the high number of sales, the total costs per sold device are significantly lower than they would have been without a platform and module approach. This is underlined by taking a closer look at the production costs and the margins (see figures 16 and 17). Again, the complete examination of all possible combinations would take up too much space, so in this thesis the most commonly ordered combination of sensor 3 and transmitter 2 is examined.

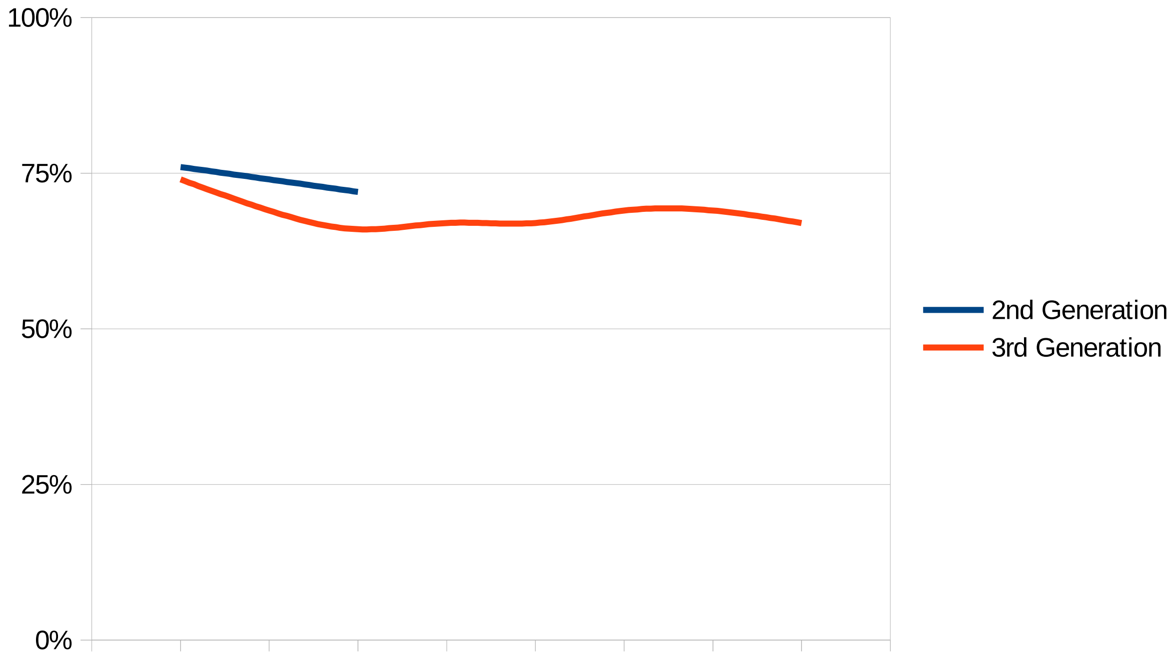


Fig. 16: Profit Margin per Piece of 2nd and 3rd Generation Flow Meter[164]

164 Own estimation

As it can be seen in figure 16, the profit margin of of the second and third generation of meters remained more or less at the same level. Figure 15 showed that the number of sales went up. The profit margin development reveals that the product offers by the company did not underly what could have been expected according to product life cycle theory: a decline in profit margins over the years.[165]

A comparison between the production costs of the second and third generation of meters uncovers the reason behind. The third generation of meters started out more expensive than the second generation in total production costs, yet it saw a sharp drop after only a short time. Taking into account the significant increase in numbers of variants, explanations like the learning curve[166] clearly do not apply.

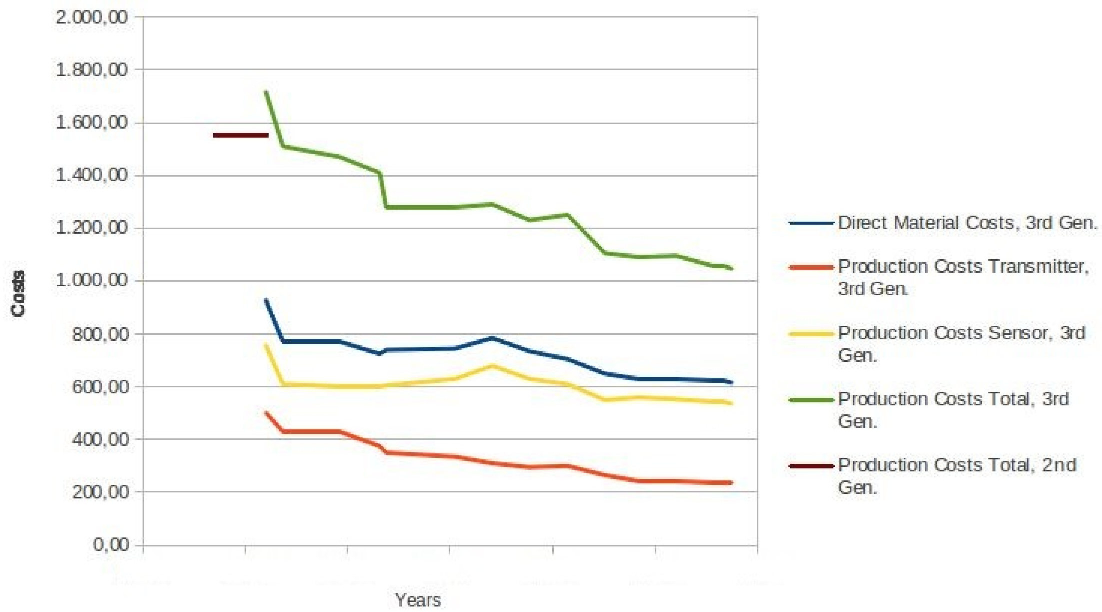


Fig. 17: Production Costs of 2nd and 3rd Generation Industrial Flow Meter[167]

The fast and steep decline of the production costs was evoked by the company's ability to offer a broad variety with recombination of existing modules. The costs for development, production and logistics as well as for administration were kept at a low level, while the prices for the meters could be maintained at a constant level.

165 Polli & Cook (1969)
166 Yelle (1979)
167 Company internal statistics

As a conclusion it can be stated that the usage of modules allowed the company not only to enter a highly competitive market, but also enabled them to expand their market share. They were able to offer a high number of variants, satisfying a fast growing number of customers while lowering their costs.

7.8 Outlook: the Next Generation of Platforms

After the first generations of platforms have proven to be a success factor for the company, the platforming principle is being expanded not only across the family of flow meters, but also towards different measurands that are being offered by other companies of the same enterprise. More synergetic effects are expected like even lower costs in logistics and production and a higher acceptance of the devices by the customers. The latter will be caused by the alignment of the human-machine-interface and the resulting ease of use – if the customer can operate one meter, he will be able to operate all the other meters as well. This will especially be an asset for industrial customers that run a variety of different meters on site, for example in refineries or chemical plants, where it's necessary to measure flow, pressure, temperature, level etc.

As it could be shown above, the efforts of setting up a modular design, establishing a platform and expanding that platform continuously across the complete offer in measurement devices, has ensured the success of the company. This is reflected in the gains in market share, which has risen from being one of many vendors to now being the second biggest vendor worldwide.[168]

Again, the hypotheses given in chapter 5 are to be reassessed:

a) in a time and on a market that saw a high number of different vendors, the market pull for the new device was strong enough to generate enough profit for the company for following their "same part strategy". Clearly, the device offered by the company showed differentiation significant enough to not only enter the market, but also distinguish itself from the other designs. A comparison between this particular device and the others shows that it was more compact and more lightweight than the rest of the choices. This advantage could be achieved, because the usage of already existing electronic parts allowed the developers to concentrate mostly on the mechanical or sensor part. The savings in size and weight not only reduced the material usage and thus the costs, but also allowed the customers to put the device into applications where this new technology hadn't been put in before due to restrictions of space for example.

b) Considering that the first flow meter operating by the Coriolis measurement principle by the company was no real platform device, but benefited the "same parts strategy", one has to examine the second generation for evaluating the development time of the platform. However, comparing the lifecycle of the average industrial flow meter, it can be shown that the first Coriolis flow meter offered by the company showed a considerably shorter lifecycle than any flow meter had had on the market before: eight years after its introduction, the successor was introduced. Conventional meters (see chapter 7.1) had seen much longer lifecycles. Differential pressure based devices for example have been standardized in the 1950s[169] and to this day are still produced in the same mechanical setup. Meters based on the positive displacement principle have been on the market for more than 100 years.[170] Also the closest competitor that offered Coriolis flow meters, the company that was first on the market, needed more than 12 years to offer the next generation of their meter.

168 Yoder (2010)
169 DIN 1952 (1948)
170 Tränkler, Reindl (2014)

The platform not only shortened the development times and thus forced a new lifecycle upon other vendors, it also introduced a number of variants that had been unknown to the market before. Customers would quickly realize that they now were given a set of meters that would more easily fit into their applications than any meter before. “Customization” even allowed for a much faster delivery time for very specialized, custom-tailored devices, should one of the standard offers still not fit the requirements. Changing a single module on the platform was mostly all that needed to be done. Consequently the number of customized products rose to a share in orders of more than 10%. The time needed to process these orders was reduced from several weeks to 48 hours.[171] It is evident that without being able to satisfy 10% of orders at an acceptable price and within acceptable time, a significant market share would be lost.

c) The level of commonality vs. modularity was kept beneficial. Even though the number of variants rose quick and reached a very high number, the amount of modules needed for those was kept low. It was shown that indeed the balance between variants and modules was improved throughout the years, enabling the company to offer more adaptations for the customers, while reducing their internal stock keeping and costs for logistics and production.

Putting these three hypotheses in order and giving them a rank on which of them contributed most to the success is futile. As shown in chapter 6.4, all three determine the success or the failure of a platform. The example of the Coriolis flow measurement device discloses how the correct practice supports all three of them. The success factors are manifold, yet so are the pitfalls. Considering what has been laid out before, it becomes becomes evident that not every product or market environment allows for the implementation of the hypotheses in praxis. Especially for companies that do not perceive the introduction of variants and platforms as something that has to be implemented as a core competence within the organization, platform strategies will have a high risk of failure.[172] If the company is not able to detach internal complexity of external variety, the introduction of a platform most likely leads to additional complexity and thus torpedoing the idea it stands for: reduction of complexity and costs.[173]

171 Company internal statistics 2012, based on order entry in pieces

172 Boutellier, Schuh, & Seghezzi (1997)

173 Malik (2008)

The lifecycle of a consumer product like the electric toothbrush for example was by far too short to be able to expect a positive revenue within the runtime of the first generation. In this case the vendor wasn't able to await the second generation, because the money that had been spent on the development of the platform caused decision makers to cancel the further developments. The competitive environment had grown too strong with cheaper products for them to cling to their original strategy. The instance of their direct competitor however shows that those were indeed successful with their platform. Mostly because they had been on the market already when competition was still young and moderately weak. In a nutshell it can be stated that timing is of essence: the shorter the lifecycles of the product, the more difficult it becomes to successfully implement a platform at a stage when second or third generations of competitor's products are already available. If however, the platform enables the vendor to shorten the existing lifecycles, this is rewarded by a competitive advantage. It not only drives the competitors into more costly development of new products, but also singularizes the vendor as a leader in innovation.

Especially when the platform is not able to open a full basket of varieties, each meeting a certain customer's requirement, the market pull stays way behind expectations. Thus breaking even becomes even harder. The same holds true for internal structures: if the platform proves itself to be too complicated or too detailed, the costs for development, production and logistics will prolong the time until money is to be earned. Most often this leads to an untimely abandonment of the platform strategy and the advantage of being able to use similar or same modules over several product generations is undone.[174]

174 Pedersen (1999)

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