Platform Assessment Matrix (PAMatrix): A Method to Support Decision Making on Product Platforms

Doctoral Dissertation

by

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Abstract

In the last century there have been drastic changes in the way products are developed and manufactured – manufacturing technologies have advanced and at the same time global competition has increased tremendously. For companies to survive, the name of the game has been to offer greater product variety, in more frequent intervals, and for a lower price. Mass production has been replaced by mass customization, where the basic rule is that the customers should get exactly what they want, at the time they want it.

A partial remedy to concurrently lower cost as well as provide customers with a greater number of variants has been to use platforms*. Platforms in the manufacturing industry have at times been highly advantageous while in other instances they have caused more problems than benefit. Platforms exist in different contexts and scope, and it has been found that companies need to improve their platform management skills in order to increase the general level of competitive advantage.

This dissertation proposes that a company can considerably improve the management of its platforms by increasing its holistic understanding of them. To do this, platforms are viewed from different viewpoints that aim to both display the effect a platform has on its surroundings, as well as the effect its surroundings has on it. This approach has been incorporated into a method called the PAMatrix (Platform Assessment Matrix) that uses a synthesis of cross-functional, subjective expert opinion and consensus based decision making.

The PAMatrix method uses already existing implicit and explicit knowledge to improve decision making on how to manage each individual platform. First a

* In this dissertation, a platform is defined as the set of core assets that are reused to create a competitive advantage.

set of platforms are identified that the company views as key enablers for creating a competitive advantage. The platforms are then assessed from several different viewpoints – each capturing a partial evaluation of the platforms' status or effect. After an assessment of a viewpoint, each stakeholder individually suggests a specific strategic action plan along with a weight factor of how important the viewpoint is to the overall assessment of the specific platform. Finally, the discrete action plan suggestions are collected and jointly assessed and debated – based on which, a final strategic action plan can be made.

The method has been tested in three industrial situations, where its use has been considered beneficial and platform understanding has increased.

Preface & Acknowledgements

During my engineering studies in Germany and Sweden, I focused on subjects that were quite cross-functional – that connected technical requirements and economic feasibility; e.g. production management, logistics, and operations research. Later, in actual work situations in the industry, I became aware that companies often have fantastic abilities within specific functional departments, but lack the skill to unite these abilities together; there is in general a lack of cross-functional vision and understanding of overall effects. I got hands-on experience on how important it is to incorporate a holistic way of thinking into every channel of the company, and moreover how difficult it was to actually do this.

When I returned back to university to pursue a PhD within Engineering Design, the initial plan was to delve into the relatively narrow topic *light-weight automotive architecture*. Due to my background, I was more interested in looking at phenomena in a broader context – from the customer needs and back up the whole supply chain to the research centers and development departments. And so the focus gradually shifted from the specific to the general; slowly but surely the topic *light-weight automotive platforms* evolved into the topic *automotive platforms* which in the end evolved into the topic *assessment of platforms* in the manufacturing industry in general.

I owe gratitude to a number of people: First of all this dissertation could not have been made without the patience and assistance of Professor Hans Petter Hildre whose ability to crystallize fuzzy thoughts is admirable. I'd also like to thank Kjetil Kristensen, Jóhannes Blöndal Sigurjónsson, and Ulrik Lie for their helpful feedback, as well as Mogens Myrup Andreasen, Tormod Jensen, Silje Stormo, Jens Røyrvik and Katja Hölttä for useful discussions.

Throughout the years of my studies, my parents have always been there for me, supporting me in my decisions and amazingly never criticizing my choices. Thanks also to my dear siblings and most of all a thanks to Siri for her patience, support and for generally putting up with me! Now it's your turn!

List of Appended Papers

Paper A **The term platform in the context of a product developing company**
Kristjansson, A., Jensen, T., and Hildre, H.-P.
Proceedings of Design 2004, Dubrovnik, 2004.

Paper B **A Framework for Evaluating Platforms in Product Developing Organizations**
Kristjansson, A. and Hildre, H.-P.
Proceedings of 7th Workshop on Product Structuring - Product Platform Development, Gothenburg, Sweden, 2004.

Paper C **Platform strategy: a study of influencing factors**
Kristjansson, A. and Hildre, H.-P.
Proceedings of NordDesign2004, Tampere, Finland, 2004.

Paper D **PAMatrix: a method to assess platforms in product developing companies**
Kristjansson, A. and Hildre, H.-P.
Proceedings of NordDesign2004, Tampere, Finland, 2004.

Paper E **Using the Platform Assessment Matrix (PAMatrix) in Praxis: Empirical Studies (Preliminarily accepted for oral presentation)**
Kristjansson, A. and Hildre, H.-P.
Proceedings of ICED'05, Melbourne, Australia, 2005.

Papers not included due to overlap in content or being outside the scope of the dissertation

I **The Automotive Design Process - Advanced Concurrent Engineering**
Kristjansson, A., Blankenburg, D., Hildre, H.-P., and Rølvåg, T.
Proceedings of European Concurrent Engineering Conference (ECEC'2002), Modena, Italy, 2002.

II **What is a 'Light-Weight' Automobile? – Comparing Apples with Apples**
Kristjansson, A., Blankenburg, D., and Hildre, H.-P.
Proceedings of NordDesign2002, Trondheim, Norway, 2002.

III **Workflow architecture for a dispersed automotive development network**
Kristjansson, A., Kristensen, K., and Hildre, H.-P.
Proceedings of ICED'03, Stockholm, Sweden, 2003.

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1 INTRODUCTION

The manufacturing industry today can be characterized as supplying to a "buyers market," i.e. the customers are in a position to dictate what should be sold, at what time, and in many cases, at what price. To gain a competitive edge, companies strive to lower internal cost by using the virtues of scale effects and standardization, but at the same time, quite paradoxically, also aim to increase product variants, and decrease time to market.

In this setting, using product platforms has been found to be useful to fulfill both goals; more specifically, product platforms have been found to be enablers of competitive advantage – by increasing the possibility to create differentiation, to lower cost, or to focus on a specific market niches. Platforms are shared over a range of products, and typically generate the core function of each product. Variants are then created by building upon the platform and changing e.g. the looks of the product or adding features.

Platforms have proven to be advantageous but at the same time to often include overlooked negative side effects – diminishing their overall effectiveness. Employees throughout the organization furthermore often have a vague and conflicting understanding of their platforms – of their effects, limitations, strengths and weaknesses.

The motivation of the work presented in this dissertation derives from the growing importance of platforms in the manufacturing industry, as well as the apparent lack of tools to holistically assess them. By definition, research within the field of Engineering Design has to ultimately be useful for the industry [1]. This was very much a prerequisite of the method developed in this dissertation – the Platform Assessment Matrix, or PAMatrix for short. It is a practical method, i.e. relatively time-efficient to use, and relatively easy to understand, without however sacrificing its vigor to assess and increase the understanding of platforms in the manufacturing industry. To do so it uses already existing explicit and tacit knowledge from cross-functional stakeholders within a company. It should be used to create an arena to make platforms apparent – the goal being to create a better understanding of the platforms, and ultimately improve strategic decisions made upon them.

In this chapter, the topic of the dissertation is established. The industrial motivation of using platforms is described and examples given of their importance. A problem statement is introduced, where it is argued that a simple method to assess platforms is needed. Related work is briefly described – the goal being to understand the context within which the proposed research exists. The objectives of the dissertation are listed, along with research questions and assumptions. The contribution of the research is proposed and finally the outline of the work is introduced.

1.1 Industrial Motivation for Using Platforms

> The effectiveness of the firm's new product generation activity lies in: 1) its ability to create a continuous stream of successful new products over an extended period of time; and 2) the attractiveness of these products to the firm's chosen markets. – Meyer et al. [2]

The last century's shift from workshop-, to mass production, and then to mass customization, has had dramatic consequences on the overall quality, cost, and availability of products [3]. Industries have become more competitive and the trend is that the customer shall continuously get more value for a lower price.

There is evidence that for companies to survive, product development time must be shortened and product variety increased [4-8]. Furthermore, companies have to decrease cost, and at the same time they have to provide the customer with exactly what he or she demands, at the right price. Product platforms are recognized as being a partial remedy to fulfill both of these two seemingly contradictory goals [9].

Many examples exist, demonstrating the advantage of using platforms in the manufacturing industry. Meyer and Lehnerd [9] describe how Black & Decker Corporation had great success with their double insulation program, where they, in the early 70s, redesigned the product line and developed a family of products through commonality and standardization: Before the program, Black

& Decker had a product portfolio of 122 different models, with uncoordinated designs, materials, and technologies. Alone its power tools used 30 different motors, each manufactured by a different set of tools. Furthermore, 60 different housings were needed to accommodate variations in power and application – e.g. for saws, drills and sanders. On top of all of this, 104 different armatures were needed (each requiring its own tooling) and dozens of different switches and buttons populated the company's parts bins and bills-of-materials. Black & Decker invested 17 million dollars and three years to complete the double insulation platform program. The changes were drastic; much of the work in design and tooling was eliminated due to the large amount of standardization – included in the platform were motors, bearings, switches, gears, cord sets, and fasteners. The financial payoff was enormous; e.g. instead of the previously estimated need of 600 people for motor manufacturing, the new system required only 171 people – saving millions of dollars in labor cost alone. In addition, inventories went down, scrap rates fell, cycle times for new derivative products greatly shortened, and in general scale effects were increased enormously. Competition soon felt the consequences of Black & Decker's new platform approach. Over a period of 5 year most of the major players in the market left the power tool business, unable to compete against Black & Decker's attractive and moderately priced product portfolio.

The importance of using a product platform in the SONY WALKMAN® product family has also been well documented [5], where they introduced nearly 250 models based on merely three platforms – most distinguished by making small changes in features, packaging, or appearance. Similar success stories have been described regarding Motorola's bravo pager [3], and even for Steinway & Sons pianos' [10]:

> Steinway customizes each piano, however, making it a handmade work of art. Steinway offers no two identical pianos, yet produces only a handful of core models. – Wheelwright & Clark [10]

But the use of platforms has not only had positive consequences. As an example, in the mid-80s GM arguably went too far in their focus on reducing variations and sharing common platforms. There was a striking similarity about their vehicles and GM quickly earned a reputation for producing boring "cookie-cutter" cars where the "wow factor" was seriously lacking [11]. Another similar example of negative side-effects of platform use comes from the VW Group[1]. From 1993 to 1999 they managed to lower cost tremendously by producing more modules on fewer platforms – cutting the number of used platforms from 16 to 4. As an example, the company's Platform A carries the VW Golf, VW Jetta/Passat, VW New Beetle, Audi TT, Skoda Octavia, Seat Toledo, and Seat Leon, along with a number of other models (Figure 1-1).

Figure 1-1: A few of the automobiles that use the VW A-Platform with 65% component sharing

The cars share a *common architecture* and 65% of the same components [13]. At the same time as they managed to cut costs and introduce a wide array of new models, negative side effects to using a platform approach emerged. As an example, unwanted cannibalization effects became apparent where price-conscious buyers traded down seeing the similarities among VW, Audi, Seat, and Skoda vehicles. As an indication of this, in the year 2000 Skoda registrations grew 19% while VW brand registrations dropped 6% [14]. Undesirable functions and unexpected technical problems also appeared – as an example the Audi TT had difficulties with rear wheel pressure directly related to the platform. Furthermore, the platform arguably can have negative effects on long-term innovation [15].

These examples imply that a platform can both have positive as well as negative effects – as depicted in the illustration bellow.

[1] The recognized global leader in platform strategy for passenger cars [12].

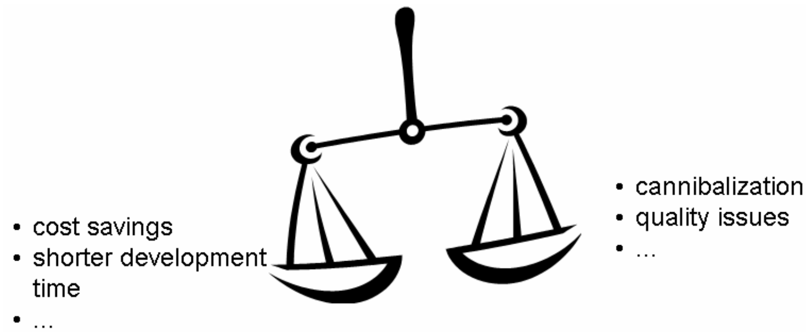

Figure 1-2: A platform can at the same time have positive and negative effects

In this section the industrial motivation for using platforms has been described, and we have seen that platforms can have major positive effects as well as negative side-effects. In the next section the problem statement is presented.

1.2 Problem Statement

Literature reveals that there are greatly divided opinions of what exactly a platform in the manufacturing industry is (see e.g. [16, 17]) , and furthermore that there is a genuine lack of methods to cross-functionally and holistically assess platforms in their given context. As an example, the unwanted cannibalization at VW[2] had not been estimated or measured[3], and while the platform saves cost, using the platform did have considerable challenging negative side effects.

Companies are relying more and more on platforms to decrease cost as well as to shorten development time and increase the number of product variations. In this setting, proper management of the platform is of key importance – being able to make the correct decisions on which products should share the platform, the correct life-time for the platform, and the level of platform maintenance.

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[2] Please see previous section.

[3] Personal note from a senior VW executive at the ATA 2003 in Florence, Italy.

Very limited research effort has been made on facilitating the management of platforms [16]; the main research focus is on the development of platforms and not on the management of the platforms once they do exist[4].

Cross-functional communication ability and -analysis is of major importance for any engineering design company [18-20]. Platforms have proven to be one of the fundamental enablers of competitive advantage [21]. As such, a cross-functional evaluation of platforms is vital, as they do indeed influence the whole organization – from research & development and procurement, to manufacturing, marketing & sales, and service. Companies must be able to understand the positive and negative effects that a platform has in a cross-functional perspective to be able to better manage them. Only by fully understanding these effects can a company make sound decisions regarding strategic action steps for their platforms; in other words, a lack of understanding directly jeopardizes management's ability to make correct decisions. Today when managers and other stakeholder make decisions regarding platforms, they have to count on intuition as they mostly consider a small set of factors, e.g. number of products based on platform and cost of derived product.

Platforms exist in different contexts and scope, and studies have shown that in some cases they have proven to be advantageous [5], while in others they have proven not to be [22]. An important question is: Can companies acquire a better understanding of their platforms in their specific context in order to better manage them? Furthermore, how can this be done in a relatively modest time frame? Otto and Hölttä support this finding and argue that there is an apparent lack of comprehensive platform concept evaluation tools [23]. Furthermore, Simpson [24] finds that researchers should strive to understand better the impact of platform-based product development.

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[4] In Chapter 1.3 related work is discussed.

It is clear that there is a great need for a pragmatic and simple method to increase cross-functional platform understanding, and so support a company's strategic decision making process.

1.3 Related Work

Traditionally, Engineering Design literature has focused on the development and evaluation of single products [25, 26]. Meyer and Lehnerd [9] argue that such a focus on individual customers and products results in "a failure to embrace commonality, compatibility, standardization, or modularization among different products or product lines."

In the last decade, research on product platforms and product family design has matured rapidly [24]. It is in general quite diverse in nature and Fellini et al. find that it can be categorized as following two approaches [27]:

- *Approach A* is more quantitative and uses mathematical formulations of optimal design problems but is limited by the ability to model a given situation, while
- *Approach B* is more qualitative, addressing important business issues, common terminology, different schools of thought, and real-world case studies.

The research of this dissertation follows Approach B and focuses on areas within the platform research field that have previously not been extensively looked into. In Table 1-1 the research area of this dissertation is compared to the research focus within the field in general.

Table 1-1: The focus of this dissertation in reference to the general focus within the platform research field (Areas partly adapted from [24])

		Focus of this dissertation	Research focus in general
Area 1	Product family planning and platform development	●	⬛
Area 2	Platform management	●	▪
Area 3	Assessing platforms/platform-based product development & Case studies	⬤	■
Area 4	Design for Manufacturing and Assembly (DFMA)		▪
Area 5	Web-based platform customization strategies		▪
Area 6	Support for small- and mid-sized manufacturers		▪
Area 7	Overcoming organizational barriers to platform-based product development & Platform understanding	●	▪

Product family planning and platform development

Within product family planning and platform development, there exist a variety of optimization-based techniques [24]. Here the main focus is on finding the optimal tradeoff between standardization and uniqueness. Optimization approaches most often follow the assumptions: (1) Maximizing product performance maximizes demand, (2) Maximizing commonality minimizes production costs, and (3) Resolving the tradeoff between (1) and (2) yields the most profitable product family [24]. As an example of work within this research area, Simpson and Souza [28] introduce a genetic algorithm-based approach for product family design to balance the commonality of the products in the family with the individual performance (i.e., distinctiveness) of each product in the family, and de Weck et al. [29] introduce a methodology to determine the optimum number of product platforms to maximize overall product family profit with simplifying assumptions derived from target market segment analysis, market leader's performance vs. price position, and a two level optimization approach for platform and variant designs. Numerous other optimization-based approaches for product family design have been suggested (e.g. [27, 30-41])[5] and they can be divided into being single step/stage or multi-step/stage optimization approaches. In single-step approaches, one tries to optimize the product platform and derived family of products concurrently, while in a multi-step approach one tries first to optimize the platform and then optimize the individual products belonging to the product family in the following steps. Simpson [24] finds that in order for these methods not to lead to sub-optimal product families, it is vital to explicitly model the market demand for the products in the family and their associated manufacturing costs. Otto & Hölttä [23] argue that a very limited amount of factors are viewed in these optimization-based approaches. They write:

> [Generally such] works restrict to developing a couple focused criteria when evaluating platforms. The main focus seems to be on maximizing the commonality while trying to maintain the product performance requirements. Yet, when using only a few criteria to develop or evaluate platforms, one must not ignore the others. For example, one may have optimized the performance and cost of the platform but is it more reliable than another? Does it have lowest service cost? Is it easy to outsource major subsets? Is it more flexible than another platform? etc. This issue often arises e.g. when comparing two alternative platform concepts, concepts, or deciding whether to update or replace a platform. – Otto & Hölttä [23]

Platform management

McGrath [42], Meyer and Lehnerd [9] and others [43-46] discuss the management of platforms at a very strategic level. Halman et al. [16] find that little work has been done in regards to finding practical methods to manage platforms. They write:

> Available literature so far has mostly focused on the underlying concepts and benefits of product family development (i.e. effective and efficient product development through reuse) and less on investigating what might be successful strategies to manage the risks and problems related to platform and product family development and implementation. Academic scholars should focus also on how to

[5] For those interested, Simpson [24] offers a comprehensive overview of the status of research within this particular research area.

> transfer their developed knowledge in a way that is easy accessible and acceptable for practitioners. – Halman et al. [16]

Meyer et al. [2] argue that quantifying the economic benefit of platform-based product development is important for strategic decision making. Platform strategy is further discussed in Chapter 2.2.2.

Assessing platforms/platform-based product development & Case studies

Many studies have demonstrated both that platforms have been useful [5, 9, 16], as well as non-beneficial [22]. A number of metrics have furthermore been suggested to quantify these benefits/drawbacks – metrics for platform commonality [47-49], metrics for platform efficiency and effectiveness [9], metrics for product variation [27, 39, 50-52], metrics for functional similarity [53], and metrics for generational variety [47]. As an example, Meyer and Lehnerd [9] suggest that the efficiency and effectiveness of platforms can be measured as follows:

$$\text{Platform efficiency} = \frac{\text{Derivative product engineering cost}}{\text{Platform engineering cost}}$$

$$\text{Platform effectiveness} = \frac{\text{Net sales of a derivative product}}{\text{Development cost of a derivative product}}$$

Despite the number of metrics identified to evaluate platforms, little research has been performed on creating a holistic evaluation.

Otto & Hölttä [23] criticize the apparent lack of comprehensive platform concept evaluation tools. They find that excellent work has been performed in developing *single product* concept evaluation methods. They argue that a platform concept has different requirements due to its longer lifetime and that it must enable several derivative products. These added requirements make the single product concept evaluation methods not directly applicable for a platform concept.

They suggest a multi-criteria view of platforms to assess their performance [23]. This work is perhaps the most similar to the research presented in this dissertation; both have the same approach in analyzing platforms from an array of viewpoints/metrics; each viewpoint capturing a subjective evaluation of an important aspect regarding the platform. The intermediate results are then pieced together in an overall picture which should give a better understanding of its actual performance in its particular context. Simpson [24], finds that researchers should strive to understand better the impact of platform-based product development.

Overcoming organizational barriers to platform-based product development & Platform understanding

As mentioned earlier, cross-functional communication ability and -analysis is of major importance for any engineering design company [18-20]. Juuti & Lehtonen [54] find that a basic understanding of platforms in organizations is missing, and use a simulation game to motivate the adoption and understanding of platforms where mental models, beliefs and other human factors are considered.

Little work has been done to promote common cross-functional understanding of the impact, performance and potential of platforms.

In the next section the objectives of the dissertation are presented.

1.4 Objectives

The work in this dissertation focuses on creating a relatively time efficient and user friendly method that enables companies to gather and discuss a structured set of comprehensive information to increase the understanding of their product platforms. This is important as an increased understanding of a platform arguably improves the ability to manage a platform - and so ultimately competitive advantage can be improved. The method should enable stakeholders to define, make apparent, discuss key aspects of, create a common understanding of, evaluate, and create a common ownership of a platform. According to Ulrich & Eppinger [26], a design methodology is a procedure for completing activities, and is valuable for three reasons: 1) the decision process is made explicit, 2) important issues are not forgotten, and 3) a record of the decision-making process is created. The method should do this, i.e. make explicit the decision process, systematically assess important issues, and document the decision making process.

To reach the objectives, three research questions have been defined, as presented in the following section.

1.5 Research Questions and Assumptions

1.5.1 Research Questions

Correlating to the objectives of the dissertation, there are three basic research questions:

RQ1. Is it possible to define the term *platform* in a way that embodies the core essence of the multiple current definitions from the academia?

RQ2. How can a platform be viewed to create a holistic understanding of its current state?

RQ3. Can a cross-functional assessment of a platform facilitate and stimulate discussion, common understanding, consensus based decision making, and common ownership, with regards to the platform?

1.5.2 Assumptions

In the dissertation a number of assumptions are made.

A1. A product platform can be understood indirectly by capturing how it affects, and is affected by, its surroundings.

A2. The main goal of a product platform is to create a competitive advantage. The platform can do this by following one of three generic strategies: Creating differentiation, enabling cost leadership, or focusing on a niche market[6].

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[6] This is adapted from Michael Porter three generic strategies to create competitive advantage [55].

A3. A more comprehensive understanding of a platform, improves the ability to manage the platform.

A4. The level of competitive advantage can be increased if the level of platform understanding was increased.

1.6 Contributions

The main contribution of the dissertation is to introduce a method for companies to holistically understand platforms. It does so by utilizing a set of defined and described viewpoints, and by systematically and cross-functionally gathering explicit and tacit information to stimulate and facilitate common understanding, discussion, and a common ownership of platforms.

1.7 Outline

The original plan was to base this dissertation on five peer-reviewed conference papers. However, from the publication of the first paper (Paper A) until the last (Paper E), considerable iterations were made, outdating or making irrelevant some of the findings in earlier papers. The decision was therefore made to write the dissertation as a monograph, referring however at times to the appended papers. As far as possible, the papers are all inclusive and mutually exclusive (Figure 1-3).

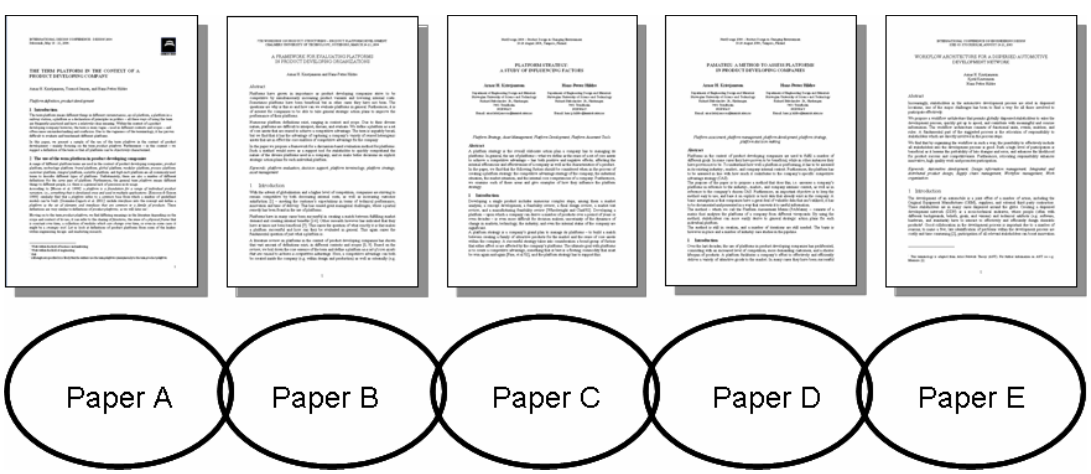

Figure 1-3: The appended papers aim to be mutually exclusive and all inclusive

In Chapter 1, the industrial motivation for using platforms is discussed, the problem statement, related work, objectives, research questions and assumptions are presented, and finally the contribution of the dissertation is made clear.

In Chapter 2, the shift from mass production to mass customization is reflected, and platforms in the context of engineering design are discussed. Furthermore, a definition of a platform in the manufacturing industry is proposed.

In Chapter 3 the research within engineering design as well as the specific research method of the dissertation is introduced.

In Chapter 4 the development as well as an extensive overview of the Platform Assessment Matrix (PAMatrix) method[7] is described.

In Chapter 5 the case studies, which have been used to iteratively improve the method as well as validate the method, are discussed.

In Chapter 6, findings and conclusions are summed up and further research possibility is discussed.

Finally, in the Appendix, the appended papers are included.

[7] The chapter presents an extended and slightly altered version of the method as described in the appended paper D.

2 PLATFORMS IN THE MANUFACTURING INDUSTRY

In this section the move from mass production to mass customization is discussed. Furthermore, platforms in the manufacturing industry are introduced and a platform definition that embodies the core essence of the multiple current definitions from the academia suggested.

2.1 Moving from Mass Production to Mass Customization

2.1.1 Mass Production

Mass production was an offspring of the Industrial Revolution and offered for the first time readily available high volumes for a relatively low price[8].

It was however first with the monumental work of Frederick Winslow Taylor [56] that the basis for mass-production was created. In "The Principles of Scientific Management" he promoted a sharp division of labor where workers performed only a narrow set of tasks:

> Under our system a worker is told just what he is to do and how he is to do it. Any 'improvement' he makes upon the orders given to him is fatal to his success. – Taylor [56]

One of the early adapters to Taylor's principles was the Ford Motor Company. In 1913 the company implemented the "moving assembly line" at its Highland Park plant in Michigan. The new technique allowed individual workers to stay in one place and perform the same task repeatedly on multiple vehicles that passed by them. The line proved extremely efficient and helped the company

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[8] Pine [3] finds that the Industrial Revolution replaced "hand tools with machinery and mechanization as the primary instruments of production."

to greatly surpass the production levels of their competitors – and make the vehicles more affordable [57].

Mass production makes products more affordable as it creates economies of scale throughout a company's value chain. As an example of its benefits, the time needed for administration is lessened, purchasing power is increased as larger batches are ordered, scrap rates are lowered as the learning curve climbs, and the level of complexity is generally lowered. The downside to mass-production is that it is at opposite terms with product variety. The whole idea is to repeat exactly the same physical activities with exactly the same set of assets (components, man-power, machinery, etc.).

Product variety is something that only in the last decades has become an important ingredient for companies to compete with. It is very seldom that a company can compete by offering only one product variant – as opposed to the early days of mass production when Henry Ford famously said:

"You can have any color you want, as long as it's black."
-Henry Ford on options for the Model T, 1914

2.1.2 Product Variety

Companies use product variety to fulfill a broader scope of market needs. The traditional downside has been that variety costs; increased complexity, slower learning curve, greater scrap rates in manufacturing, higher risk of design fault, higher logistics cost, and higher purchasing costs, are just some contributing factors. In general, variety impacts marketing, design and manufacturing complexity; and imposes costs throughout the supply chain.

The number and variety of products observed at any point of time in a given industry results from a complex selection mechanism where various economic forces interact [58]. As an example, the need for product variety should increase when the degree of income- or taste differences between consumers grows larger. Another example would be that different types of products are more attractive as there is less to gain from consuming more of a specific product [59].

In the current market place, customers can no longer be lumped into a homogeneous group; they expect to be treated as individuals with different needs [3]. The trend is that new models are introduced in the market more frequently and the number of mass-produced models is decreasing [60]. Offering a large palette of product variants has for long been recognized as a powerful way for companies to compete – in fact Whitney [61] argues that companies essentially need product families to survive.

Summing up, on one hand the need for variety of products is apparent, while on the other hand cost advantage from concentrating productive effort on a limited number of products is advantageous – an advantage which is greater the higher the amount of overhead costs in production.

2.1.3 Mass Customization

In recent decades there has been a shift from mass production to mass customization[9] due to tougher global competition [10] and the need for product variety. Mass customization aims to provide goods and services that fulfill individual customers personal needs with near mass production efficiency – it is the customization and personalization of products and services for individual customers at a mass production price [62].

> The imperative today, is to understand and fulfill each individual customer's increasingly diverse wants and needs—while meeting the co-equal imperative for achieving low cost." – *Anderson and Pine [63]*

Traditionally customization and low cost have been mutually exclusive but with mass customization one tries to develop ways to realize both, i.e. combine variety with economies of scale. This can be obtained by e.g. customizing the products by use of product configuration systems [64], or/and platforms [47].

In this section the need for mass customization has been argued to derive from the demand of product variety at mass-production prices. In the next section platforms in the manufacturing industry are introduced, which according to Martin [47], are a good way to minimize design costs and to

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[9] The concept was originally mentioned be Stan Davis [62] and later further developed by Pine [3].

reduce the time-to-market of future products – i.e. a key enabler for mass customization.

2.2 Platforms

A platform in the manufacturing industry is in its nature cross-functional and holistic. It affects and is affected by a number of factors, both within the company's boundaries, as well as externally. It enables a company to deliver variants at a greater pace, and at the same time it creates savings throughout the value chain – through purchasing from suppliers, handling of logistics, positive learning curve effects through the use of fewer assets, and generally reduced complexity.

Developing a single product includes numerous complex steps, among them a market analysis, a concept development, a feasibility review, a final design review, a market test review, and a manufacturing feasibility review [10]. Developing a platform, upon which a company can derive a number of products over a period of years or even decades, is even more difficult for decision makers – uncertainty of the market dynamics, technology dynamics, industry dynamics, and even in the internal status of the company, are significant.

In the following illustration, a number of product families are shown. All of them use a platform in one form or the other.

Figure 2-1: An example of product families that use platforms.

The platforms in Figure 2-1 are perhaps not easy to identify. In some cases they are visible, while in other cases they are not. In some cases they are composed of components, while in other cases they have not a single shared component, but rather use the same production method. This brings us to the question of what exactly a platform is in the manufacturing industry.

2.2.1 A Definition of the Term Platform in the Manufacturing Industry

A range of different platform terms are used in the context of engineering design; *product* platform, *technology* platform, *brand* platform, *global* platform, *modular* platform, *process* platform, *customer* platform, *integral* platform, *scalable* platform, and *high-tech* platform are all commonly used terms to describe different types of platforms. Unfortunately, there are also a number of different definitions for the *same type* of platform. Furthermore, the general term *platform* means different things to different people, i.e. there is a general lack of precision in its usage.

According to Moore et al. [65][10] a *platform* is *a foundation for a range of individual product variation,* i.e., *something that is developed once and used in multiple applications*. Ericsson & Erixon [66][11] similarly find that a *platform* refers to a *common base* from which a number of predefined models can be built. Gonzales-Zugasti et al. [40][12] include *interfaces* into the concept and define a *platform* as *the set of elements and interfaces that are common to a family of products*. These definitions are very similar to definitions of *product platforms,* as later demonstrated[13].

Moving on to the term *product platform*, differing interpretations have been found in the literature depending on the scope and context of its use; it can refer to the sharing of *functions*, the reuse of a *physical frame* that is constant over time, a collection of *modules which can change* over time, or even in some cases it might be a *strategic tool*.

Let us look at definitions of product platforms from some of the recognized researchers within engineering design- and marketing. In its most simplistic form, a product platform refers merely to the sharing of physical components over a range of products. Meyer & Lehnerd [9][14] define a product platform as a set of common components, modules, or parts (especially the underlying core technology) from which a stream of derivative products can be efficiently created and launched. Sawhney [46][15] finds that a product platform is set of subsystems and *interfaces* that form a common structure from which a stream of derivative products can be efficiently developed and produced. This is very similar to Gonzales-Zugasti et al.'s [40] definition of a *platform* mentioned earlier.

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[10] Work within the field of business and marketing.

[11] Work within the field of engineering.

[12] Ibid.

[13] Although not specified it is likely that the authors use the term *platform* synonymously to the term *product platform.*

[14] Meyer works within management.

[15] Works within management of electronic commerce and technology.

Adding the term *design* to the concept, Meyer & Utterback [67][16] and later Nayak et al. [39][17] argue that a product platform encompasses the design as well as the components which are shared by a set of products. Similarly, de Weck et al. [29][18] find that a product platform is a set of *design variables or components* that is commonly shared across the product family.

A different perspective is seen from those who find that the reuse of *technology*[19] is the main factor of a product platform. Maier & Fadel [43][20] define a product platform as *the technology that all the members of the product family have in common,* and upon which different product variants are designed (or "instantiated") by individually adding technology to the platform. Similarly McGrath [42][21] and Siddique et al. [68][22] argue that *a product platform is the lowest common denominator of relevant technology in a set of products or a product line*[23].

Robertson & Ulrich [69][24] include all of the above into their definition of a product platform – finding that it is *the collection of assets that are shared by a set of products*. These assets can be divided into four categories, consisting of components, processes, knowledge, and people & relationships.

McGrath [42] furthermore finds that a product platform is *a collection of common elements, particularly the underlying technology elements, implemented across a range of products.* At the same time he emphasizes that a product platform is *primarily a definition for planning, decision making, and strategic thinking*; it is the set of *architectural rules* and *technology*

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[16] Utterback works within management and innovation.

[17] Work within the field of engineering.

[18] Ibid.

[19] Here the term technology is used for a physical entity.

[20] Work within the field of engineering.

[21] Works within strategic management.

[22] Work within the field of engineering.

[23] It is important to notice however, that in many cases concepts such as *technology* and *design* mean different things to different people.

[24] Work within the field of information- & product development.

elements that enable multiple product offerings and defines the *basic value proposition*, *competitive differentiation*, *capabilities, cost structure, and life cycle of these offerings*. Here it is clear that the platform encloses the core competency of the organization; that *certain something* that gives the organization a competitive advantage.

Significantly different is the definition from Farrell & Simpson [70][25] of a product platform, as it is not a steady, unchangeable foundation or basis, but rather a *design architectural* concept that can change[26]. They argue that the product platform provides the basis for the product family, which is derived through the addition, *substitution, or exclusion* of one or more modules from the platform or by scaling the platform in one or more dimensions.

Sudjianto & Otto [72][27] move from viewing a product platform as mainly being *a collection of physical assets* to being *a set of shared functionality across multiple products.* In the case of the use of multiple brands, *a product platform is a set of functions shared across multiple products each within a different brand.* It is clear in this case that the definition has a different character, as there is no certainty of reuse of components although functions are reused[28]. Furthermore, they define a brand platform as *the set of shared brand signatures and modules* over a range of products. Here a brand signature is a function or aesthetic element made common to a brand's offerings, to maintain brand identity.

The findings imply a gradual increase in *scope* in the *product platform* definition – from including only physical components and modules, to including technology, human resources, design, and functionality.

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[25] Work within the field of engineering.

[26] As an example in the automotive industry a platform can include interchangeable modules [71]. The chassis may even have different lengths as long as the same stamping dies are used.

[27] Work within the field of engineering.

[28] Even if we assume a one-to-one matching between the physical components and the functional elements – i.e. what e.g. Ulrich [73] refers to as modular architecture – we cannot assume the reuse of components.

According to McGrath [42] *technology platforms* are managed differently from product platforms in that product platforms are a market-facing construct, and, although developed collaboratively with R&D, they are managed by a business unit. Technology platforms are in a sense, a core competency for technology-based companies. They do not lend themselves to the building block modules and interface structure of product platforms – whereas the key technical issues for a product platform revolve around the design of *the element integration and the architecture* – for technology platforms, they are more complex; they include road-mapping of relevant product platform elements and predictable, on-schedule technology delivery. Finally make-buy decisions are different for a product platform as they are made at the element level, while for a technology platform, make/buy and licensing decisions are made at the technology, patent, and portfolio level.

Ulrich & Eppinger [26][29] find that a platform product is built around a pre-existing technological subsystem (a technology platform). As an example, the tape transport mechanism in the SONY WALKMAN®, the Apple Macintosh operating system, and the instant film used in Polaroid cameras. A technology platform has already demonstrated its usefulness in the marketplace in meeting customer needs. Furthermore, they find that platform products are very similar to technology-push products in that the team begins the development effort with an assumption that the product concept will embody a particular technology. Gawer & Cusumano [44][30] find that a *high-tech* platform is an evolving system made of interdependent pieces that can each be innovated. The concept of *platform thinking* is defined by Sawhney [46] as the process of *identifying and exploiting the shared logic and structure in a firm's activities and offerings* to achieve leveraged growth and variety. It can be applied to the firm's products, brands, target markets, geographical markets, and business processes. He finds that each of these dimensions is a vector for growth and variety creation, and together these dimensions enable firms to

[29] Work within the field of product development.

[30] Work within the field of management.

achieve leveraged high variety. He describes five types of platforms to facilitate the analysis of the firm's activities and offerings, i.e. a *product platform*, a *global platform*[31], a *customer platform*[32], a *process platform*[33], and finally a *brand platform*[34].

It is clear that there exist numerous types of platforms within the context of the manufacturing industry. Furthermore, a definition of the same *type* of platform can vary considerably as the example of a *product platform* in Table 2-1 shows.

Table 2-1. A summary of the product platform definitions displayed in the section

#	Author(s)	Strategic thinking tool	Planning tool	Decision making tool	Reuse of knowledge	Reuse of functionality	Reuse of design/ design variables	Reuse of architectural rules	Reuse of people and relationships	Reuse of processes	Reuse of a product foundation/ basis	Reuse of technology/ technology elements	Reuse of interfaces	Reuse of modules/ subsystem	Reuse of components/ elements	Reuse of single monolithic part
1	Meyer & Lehnerd [9]													X	X	
2	Moore et al. [65]										X					
3	Ericsson & Erixon [66]										X					
4	Gonzalez-Zugasti et al. [40]												X		X	
5	Sawhney [46]													X		
6	Meyer & Utterback [67]						X								X	
7	Nayak et al [39]						X								X	

[31] Consisting of a core offering that is common across global markets and customized elements that enable speedy and cost-effective localization of the firm's offerings to country-specific conditions and customer preferences.

[32] The *beachhead* that the firm chooses as its point of entry into a new market can be conceptualized as the firm's *customer platform.*

[33] E.g. manufacturing processes, design work-steps, assembly procedures, and logistics handling procedures.

[34] Platform thinking applied to brand management allows a firm to exploit synergies among brands, to minimize overlap among brand identities, and to achieve coherence and clarity of positioning across the product family.

(Continued from previous page)

#	Author(s)	Strategic thinking tool	Planning tool	Decision making tool	Reuse of knowledge	Reuse of functionality	Reuse of design/ design variables	Reuse of architectural rules	Reuse of people and relationships	Reuse of processes	Reuse of a product foundation/ basis	Reuse of technology/ technology elements	Reuse of interfaces	Reuse of modules/ subsystem	Reuse of components/ elements	Reuse of single monolithic part
8	de Weck et al [29]						X									
9	Maier & Fadel [43]											X				
10	Gonzalez-Zugasti & Otto [30]													X[35]		X[36]
11	Robertson & Ulrich [69]				X				X	X					X	
12	McGrath [42]	X	X	X				X				X			X	
13	Sudjianto & Otto [72]					X										
14	Farrell & Simpson [70]													X		

Finally, it is clear that in some cases greater precision is needed in what is meant by the term platform.

In this dissertation, in the context of the manufacturing industry, a platform is defined as:

a collection of core assets that are reused to achieve a competitive advantage

The term *core* indicates that the asset is centre in the organizations understanding of what is essential for the product to be competitive. In most cases, core assets are proprietary, engineered by the members of the organization – the expertise of use of specific material, the secret multi-step process of manufacturing a Silicon Carbide (SiC) semiconductor wafer, or for that matter the secret mixture of the Coca Cola syrup, are all examples of an organizations reuse of core assets. Furthermore, *assets* can be divided into components, processes, knowledge, and people & relationships [69]. A competitive advantage can be created by following one of three generic strategies: differentiation, cost leadership, or focus [74]. Based on this train of

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[35] Modular platform.

[36] Integral platform.

thought, all platforms can be said to have a specific goal – to create a competitive advantage by facilitating the creation of variants, by promoting cost leadership, or by supporting a focus on a niche market.

The strength of this definition is that represents the core essence of the multiple current definitions from the academia. Furthermore, it empowers a company to "put its finger on" the set of core assets that matter the most for creating a competitive advantage. It is free to "color out of the box" and gather together the assets it finds useful and logical to view together, even though they might at first sight not fit into a standard form.

2.2.2 Platform Strategy

As with the term *platform*, the term *platform strategy* means different things to different people.

McGrath [42] finds that a *product platform strategy* is the basis for product strategies. He defines a product platform as *a collection of common elements, particularly the underlying technology elements, implemented across a range of products.* At the same time he emphasizes that a product platform is *primarily a definition for planning, decision making, and strategic thinking*; it is the set of *architectural rules* and *technology elements* that enable multiple product offerings and defines the *basic value proposition*, *competitive differentiation*, *capabilities, cost structure, and life cycle of these offerings*. Here it is clear that the platform encloses the core competency of the company; that *certain something* that gives the company a competitive advantage.

Muffatto [71] argues that a platform can be seen from a *strategic*, an *organizational*, and a *technical* perspective and that the introduction of a *platform strategy* affects product development performances, in particular, cost and lead-time reduction, the international operations and the R&D management strategies of companies. He finds that a platform strategy is strongly linked to the way platform development is organized in relation to the other parts of the whole product and that every company recognizes the platform strategy as a *key issue in their future domestic and international* *strategy*. Furthermore, he states that a platform strategy affects a number of issues, in particular the relationship between platforms and models and between platforms themselves, the relationship with the supplier base, and the relationship with subsidiaries in other countries and with other companies.

Meyer & Lehnerd [9] describe different platform strategies in terms of utilizing platforms over different market segments. They identify three strategies in the context of a market segmentation grid (Figure 2-2). The first strategy is *niche-specific platforms with little sharing of subsystems and manufacturing processes* (Figure 2-2a).

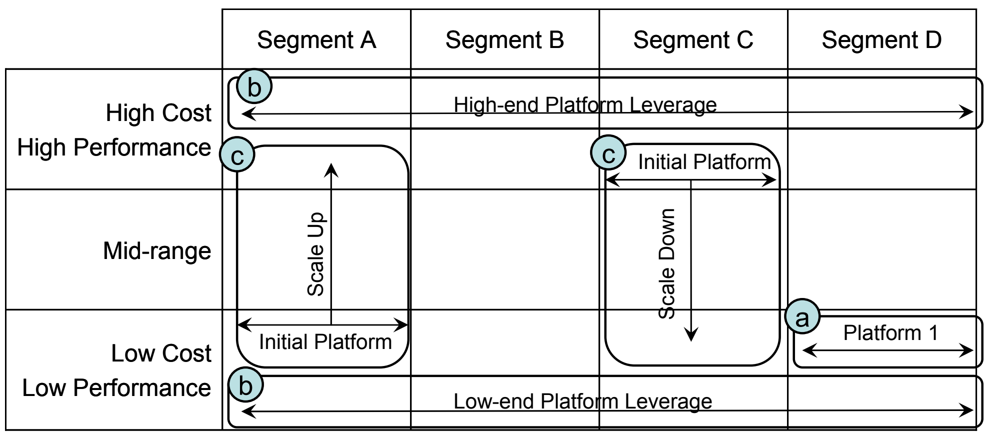

Figure 2-2. A Market Segmentation Grid with Three Platform Strategies (adapted from Meyer & Lehnerd [9])

The second strategy is *horizontal leverage of key platform subsystems and manufacturing processes* (Figure 2-2b). Finally, the third strategy is *vertical scaling of key platform subsystems* (Figure 2-2c). In addition, they define a *Beachhead Strategy* as being a mix of horizontal leverage and vertical scaling. They suggest a five-step process for companies to define their platform strategy: 1) segment markets, 2) identify growth areas, 3) define current platforms, 4) analyze competing products, and 5) consider future platform initiatives. As can be seen, their view of a *platform strategy* has to do with leveraging platforms to different market segments.

According to de Weck et al. [29], a platform strategy is essentially an effective and deliberate program of component reuse which takes advantage of the economies of scale across the product family, while minimizing the negative impact of reuse on individual product variant distinctiveness and performance.

Gawer & Cusumano [44] refer to *Platform Leadership* as the objective to drive innovation in the industry. In their opinion, a platform is a standard, e.g. the Microsoft's Windows operating system, or the VHS standard. They look at *platform strategy* as an action plan to become the dominant platform on the market. They suggest a framework – the *Four Levers of Platform Leadership* framework – that managers can use to design a strategy for platform leadership or make their existing strategy more effective. The framework has the following four *levers*: 1) scope of the firm, 2) product technology (architecture, interfaces, intellectual property), 3) Relationships with external complementors, and 4) internal organization.

It is clear that these five views of *platform strategy* differ a great deal, depending on, among other things, what the authors put into the term *platform.*

As stated earlier, the term platform is defined as a set core assets that are reused to achieve a competitive advantage. The definition of the term platform strategy refers then to a company's elaborate and systematic plan of action to manage a group of platforms, both individually as well as in regards to how they work together as a group; it is a company's grand plan to manage its platforms – to build a match between creating a family of attractive products for the market and the reuse of core assets within the company. A platform strategy includes decisions on e.g. how long a platform should exist and the choice of products that are based on each platform. A successful strategy takes into consideration a broad group of factors that either affect or are affected by the company's platforms. The ultimate goal with platforms is to create a competitive advantage, something that at best is a fleeting commodity that must be won again and again [75], and the platform strategy has to support this.

In Paper C, platform strategy is described in greater detail.

2.2.3 Benefits of Platforms

As mentioned in Chapter 1.1, considerable benefits have been documented from using platforms in the manufacturing industry. Sanderson & Uzumeri [5, 76] demonstrate how SONY managed to launch to market some 250 models of SONY WALKMAN® during the 1980s. Meyer & Lehnerd [9] illustrate how Black & Decker managed to use product platforms to both lower cost and offer a greater variety of attractive products.

Roberson & Ulrich [69] find that:

> "By sharing components and production processes across a platform of products, companies can develop differentiated products efficiently, increase the flexibility and responsiveness of their manufacturing processes, and take market share away from competitors that develop only one product at a time."

By using product platforms, companies can reduce development time and system complexity, reduce development and production costs, and improve the ability to upgrade products. Furthermore, they improve learning across products, reduce the need for testing and certification[37] of complex products such as aircraft, spacecraft, and aircraft engines [24], and enable greater flexibility between factories and increased factory usage. As an example, in the automotive industry sharing underbodies between models can yield a 50% reduction in capital investment, especially in welding equipment—and can reduce product lead times by as much as 30% [71].

2.3 Platform Assessment

Although benefits have been documented due to the use of platforms, they have at times also had a negative impact as earlier reflected. There is a definite need to be able to holistically assess platforms to support companies with their decision making.

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[37] The logic here is that by using a platform, the platform can be tested as whole rather than its individual parts. The same logic applies to certification.

Despite the fact that there exist numerous methods to develop platforms based on optimizing a few criteria (see Chapter 1.3), there is a lack of comprehensive platform concept methods [23]. One of the major challenges is that platforms exist in different types of context and scope that have to be taken account to, i.e. the effect that the platform has on its environment and vice versa have to be considered.

3 RESEARCH METHODS

Research is systematic enquiry, the goal which is knowledge – *Archer [77]*

There are many definitions of research design, but the essence of it can be said to be that (a) the design is an activity- and time-based plan, (b) it is always based on the research question, (c) it guides the selection of sources and types of information, (d) it is a framework for specifying the relationships among the study's variables, and finally (e) it outlines procedures for every research activity [78].

In this chapter, some views of research in engineering design are presented before the actual research method used for the dissertation is established. Finally, data collection and validation are discussed.

3.1 Research in Engineering Design

Engineering design is a relatively new field which encompasses a wide range of multi-disciplinary activities aimed to improve the product development process. Its importance has grown in recent decades in line with the intensification of global competition. In parallel to the growing popularity of the discipline, research activities have also flourished.

In this section, first the motivation for the foundation of the discipline engineering design is contemplated, and second, research within the field is studied.

3.1.1 Motivation of Engineering Design

The shift from workshop-, to mass production, and then to mass customization, has had dramatic consequences on the overall quality, cost, and availability of products. In recent decades there has been a shift from mass production to mass customization due to tougher global competition [10]. Mass customization aims to provide goods and services that fulfill individual customers personal needs with near mass production efficiency.

One of the consequences of these shifts has been an exponential growth of complexity in the design process. In short, there have been major changes in the industry, causing more frequent design changes in products, changes in product development processes, changes in the marketplace, and changes in partnering. It's getting harder to improve system performance from advances in individual disciplines [79].

It is in this context that engineering design has grown as a discipline. Engineering design is a purposeful[38], social (team) and cognitive (individual) activity undertaken in a dynamic context [80]. It is a discipline that creates and transforms ideas and concepts into a product definition that satisfies customer requirements. The role of the design engineer is the creation, synthesis, iteration, and presentation of design solutions. The design engineer coordinates with engineering specialists and integrates their inputs to produce the form, fit, and function documentation to completely define the product [81].

3.1.2 Engineering Design Research

The aim of engineering design research

> The characteristics of design and the aim of engineering design research, i.e. to change the present for the better, requires design research to have its own methodology based on elements of methodologies in other research areas.
> *– Blessing & Chakrabarti [82]*

The aim of research within engineering design can be said to be threefold [83]:

1. The formulation and validation of models and theories about the phenomenon of design,
2. The development and validation of knowledge, methods and tools – founded on these models and theories, and
3. To improve the design process, i.e. support industry producing successful products.

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[38] Aimed at changing existing situations into preferred ones.

In general the overall aim is to support the industry by improving the understanding of engineering design and, based on this, develop knowledge, in the form of guidelines, methods and tools that can improve the chances of producing a successful product [82]. It is essential that design research is scientific in order for the results to have validity in some generic, practical sense [82].

A note on engineering design research

Research activities have been quite diverse in nature and context. Cantamessa [84] finds that it is no simple matter to define the contents, the research approach or the community behind research in engineering design. He identifies the youth of the discipline, the numerous disciplinary backgrounds of the researchers involved, and that there is no field in natural science from which design engineering derives, as the main cause. Blessing [1] agrees and finds that the outcome of several discussions on engineering design research with groups of PhD students who had been involved in design research for a few years showed that there is a distinct lack of clarity about what constitutes engineering design and how to go about it.

In *science of research* literature, it is clear that such multi-disciplinary characteristics are not uncommon for a research field. Gibbons et al. [85] find that a new type of knowledge generation has come into being, both in the natural and social sciences, as well as in the humanities, which they call mode 2[39] knowledge production. It is characterized as trans-disciplinary, carried out in a context of application, and heterogeneous, while the old mode (mode 1) is disciplinary, problems are set and solved in a context governed by the, largely academic, interests of a specific community, and homogeneous.

[39] This is in line with Nilsson's [86] findings that science researchers have continuously provoked our basic view of the motivation for science. He makes account for how the creation of science can be seen as motivated by numerous forces, taking into account history, sociology, anthropology, philosophy, and other factors.

Knowledge production within engineering design is mode 2 and a trans-disciplinary set of "goggles" are needed when trying to understand the nature of research within engineering design[40].

3.2 Design Research Methodology (DRM)

In this section the research methodology for the dissertation is introduced. It was chosen due to its robust, efficient, effective and rigorous approach.

To deal with the multidisciplinary nature of engineering design research, Blessing et al. [82, 83] propose a methodology called the Design Research Methodology (DRM) to help researchers in identifying research areas and projects, and in selecting suitable research methods to address the issues. Furthermore, it has the goal to piece together various types of research, to encourage a reflection on one's own research, and to provide pointers to methods in other disciplines that can be used [82].

The methodology consists of four stages, Criteria, Descriptive Study I, Prescriptive Study and Descriptive Study II (Figure 3-1).

[40] Sørensen [87] argues that the notion of trans-disciplinary research has been initiated due to the lack of a general holistic overview; the poly-technically educated engineer should encompass the competence to apply science to praxis. One has to study the product realization process as a whole, including the use of resources in the manufacturing process and the disposal of products after their useful life. Such improvement of the design process requires the insight from numerous multi-disciplinary fields; management and communications, application of psychological principles, use of statistically-based quantitative methods, as well as advances in mathematics, computer science and other sciences – all applied in an engineering context [79].

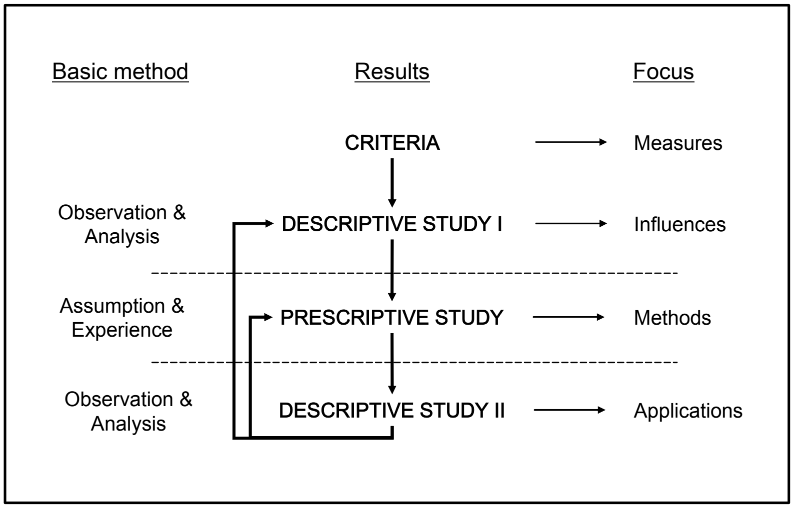

Figure 3-1: DRM framework (adapted from Blessing and Chakrabarti [82])

Criteria

In the first stage of the methodology the success- and measurable criteria are formulated. The expected research aim is identified, and the focus of the research project is set. It provides the focus for the Descriptive Study I, on finding the factors that contribute to or prohibit success. It furthermore creates a focus for the Prescriptive Study on developing support that address those factors that are likely to have most impact. Finally it enables the evaluation of the developed support/tool (Descriptive Study II).

Descriptive Study I

This stage of the methodology emphasizes the importance of descriptive studies to increase our understanding of design, in order to inform the development of the design support. It furthermore identifies the factors that influence the formulated measurable criteria and explains how they influence these. It provides a basis for the development of support to improve design. Finally, it provides more details that can be used to evaluate the developed design support.

Prescriptive Study

This stage emphasizes the importance of developing an impact model (or theory) as the basis for systematic development. It develops an impact model or theory, based on the reference model or theory from the Descriptive Study stage, describing the expected improved situation.

Furthermore, it develops the support in a systematic way. Finally, it evaluates the support with respect to e.g. its in-built functionality and consistency.

Descriptive Study II

The final stage of the methodology emphasizes the need for different types of evaluation to assess the developed support, and the need to evaluate more aspects than only functionality. The goal is to identify whether the support can be used in the intended, and that it addresses the factors it is supposed to address (application evaluation). Finally, an evaluation is made whether this indeed contributes to success (see the feedback arrows in Figure 3-1), thus addressing the impact as well as the reference model. In the following table, the roles of each of the DRM stages are summarized.

Table 3-1: Roles of each of the DRM stages (Blessing and Chakrabarti [82])

STAGE	ROLE OF THE STAGE
Criteria	Here DRM emphasizes the need for formulating a success- as well as a measurable criteria. More specifically the role of the stage is: • To identify the aim that the research is expected to fulfill, and the focus of the research project. • To focus Descriptive Study I on finding the factors that contribute to or prohibit success. • To focus the Prescriptive Study on developing support that addresses those factors that are likely to have most influence. • To enable evaluation of the developed support (Descriptive Study II).
Descriptive Study I	Here DRM emphasizes the importance of descriptive studies to increase our understanding of design in order to enlighten the development of design support. More specifically the role of the stage is: • To identify the factors that influence the formulated measurable criteria and how they influence these. • Provide a basis for the development of support to improve design. • Provide more details that can be used to evaluate developed design support.

(Continued from previous page)

STAGE	ROLE OF THE STAGE
Prescriptive Study	Here DRM emphasizes the importance of developing an impact model (or theory) as the basis for systematic development. More specifically the role of the stage is: • To develop an impact model or theory, based on the reference model or theory from the Descriptive Study stage, describing the expected improved situation. • To develop support in a systematic way. • To evaluate the support with respect to its in-built functionality, consistency, etc.
Descriptive Study II	Here DRM emphasizes the need for different types of evaluation to assess the developed support, and the need to evaluate more aspects than only functionality. More specifically the role of the stage is: • To identify whether the support can be used in the situation for which it is intended, and that it does address the factors it is supposed to address (application evaluation). • Success evaluation to identify whether this indeed contributes to success (see the feedback arrows in Figure 3-1) thus addressing the impact as well as the reference model.

It is not expected that each of the stages of the methodology is executed in depth in every single project. In the next section the case study approach is introduced.

3.3 The Research Design of this Dissertation

The research in this dissertation started as an exploratory process where the general research focus was gradually crystallized. In this first phase, the exploration of secondary data was useful–while the actual problems regarding platform assessment were uncertain. Through the exploratory process, the platform concept was made clear, priorities were established, and the general research design method was decided.

After the research questions had been formalized, the study departed from being exploratory to being more formal. Data was collected both through extensive reviews of literature (secondary data) as well as empirically (primary data), where both observations as well as surveys were used[41]. As the time frame of the research was relatively short, longitudinal observations were impossible. Instead the time dimension of the study was cross-sectional, i.e. the observation was carried out once and represented a snapshot of one point in time. Case studies were used to iteratively improve the method as well as validate whether it was of use for the small sample of companies visited (i.e. no universal validation).

The research followed the third type of design research according to DRM. This is depicted in (c) in Figure 3-2; a review was used for the Criteria Formulation and Descriptive Study I, a detailed Prescriptive Study was performed and finally an initial Descriptive Study II was carried out.

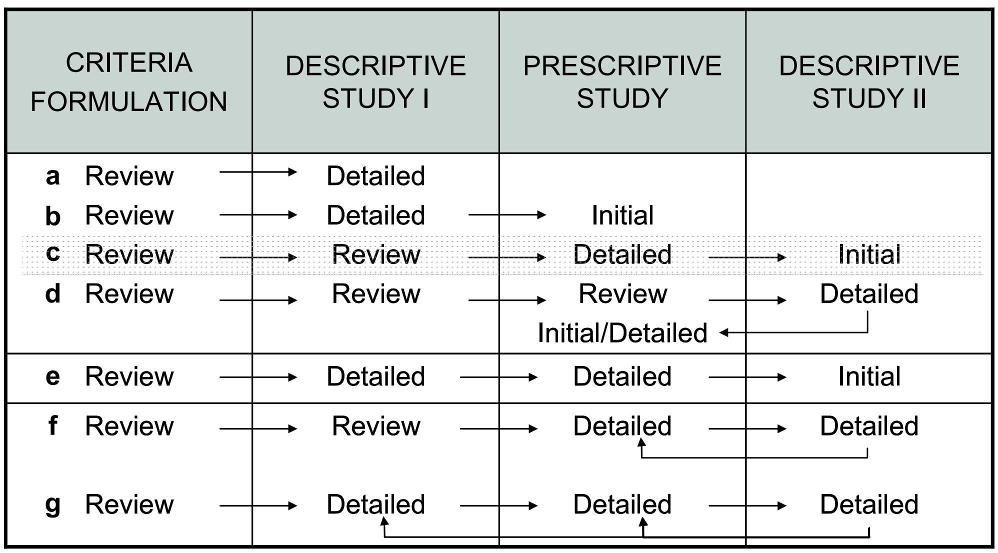

Figure 3-2: Different types of design research derived from the proposed methodology. This research follows the third "type" of design research, marked with (c). (Adapted from Blessing & Charkrabarti [82]

Criteria definition

Based on reflection, the level of competitive advantage was taken as the overall criteria for success, while the level of platform understanding was defined as the measurable criterion for the research.

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[41] See Chapter 3.5 for further information on data collection.

The time frame of the project was limited, and so literature was consulted and assumptions were made that the level of competitive advantage could be increased if the level of platform understanding was increased.

Figure 3-3 shows the logical steps used to connect the measurable criteria with the success criteria.

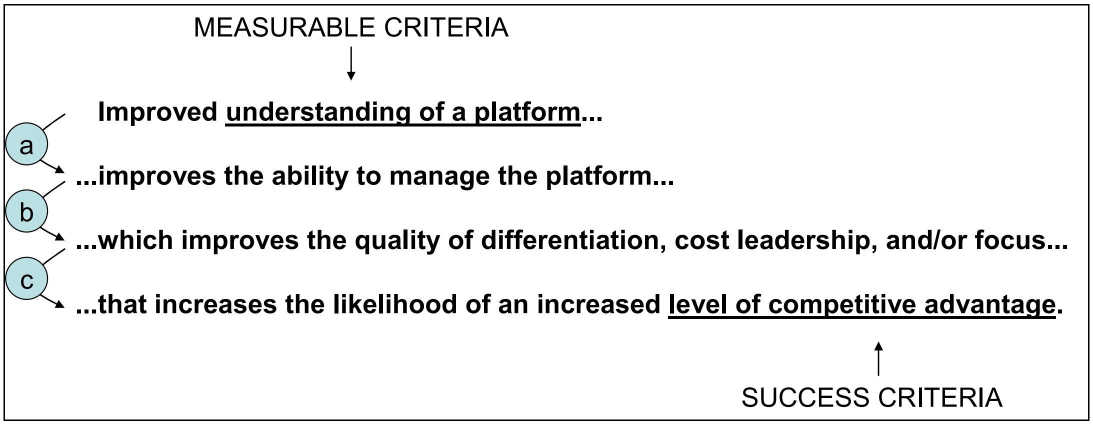

Figure 3-3: The logical steps between the measurable- and success criteria

First of all, the assumption is made that improving the understanding of a company's platforms, improves the ability of the company to manage its platforms (a). The second assumption (b) is based on numerous findings that identify that platforms can be useful to improve the quality of differentiation, cost leadership, and/or focus attributes [5, 9, 13, 36, 42]. Furthermore, in his dissertation from the University of St. Gallen in 2001, Hofer [21] explicitly demonstrates that platforms can be used to create an competitive advantage. Finally, (c) Porter [55] argues that competitive advantage can be achieved by following three generic strategies, differentiation, cost leadership, or focus.

In this way the measurable criteria has been linked to the success criteria both with basic assumptions and with the help of literature. This dissertation suggests a method to improve the understanding of platforms in companies. The argument is made that if it is possible to validate that the measurable criteria can be improved, it is possible to say that the success criteria is improved. This specifically means that if the level of platform understanding is improved then the competitive advantage of the company is also improved.

Descriptive Study I (DS-I)

In this stage, literature was used to identify viewpoints that could be used to depict a platform – and so improve the holistic understanding of a platform, i.e. the measurable criterion.

The chosen approach to identify these viewpoints was to categorize them into those that describe (a) how the platform affects its surroundings, (b) how the surroundings affect the platform, (c) company internal effects of the platform, and (d) company external effects of the platform. In Figure 3-4 this is illustrated. The horizontal axis is divided into viewpoints that describe company internal and company external effects. The vertical axis is divided into viewpoints that describe how the platform is affected by its surroundings and how the surroundings are affected by a platform. As an example, in Figure 3-4, viewpoint A illustrates how the platform affects its surroundings and derives from the internal organization.

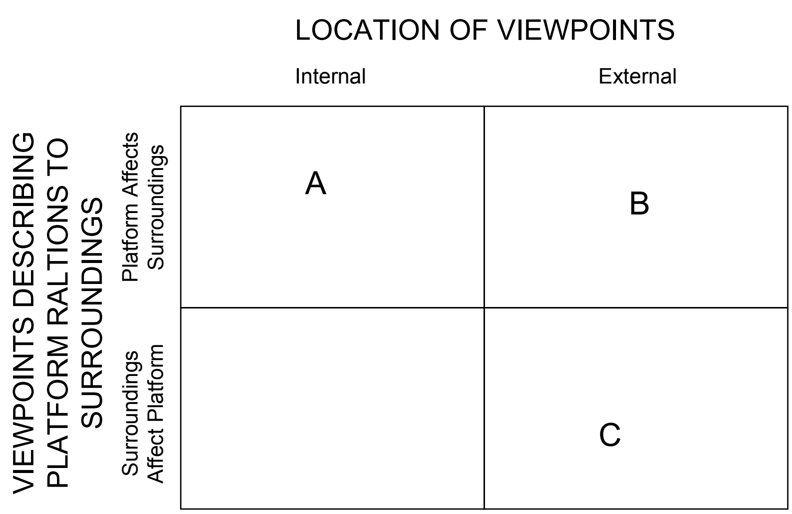

Figure 3-4: Factors can be viewed as a) affecting the platform or being affected by the platform, and b) being internal or external.

Another example would be that viewpoint C illustrates how the surroundings affect the platform and is an external factor. Note that this schema/framework is only meant to support the identification of the viewpoints.

Prescriptive Study

In this stage, a method was suggested to systematically register the information about the platform, based on the viewpoints captured in

Descriptive Study I. To develop the method the results from DS-1, own insight, and an iterative improvement process in collaboration with the industry, was used. The method, along with the logic behind it, is presented in Chapter 4.

Descriptive Study II (DS-2)

In the last stage, an initial review of the method was performed in the industry. A validation of the methods usefulness along with an evaluation of whether it improved the measurable criterion was assessed. This stage is presented in Chapter 5 and Paper E.

3.4 Addressing the Research Questions

In this section the approach to addressing the research questions is described.

RQ1: Is it possible to define the term *platform* in a way that embodies the core essence of the multiple current definitions from the academia?

This research question has been addressed by examining a vast amount of secondary literature (Chapter 2.2 and Paper A) and deducting their *essence*. Based on the findings, a definition was made.

RQ2: How can a platform be viewed to create a holistic understanding of its current state?

Viewpoints to analyze the platform were identified by setting up a framework based on the following assumptions:

- A platform is influenced by a number of company internal and external factors.
- A platform influences a number of company internal and external factors.
- A platform has a goal which is to create a competitive advantage – differentiation, cost leadership, or focus.
- A platform has side effects which can be internal and external, negative or/and positive.

The viewpoints identified aimed to depict the platform in a holistic way. The goal was not to find the *optimal and final* set of viewpoints, but rather to demonstrate the usefulness of the approach in general – i.e. to use viewpoints to create a holistic picture to improve understanding.

For different companies, a different set of viewpoints (or at least a different weighting of importance of the viewpoints) is to be expected. Chapter 4.6, Papers B and C further address this research question.

RQ3: Can a cross-functional assessment of a platform facilitate and stimulate discussion, common understanding, consensus based decision making, and common ownership, with regards to the platform?

In Chapter 4 and Paper D this research question is addressed. Basically the viewpoints identified in RQ2 are systematically examined in a matrix[42]; first by individually interviewing a group of internal cross-functional stakeholders and later jointly in a workshop.

3.5 Data Collection

Research is in most cases based upon the work of others. The research in this dissertation is no exception. Secondary data was used to understand the "lay of the land" in regards to platforms in the manufacturing industry. Furthermore, secondary data is a substantial part of the method developed in the dissertation, i.e. the PAMatrix (Chapter 4). In this section the data collection method is described.

3.5.1 Secondary Data

Secondary data was used in all steps of the research process (based on DRM), from Criteria Definition to the Descriptive Study II. The material originated from online data-bases, design engineering conferences and workshops. The scope of the dissertation is quite broad and it would have been non-value adding to try to discover everything.

[42] The Platform Assessment Matrix (PAMatrix).

In Table 3-3 the specific use of secondary data is listed.

3.5.2 Primary Data

The PAMatrix method was iteratively improved based on observations and feedback from industry-situated stakeholders.

A case study approach was used, which is important where a greater emphasis on a full contextual analysis of fewer events or conditions and their interrelations is needed [78]. In general, case studies are the preferred strategy when “how” or “why” questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context [88].

The critics to the case study approach argue that investigators who do case studies have deviated from their academic disciplines; their investigations, have insufficient precision (that is, quantification), objectivity, and rigor [88]. Furthermore, case studies have been maligned as “scientifically worthless” because the do not meet minimal design requirements for comparison[78].

On the other hand, the supporters of the case study approach argue that they have a significant scientific role, as they can e.g. be used to falsify universal scientific propositions by a single counter instance [78]. Others find that there is a striking paradox in the claim that the case-study method has serious weaknesses and the number of investigators using the method; case studies are frequently used in social science research (e.g. psychology, sociology, political science, anthropology, history, and economics, urban planning, public administration, public policy, management sciences and education), dissertation research, and evaluation research [88].

The setup of the case study in this dissertation is described in Chapter 5.

The communications approach entails surveying people and registering their input for analysis. The strength of the method lies in its versatility where abstract information of all types can be gathered by interviewing others. The drawback of the method is that the motivation of the participants is not always optimal and therefore the quality of the answers might vary [78]. Figure 3-5 demonstrates a number of factors that influence participant motivation.

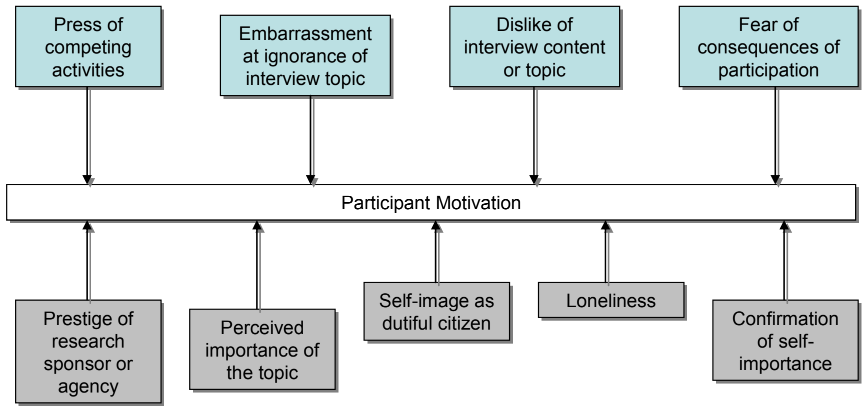

Figure 3-5: Factors influencing participant motivation (adopted from Cooper & Schindler [78])

The quality and quantity of information collected depends heavily on the ability and willingness of participants to cooperate.

Observation is used to gather a range of insight and stimuli; the atmosphere in the company, facial expressions in responding to questions, hesitations, bewilderment, happiness, etc. While such observation may be a basis for knowledge, the collection processes are often disorganized. Observation qualifies as scientific inquiry when it is conducted specifically to answer a research question, is systematically planned and executed, uses proper controls, and provides a reliable and valid account of what happened [78]. In Chapter 5, a more thorough description of the observations in the Prescriptive Study is given. A survey was used to assess the usefulness of the method and is shown in Chapter 5.3.

3.5.3 Qualitative Exploration

Qualitative methodologies are used to evaluate causal relationships by holding certain variables constant through careful case selection, while quantitative methodologies are used to isolating causal relationships through large numbers of cases and statistical procedures.

Unlike quantitative techniques, causal qualitative analysis of a small number of cases facilitates investigation of [88]:

(a) important but difficult-to-quantify variables (such as power, interests, or leadership),

(b) theoretically important, empirically rare, or previously ignored cases,

(c) innovative (but, by their nature, rare) international environmental policy strategies, and

(d) causal, rather than merely correlational, relationships

3.6 Validation

Validation is of key importance in any research. Rossi et al. [89] argues that evaluators must often innovate and improvise as they attempt to find ways to gather credible, defensible evidence about social programs. Blessing & Chakrabarti [82] find that the statement is fitting to design research as well. According to Rossi et al. [89], "the main challenge here is to match the research procedures to the evaluation questions and circumstances as well as possible and to apply the highest possible standard feasible in those circumstances."

For this dissertation several types of validity are of importance [90] – these are displayed in the following table.

Table 3-2: Types of Validation

Validation Type	Description
Construct Validity	Does the collected empirical information accurately capture the concepts or variables contained in the theoretical model or propositions nominally being investigated?
Internal Validity	Does the analytic method demonstrate that, for each hypothesized causal relationship, variation observed in the independent variable correlates with observed variation in the dependent variable, and that no other variables provide a more plausible explanation of variation in the dependent variable?
External Validity	Has the researcher accurately identified the boundary between the population of cases to which the findings can be validly generalized and beyond which valid generalizations are unlikely?
Reliability:	Could other researchers replicate the research techniques used, e.g., data collection and analytic methods, and, having done so, arrive at the same results?

3.7 Summary

Summing up, the discipline of engineering design is an offspring of the continuous strive to improve the activity of creating a product. It is a pragmatic, social, and cognitive activity undertaken in a dynamic context which has become more and more important in parallel to an increasingly complex product development process.

Research within the field of engineering design derives from the need to understand and improve today's multi-disciplinary design process; shorten time to market, fulfill individual needs, decrease cost, increase quality, and provide greater variety. Research activities have been quite diverse in nature and context and there is a clear lack of clarity about what constitutes engineering design and how to go about it.

The use of the Design Research Methodology (DRM) along with information on data collection for the dissertation is summed up in the following table.

Table 3-3: A summary of the DRM used in the dissertation

Steps	Definition or Task
Success Criteria	*Definition:* Increase competitive advantage by creating a greater level of differentiation, lowering cost and/or improving the ability to focus. *Data Collection:* Secondary data was used to define the focus of the dissertation. Here the work of Meyer & Lehnerd [9], McGrath [42] and Sawhney [46] have been influential along with many others (e.g. [24, 29, 41, 91, 92]). Strategies to achieve a competitive advantage are based on the work of Porter [55].
Measurable Criteria	*Definition:* Increase the understanding of platforms. *Data Collection:* Primary data and own reflection.

(Continued from previous page)

Steps	Definition or Task
Descriptive Study I	*Task:* Here a number of viewpoints were identified which aim to address RQ2, i.e. *how can a platform be viewed to create a holistic assessment of its current state?* The mission was to provide a basis for the development of support for improving platform understanding. The objective was not to identify the *one and only* possible set of viewpoints to create a holistic understanding of a platform, but rather a solid set of viewpoints that were *reasonably* mutually exclusive and all inclusive[43]. The originally identified viewpoints were then verified with the industry.➔ Result of this stage is a reference model. *Data Collection:* secondary (e.g. Porter [55], Andreasen & Hein [93]) and primary data was used (feedback and observation from the industry). *Where addressed:* Chapter 4, along with Papers B and C address this step.
Prescriptive Study	*Task:* Construction of method to improve the understanding of platforms. Here the identified viewpoints from the Descriptive Study I are used. The method was iteratively improved in the industry. *Data Collection:* primary data was gathered by communicating with the industry. The stakeholders were personally interviewed (i.e. face-to-face communication). They were asked to rate the platform in accordance to questions within the PAMatrix. If they wished, they could make additional comments regarding their rating. In addition, observation was used during the interviewing process. Finally, a workshop was held where the collective results of the study were presented to the participants. Again, direct feedback and observation was used to monitor reactions, discussions, emotions, and group atmosphere. *Where addressed:* Chapter 4 and Paper D address this step.
Descriptive Study II	*Task:* Validation of usefulness for a limited number of companies (non-universal validation). *Data Collection:* a survey was used to capture the feedback from the stakeholders regarding the usefulness of the PAMatrix method. *Where addressed:* Chapter 5 and Paper E address this step.

[43] It is important to emphasize that it is quite possible, that other viewpoints could have been interesting to include, or that some of the included viewpoints could be removed.

4 THE PLATFORM ASSESSMENT MATRIX

In this section, the development of the Platform Assessment Matrix (PAMatrix) is described. Furthermore, an overview of the use of the method is given. It was originally suggested in Paper D[44] [94], while the logic of the method was argued in Papers A-C [17, 95, 96].

4.1 PAMatrix Development

The development of the PAMatrix involved numerous iterative modifications, the use of literature, own intuition, and cooperation with the industry. The objective was to create a method that would increase the understanding of platforms.

The first challenge was that there was no unified definition of the term platform. Considerable effort was therefore put into defining the term in such a way that embodied the core essence of the multiple current definitions from the academia. In Chapter 2.2.1 and in Paper A, the logic behind this step, i.e. the addressing of research question 1 (RQ1), is explained.

Having defined the term platform, creating a framework to improve the understanding of platforms became possible. The definition was quite broad in nature – *a set of core assets that are reused to create a competitive advantage*. It was therefore clear that the framework had to also be broad in scope, enabling the creation of a holistic understanding for all platforms. This is in line with ideas from *the Copenhagen School*, that highlight the importance of considering a plethora of cross-functional factors during a product development process [93, 97] – concurrently considering the product, the market, as well as the manufacturing process.

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[44] Due to restrictions in the length of the conference paper (Paper D), the method is explained more thoroughly in this chapter. Furthermore, some changes have been made from the published paper.

The basic idea is therefore that in order to create a sound understanding of platform, a pallet of “viewpoints” must be considered which each might differ in scope and scale but never the less enable an important partial assessment of the platform. As an analogy, one might gain a better understanding of a person by considering the viewpoints dexterity, income, and popularity. Another example would be to gain a better understanding of a house by considering aesthetics, plumbing, and distance from public schools.

In addition to the objective of creating a holistic evaluation, bringing the concept of competitive advantage into the platform term, puts a focus on the actual output of a platform, i.e. reasoning and evaluating what the actual goal is. Literature reveals that there are a number of reasons that companies use a platform, e.g. to speed up time to market, reduce complexity, and create variants. It was found that all these platform goals can be linked to the work of Porter, where he finds that a competitive advantage can be created with three generic strategies: Cost leadership, Differentiation, or Focus [55] [45]. Hofer [21] supports the assessment that platforms act as a driving force to create a competitive advantage.

Finally, literature reveals that platforms can have a number of side effects that can be negative, neutral, or positive, and affect the company both internally as well as externally.

Based on this line of reasoning, the framework depicted in Figure 4-1 has been created. Using the definition of a platform as basis, a process is followed where (1) platforms are identified, (2) their goals vs. goal fulfillment are assessed, (3) their side-effects are identified, (4) factors influencing the platform are evaluated, and finally (5) an overall assessment is made of the platform based on Steps 1 to 4 (Figure 4-1).

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[45] This is further discussed in Paper B in the appendix.

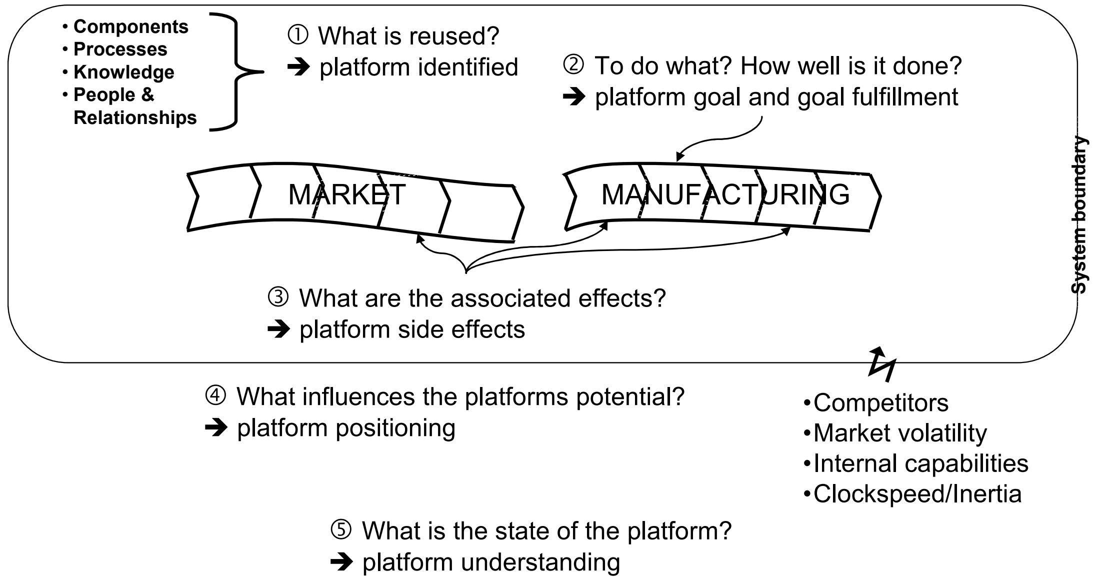

Figure 4-1: The framework for assessing platforms.

Inside the system boundary are factors that are influenced by the platform, while outside the system boundary are factors that influence the platform.

Based on this framework, along with the mental mapping tool suggested in Figure 3-4, viewpoints to increase the holistic understanding of platforms have been identified. These viewpoints are then used as the basis for the Platform Assessment Matrix method – which is explained in the next section.

The viewpoints chosen for the method are not absolute, i.e. the idea is that companies should be able to add or remove viewpoints depending on their identified needs. In clear text, the viewpoints in this chapter are a starting point and what is important is to demonstrate the idea behind the method; i.e. to systematically investigate a set of platform relevant viewpoints by a focus group in order to gain a better understanding of the platform and so be able to make better decisions.

The set of viewpoints discussed in this chapter have been iteratively chosen to make apparent a platform based on the frameworks illustrated in Figure 4-1. In cooperation with the industry, they have been used to validate the usefulness of the method This is explained in detail in Chapter 5. The viewpoints are formed by assessing a number of metrics. These metrics are in some cases adopted from the work of other researchers, e.g. from Michael Porter [55] and Clayton Christensen [98].

The viewpoints can be divided into two groups, 1) depending on where they are located – i.e. internally within the company or externally, 2) depending on whether they depict how the platform is affected by its surroundings or vice versa[46]. This is illustrated in Figure 4-2.

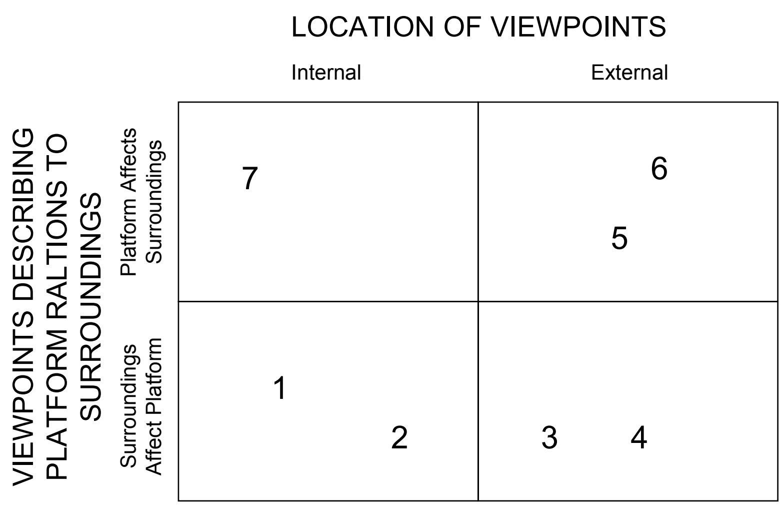

Figure 4-2: Viewpoints used in the PAMatrix can be categorized as illustrated above.

The process to create the framework required a number of iterative changes and consultation with the literature, supervisor, the industry, and colleagues. Quite early on in the process, a very basic model was created and then tested in the industry.

Merely to demonstrate the iterative improvement process, Figure 4-3 shows an example of an early test that has now been removed and partly incorporated into Step 4 of the PAMatrix[47].

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[46] This is further explained in Chapter 3.3.

[47] Please refer to 4.6.1 for further information.

Δprice [%]	Functional commonality [1-7]	Visual commonality [1-7]
Δcost [%]	Standard commonality [1-7]	Part commonality [1-7]
market segment [A-G]	Technology commonality [1-7]	value for customer [1-7]

	MRU 1				MRU 2				MRU 3				MRU 4			
MRU 1	0 %	-			105 %	2		1	132 %	3		1	262 %		3	1
						4		0								
	MRU				MRU			same	MRU				MRU			
MRU 2	-51 %				0 %	-			13 %	2		1	76 %		3	1
	MRU				MRU				MRU				MRU			
MRU 3	-57 %				-12 %				0 %	-			56 %		1	1
	MRU				MRU				MRU				MRU			
MRU 4	-72 %				-43 %				-36 %				0 %		-	
	MRU				MRU				MRU				MRU			

Figure 4-3: A sample of a part of the PAMatrix method from an early version that has been removed and partly incorporated into Step 4 (See next section).

Some of the findings demonstrated that the initial method was too complex, did not consider certain key factors, and emphasized other factors too much. After a number of iterations in the academia, the method was again tested in the industry; this time in three different companies, with 19 participants. Again, further iterative improvement was carried out and the approach and results are described in Chapter 5.

Finally, after having gone through multiple iterations, the method had evolved into the current state, as described in the next section. Throughout the iteration process, focus was kept on improving the ability to holistically understand platforms, but also at the same time on keeping the method user friendly.

4.2 Overview of PAMatrix

The PAMatrix method was developed to be used in all industries for all types of platforms[48]. It can be used both before the launch of a platform or new product, as well as during the lifetime of a platform, to holistically understand its effects and status as well as for the stakeholders of the company to create

[48] In this dissertation the method was tested in three different types of industries, which is not sufficient to externally validate the method.

a common understanding and ownership of the platform. In this section the method is explained in detail.

In the PAMatrix method, seven viewpoints are used to describe the platform. Each of the viewpoints establishes pieces of information regarding the platform, and although these pieces of information, i.e. viewpoints, are not entirely mutually exclusive and all inclusive, together they paint a reasonably accurate picture of the platforms status. The subjective opinion of a number of stakeholders' forms the basis for the evaluation. Upon the evaluation, a fruitful discussion can be held and a consensus based decision of strategic steps made. Figure 4-4 depicts an overview of the PAMatrix method.

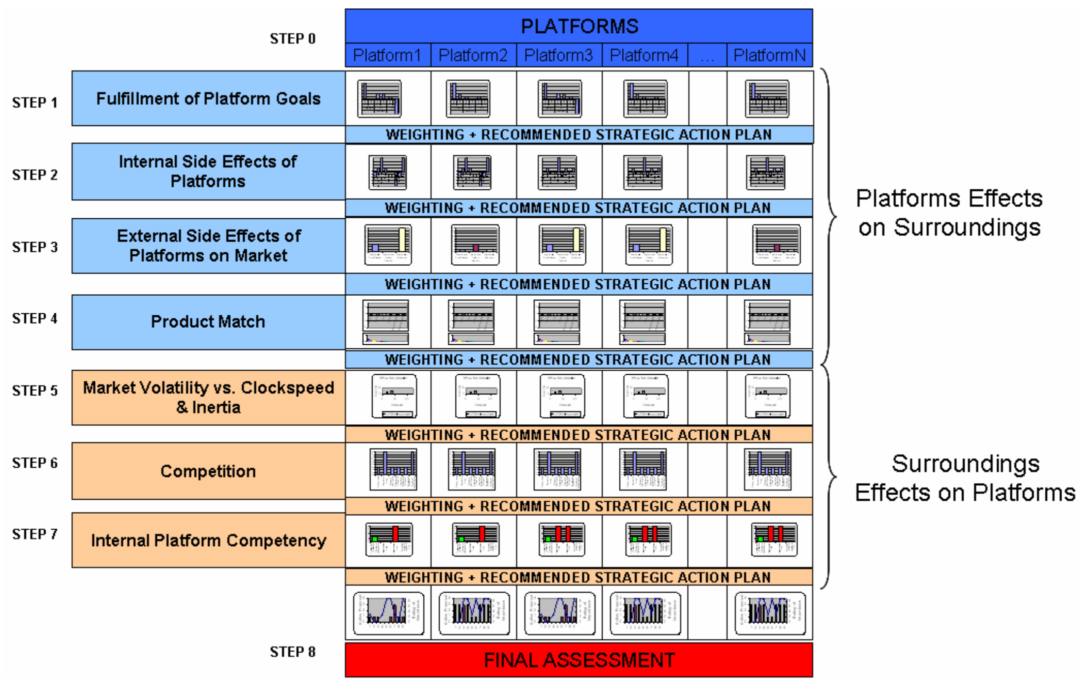

Figure 4-4: An overview of the PAMatrix method

In Step 0 a company defines a set of platforms to be analyzed. In Steps 1-4, viewpoints demonstrating the platforms effects on its surroundings are captured, while in Steps 5-7, viewpoints demonstrating how the platform is affected by its surroundings are registered. Finally, in Step 8, the results from Steps 1-7 are summarized.

Although earlier stated, it is important to emphasize that the viewpoints chosen for the method are not absolute, i.e. companies can choose to add or remove viewpoints depending on their identified needs. The seven chosen viewpoints derive from the frameworks depicted in Figure 4-1 and are more thoroughly described in Chapter 4.6.

The inherent logic of the method should make it universal, i.e. usable for most companies – whether they sell physical products or services.

4.3 Entering Data into the PAMatrix

Depending on the step in the PAMatrix, data is gathered in different ways. In Step 0, a focus group, consisting of cross-functional experts, mutually define the platforms to evaluate. Here the focus is on identifying the sets of reused assets over families of products that the focus group believes creates (or should create) a competitive advantage for the company. This step is described more thoroughly in Chapter 4.5.

In Steps 1 to 8, the chosen platforms are first graded by members of the focus group – where each member is individually interviewed. A number of rating scales are used, designed to capture the values of each step in accordance to the types of questions addressed (Table 4-1).

Finally, a joint workshop is administrated, where the combined results of the interviews are presented for the whole focus group. Here, the objective is to create a common understanding of the platform, highlight agreements and disagreements, create a common agreement (if possible), and state consensus based decisions on specific strategic platform action steps. Furthermore, the dynamics between the individuals in the focus group are monitored and registered[49].

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[49] In many ways the approach to collect data is similar to that of the Delphi Method, i.e. a team of experts within the area to be observed are first individually interviewed in closed settings before the opinions are shared amongst the interviewers and openly discussed. The main point behind the Delphi method is to overcome the disadvantages of conventional committee action [99].

4.4 Rating Scales

In this section, the rating scales used for Steps 1 to 8 are presented. In general, rating scales are used to judge properties of objects without reference to other similar objects [78]. In the PAMatrix this is the case, where stakeholders are asked to subjectively rate a single platform according to a number of viewpoints. Table 4-1 presents an overview of the rating scales used in the PAMatrix method.

Table 4-1: Grading scales used in the PAMatrix

Scale	Value	Description
Rating Scale A (RS-A)	-9	Great negative effect
	-3	Medium negative effect
	-1	Low negative effect
	0	No effect
	1	Low positive effect
	3	Medium positive effect
	9	Great positive effect

Scale	Value	Description
Rating Scale B (RS-B)	0	None (or does not apply)
	1	Low
	3	Medium
	9	High

Scale	Value	Description
Rating Scale C (RS-C)	0	High
	3	Medium
	7	Low
	9	None (or does not apply)

Scale	Value	Description
Rating Scale D (RS-D)	-9	Much worse than expected
	-3	Considerably worse than expected
	-1	Slightly worse than expected
	0	As expected
	1	Slightly better than expected
	3	Considerably better than expected
	9	Much better than expected

Scale	Value	Description
Rating Scale E (RS-E)	-9	Great negative match
	-3	Strong negative match
	-1	Minor negative match
	0	Correct match
	1	Minor positive match
	3	Strong positive match
	9	Great positive match

Scale	Value	Description
Inertia Rating Scale (IRS)	F	Financial
	T	Time To Market
	K	Know-How
	S	Standard

Scale	Value	Description
Maturity Level Scale (MLS)	E	Embryonic
	G	Growth
	M	Maturity
	A	Aging

Scale	Value	Description
Action Proposal Scale (APS)	0	Status Quo
	1	Incremental Change
	2	Drastic Change
	3	New / Split
	4	Eliminate / Merge

Scale	Value	Description
KANO Scale (KMS)	T	Threshold
	P	Performance
	E	Excitement

Rating scales A, B, C, D and E are numerical scales, using interval data. In all of them, central tendency error has been avoided by using a non-linear scale. The RS-A scale aims to capture negative, neutral, and positive effects in Steps 1 and 2 of the PAMatrix. The RS-B scale aims to capture neutral and positive effects and is used in all steps. The RS-C scale is the inverse of RS-B, i.e. it captures neutral and positive effects, but a low rating on the scale is given for a high grade and vice versa. This rating scale is used in Steps 6 and 7. The RS-D scale aims to capture whether or not the side effects listed in Step 2 were as expected. The RS-E scale captures how well the platform matches the target function, quality, cost, volume, emotional appeal and maintenance & repair of the derived products – it is used in Step 4. The Inertia Rating Scale (IRS) captures the reason of inertia – i.e. the reason why a company uses a given platform. It is used in Step 5. The Maturity Level Scale (MLS) is designed to capture the maturity level of a given platform (Figure 4-5). This graph is traditionally used to describe the maturity level of products. The platform, i.e. the reused set of core assets, can arguably be evaluated in the same way. This scale is used in Step 5.

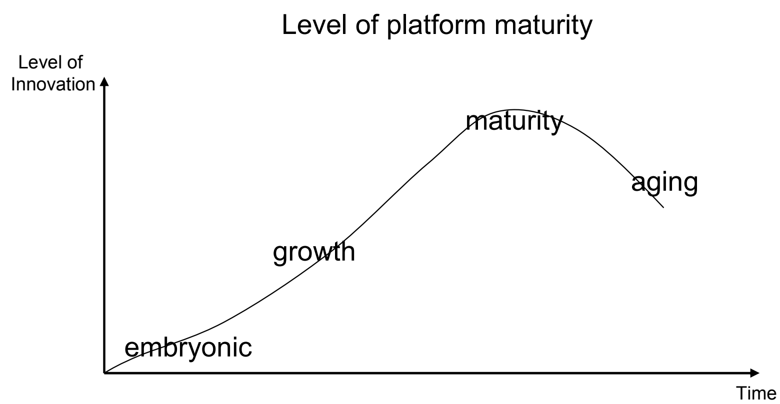

Figure 4-5: The level of innovation within the platform area changes as a function of time

The Kano Model Scale (KMS) is used to estimate the type of functions fulfilled by the platform in reference to the Kano Model (Figure 4-6). It is used in Step 5.

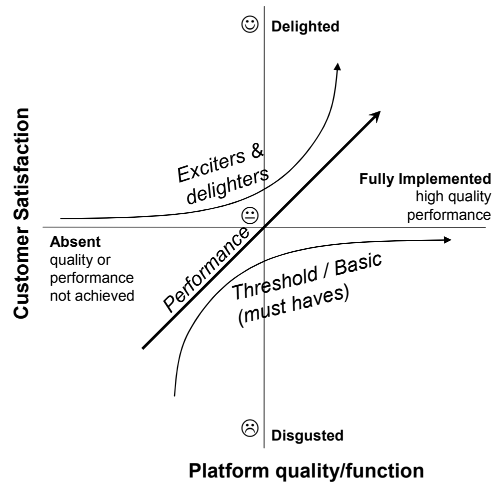

Figure 4-6: The Kano Model of Customer Satisfaction (adapted from Ullman [100])

According to the Kano model of customer satisfaction, there are three different types of product *quality* that give customers satisfaction: basic quality, performance quality and excitement quality. Using this logic for platforms, one can say that platform attributes can be categorized into the following groups: *Threshold attributes* (Basic) are attributes which must be present in order for the platform to be successful; they can be viewed as a 'price of entry'. However, the customer will remain neutral towards the product even with improved execution of these aspects. *One dimensional attributes* (Performance) are attributes whose characteristics are directly correlated to customer satisfaction. Increased functionality or quality of execution will result in increased customer satisfaction. In opposition, decreased functionality results in greater dissatisfaction. Platform price is often related to these attributes. Finally, *attractive attributes* (Exciters / Delighters) are attributes that give customers great satisfaction - and are willing to pay a price premium. However, satisfaction will not decrease (below neutral) if the platform lacks the feature. These features are often unexpected by customers and they can be difficult to establish as needs up front. They are sometimes called unknown or latent needs.

Finally, the Action Proposal Scale (APS) is used in every step to rate the need for changing the platform. After each step, a basic action proposal is given: a) Status quo, b) Incremental Change, c) Drastic Change, d) New, or e) Eliminate/Merge. Here, it is quite subjective what the different grades mean as e.g. for some *incremental change* might mean the same as *drastic change* for others. As there is however a joint workshop at the end of the method, where the results are discussed, such nuances in understanding can be resolved.

It is important to emphasize that each individual focus group member affirms his/hers subjective best guess. The point is to submit an educated guess upon which a fruitful discussion can be made.

Common errors in the rating process are caused by *leniency*, *central tendency*, and the *halo effect*. The error *leniency* occurs when a respondent is either an “easy rater” or a “hard rater.” The error central tendency occurs when raters are reluctant to give extreme judgments. Finally, the halo effect is the systematic bias that the rater introduces by carrying over a generalized impression of the subject from one rating to another. As an example, a teacher is might award a student a grade based on previous performance rather than a subjective grading[50]. As the opinions of each focus group member are presented in a common workshop, such errors are subject to debate and discussion by the group – where a common understanding is created.

Common to all steps is that they are ended by recommending a strategic action plan, rated to an APS scale. Furthermore, the importance of each step in regards to the overall evaluation of a specific platform is weighted. In this way a platform might e.g. perform poorly in regards to a specific viewpoint, but at the same time the viewpoint might be rated as being of low importance. The rating scale RS-B is used for registering the weighting (Table 4-1).

4.5 Choosing a Platform to View

In Step 0 of the PAMatrix method, the company chooses one or more platforms to evaluate. A platform can be any collection of assets the company reuses over a family of products (or has plans to reuse over a family of products) that is interesting and useful to group together and assess *as one*

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[50] For more information on rating please refer to Cooper & Schindler [78].

entity. Furthermore, the grouped assets that form the platform should be considered a creator (or potential creator) of competitive advantage[51]. As an example, the company might define a specific machine as a platform, or for that matter a set of machines; it might define a technology, patent, facility, set of components, or material type as a platform.

A useful facilitator for this step might be to categorize platforms into component-, process-, knowledge-, or people & relationships platforms (derived from Robertson & Ulrich [69]) – a platform can however be a combination of assets from different categories, e.g. a component platform and a knowledge platform. One way to identify a company's platforms is by going through all products, and abstracting the assets that stimulate competitive advantage; be they component-, process-, knowledge-, or people & relationships platforms – or a mixture of these. The identified platforms are then lined up into the PAMatrix as exemplified in Figure 4-4.

In the following figure (Figure 4-7) we see a screenshot from the PAMatrix using Microsoft Excel as a basis. Such screenshots will be used throughout this chapter to demonstrate the method. In Step 0, the users enter a platform based on where the *main part* of its assets derives from (components, processes, knowledge, or people & relationships).

[51] This follows as a platform in the context of engineering design is in this dissertation defined as a set of core assets that are reused to create a competitive advantage – by differentiation, overall cost leadership, or focus (adapted from Porter [55].

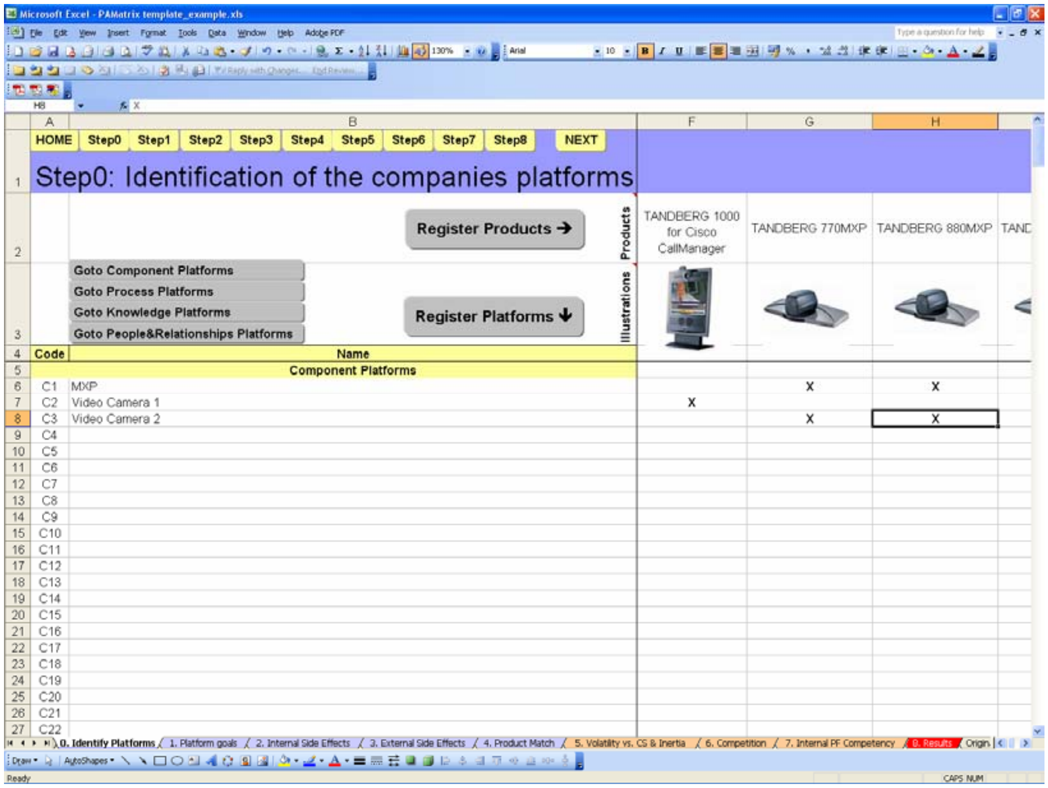

Figure 4-7: In Step 0 the company lists products and platforms used for these.

In Figure 4-7 we see how three platforms have been chosen for evaluation: The MXP Codec platform, the Video Camera 1 platform as well as the Video Camera 2 platform.

A company can basically choose freely what a platform should include. It is however not advisable to include elements with largely deviating lifecycles/clockspeeds as this can lead to ambiguous grading[52].

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[52] This is due to the fact that one of the viewpoints addresses the platform clockspeed compared to a competitors clockspeed, and there may be no misunderstanding of input.

4.6 The PAMatrix Viewpoints

4.6.1 Viewpoints Demonstrating Effects of the Platform on its Surroundings

In Steps 1 to 4, the method captures viewpoints that demonstrate the effects that the platform causes, both internally within the company, as well as externally towards the customer. The viewpoints were identified by (1) understanding how well the platform actually fulfills its goal, (2) identifying the internal side effects, (3) identifying the external side effects, and (4) understanding how the platform actually affects/matches the products that use the platform.

Step 1: Platform Goals vs. Fulfillment Viewpoint

> "product families and their successive platforms are themselves the applied result of a firm's underlying core capabilities" – *Meyer and Utterback [67]*

Every platform has one or more goals, be it e.g. to create economies of scale or to shorten product development time. Porter's three generic competitive advantage strategies framework (Figure 4-8) is used to identify what the actual goals of a specific platform was at the time it was developed. First stakeholders are asked to assess how important each of the three strategies was as a goal of the platform when it was being developed, and second of all they assess the actual impact of the platform in regards to the three strategies. The grading scales used are RS-A, RS-B, and APS (Table 4-1).

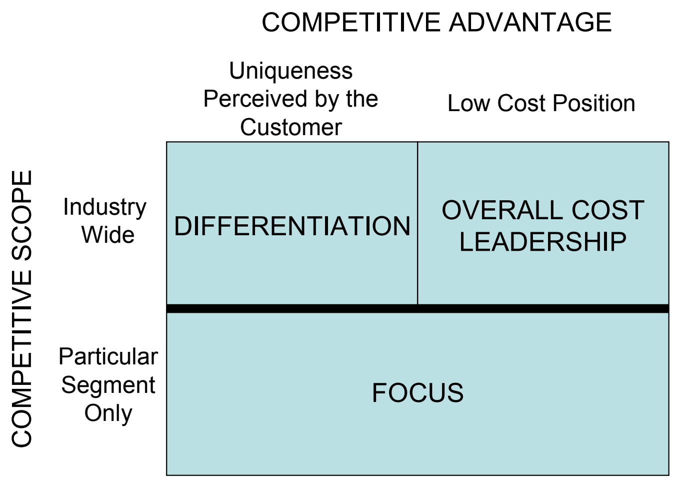

Figure 4-8: Porter three generic strategies to attain competitive advantage, Cost Leadership, Differentiation and Focus (adapted from Porter [55, 74])

In the Figure 4-9 a screenshot from the PAMatrix method is depicted where this viewpoint is created. In Steps 1 to 8, graphics are used to facilitate the comprehension of the results.

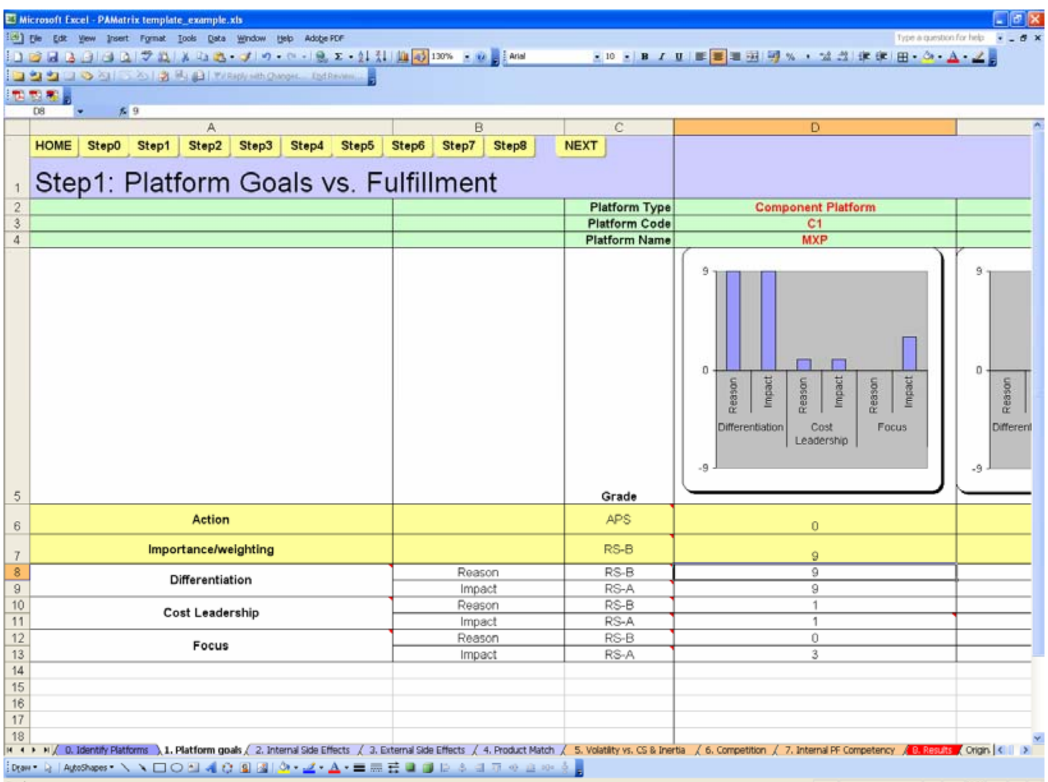

Figure 4-9: In Step 1 the goal of the platform is evaluated along with its actual impact

According to Michael Porter [55], a competitive advantage is at the heart of any strategy, and achieving it requires a company to make a choice about the type of competitive advantage it seeks to attain, and the scope within which it will attain it. He finds that a company can follow three generic strategies to attain its desired competitive advantage; Differentiation, Cost Leadership, or Focus (Figure 4-8).

Porter furthermore finds that a company should only focus on one of the competitive advantages as being “all things to all people” is a recipe for strategic mediocrity and below-average performance, because it often means that a firm has no competitive advantage at all [55].

If a company wants to have a competitive advantage for a number of segments (broad target), it can either aim to achieve *cost leadership* (at the same time achieving proximity or parity in the bases of differentiation relative to its competitors) or *differentiation* (at the same time achieving cost proximity or parity relative to its competitors by reducing cost in all areas that do not affect differentiation). By focusing on cost, a firm seeks a cost advantage in its target segment, while by focusing on differentiation a company seeks differentiation in its target segment. After a company has chosen one of the three generic strategies to create a competitive advantage, it has to align its platform strategy in accordance. This however does not imply that all platforms in the company should focus on achieving the chosen overall strategy – but crystallizes where the focus should lie.

Step 2: Internal Side Effects Viewpoint

A platform might have positive main effects but negative side effects, diminishing its overall benefits. In the second step of the process, the internal side effects that the platform has internally on the company are evaluated. A value chain is used to represent the different functions (departments) of a company[53]. Porter [55] identifies a set of interrelated generic activities

[53] To analyze the specific activities through which firms can create a competitive advantage, it is useful to model the firm as a chain of value-creating activities.

common to a wide range of firms: *primary* value chain activities (inbound logistics, operations, outbound logistics, marketing & sales, and service) and *support* activities (procurement, technology development, human resource management, and firm infrastructure). The value chain model suggested by Porter is used due its wide-spread use (Figure 4-10).

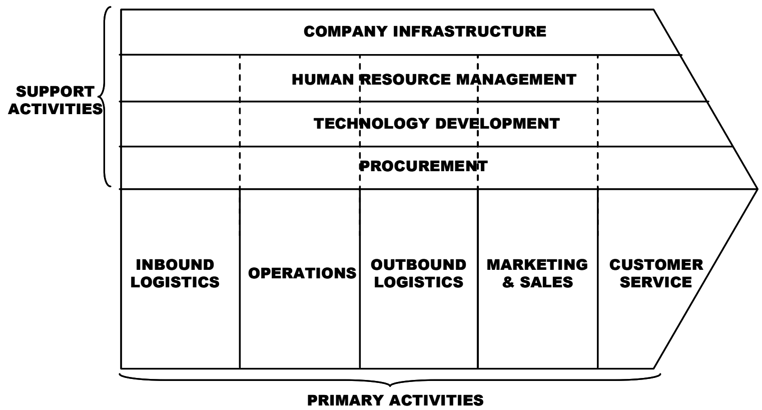

Figure 4-10: An illustration of a value chain. Adapted from Porter [55]

In Table 4-2 a description of the value chain's activities is listed.

Table 4-2: An overview of the activities used in Porter's value chain model [55]

	Activities	What it includes:
Primary Activities	Inbound logistics	Includes the receiving, warehousing, and inventory control of input materials
	Operations	Includes the value-creating activities that transform the inputs into the final product
	Outbound logistics	Includes the activities required to get the finished product to the customer, e.g. warehousing, order fulfillment, etc.
	Sales & marketing	Includes the activities associated with getting buyers to purchase the product, e.g. channel selection, advertising, pricing, etc.
	Service	Includes the activities that maintain and enhance the product's value, e.g. customer support, repair services, etc.

(Continued from previous page)

	Activities	What it includes:
Support Activities	Company infrastructure	Includes activities such as finance, legal, quality management, etc.
	Human resources management	The activities associated with recruiting, development, and compensation of employees
	Technology development	Includes research and development, process automation, and other technology development used to support the value-chain activities
	Procurement	The task of purchasing the raw materials and other inputs used in the value-creating activities

The goal of the primary value chain activities is to create value that exceeds the cost of providing the product or service, thus generating a profit margin. The support activities can be viewed as “overhead”, but some companies successfully use them to create a competitive advantage, e.g. with innovative procurement SW systems.

To make the assessment in Step 2, members of the focus group are asked to evaluate the effect that platform has on the activities/departments compared to the expected effect on the activities/departments. In Figure 4-11 a screenshot from Step 2 in the PAMatrix is shown. Here as an example, the internal side effects are registered for the MXP platform[54] where the platform had a slightly better than expected effect on Sales & Marketing. The grading scales used are RS-D, RS-B, and APS (Table 4-1).

[54] This platform is used in the TANDBERG case-study. Further information can be found in Chapter 5.

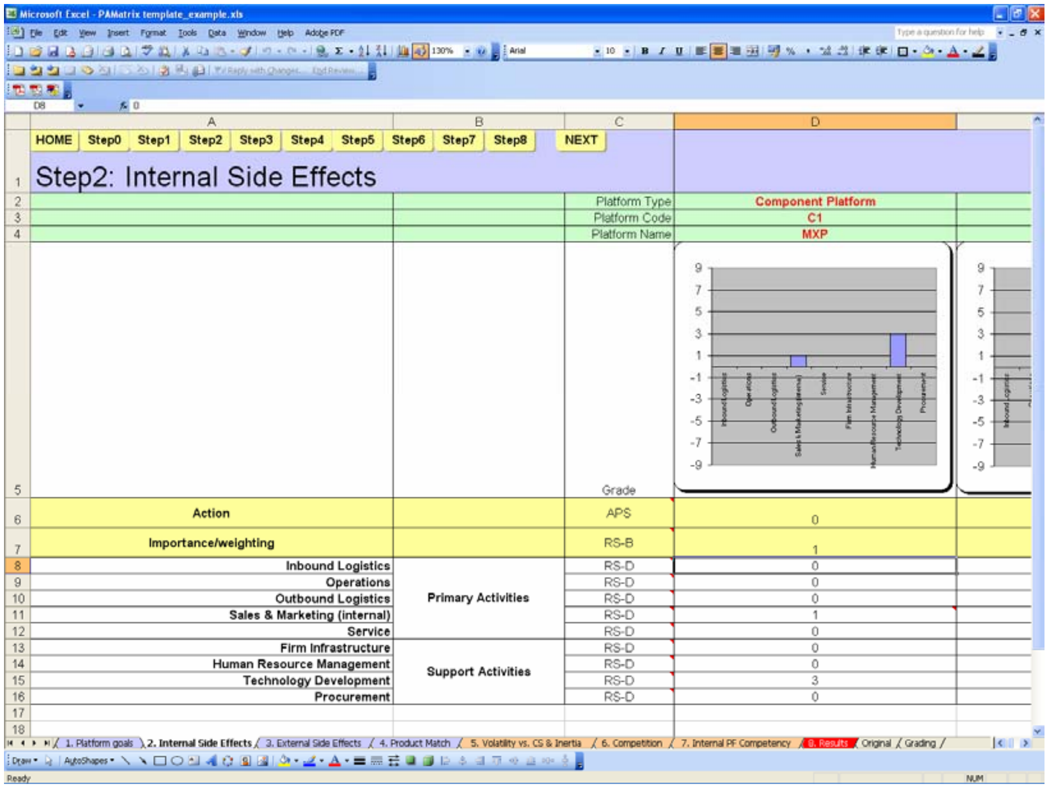

Figure 4-11: In Step 2 the internal side-effects are evaluated

Step3: External Side Effects Viewpoint

Depending on its characteristics and context, a platform deviates in its ability to be reused over price-, industry-, and product family segments. As an example, if we consider the Audi Tiptronic transmission system as a platform, and furthermore imagine that it is implemented in a Skoda vehicle (same industry- and product family segment, but different price segment) a scenario might occur where a potential buyer of an Audi chooses the more moderately priced Skoda brand, i.e. causing unwanted cannibalization. Furthermore, this might lead to an image loss for the Audi brand and an image gain for the Skoda brand. Finally, the potential buyer might choose a brand from another car maker, thus lowering the demand for vehicles from the VW Group, which owns, among others, the Audi -, Skoda -, VW - and Seat brands.

The factors identified to evaluate the external side effects are (1) the threat of unwanted *cannibalization*, (2) *demand loss*, and (3) *image loss* for three different scenarios: a) reusing a platform *over a price range (Price Range Scaling)*, b) reusing a platform *over product families (Product Families*

Scaling), and c) reusing a platform *over industries (Industries Scaling)*. The framework for mapping the market segments is partly adopted from the work of Meyer & Lehnerd [9] which is described in Chapter 2.2.2. A third axis has however been added to cover *all scaling scenarios*. In this context, scaling is used to describe the reuse of a platform in different market segments. Using a platform originally developed for a high price range market in a low price range market is an example of Price Range Scaling.

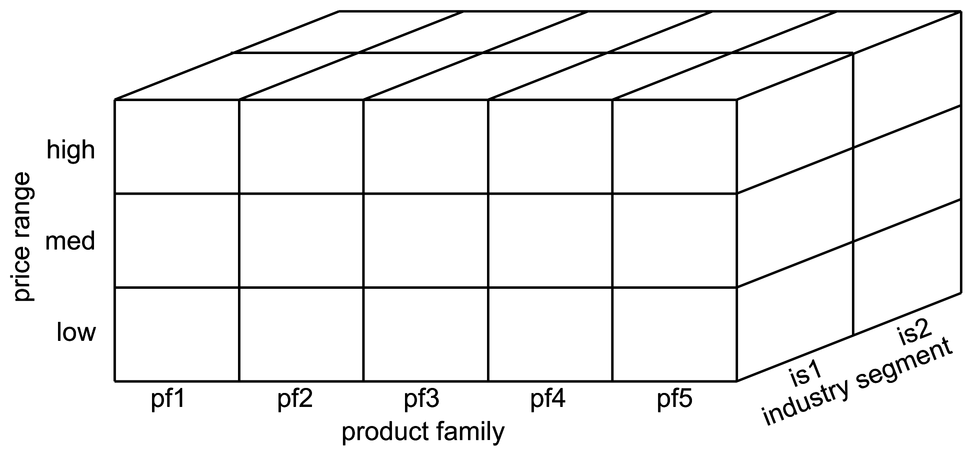

Figure 4-12: Framework for mapping market segments

The unwanted cannibalization of products has been discussed by e.g. Kim & Chhajed [101] and Krishnan and Gupta [102]. They find that commonality, of e.g. feature attributes or brand name increases the perceived similarity between product variants in the same family of products and that this possibly can cause cannibalization. In regards to diminishing demand, Hui [103] finds that there are decreasing demand returns to product variety for branded multi-product firms. Finally, an assumption is made that image can possibly be damaged if e.g. the same platform in used in both high- and low price market segments.

Figure 4-13 illustrates how the external side effects of a platform are registered in the PAMatrix. Here it is apparent that there is a medium threat of cannibalization assessed due to the use of the platform over different product families. The grading scales used are RS-B, and APS (Table 4-1).

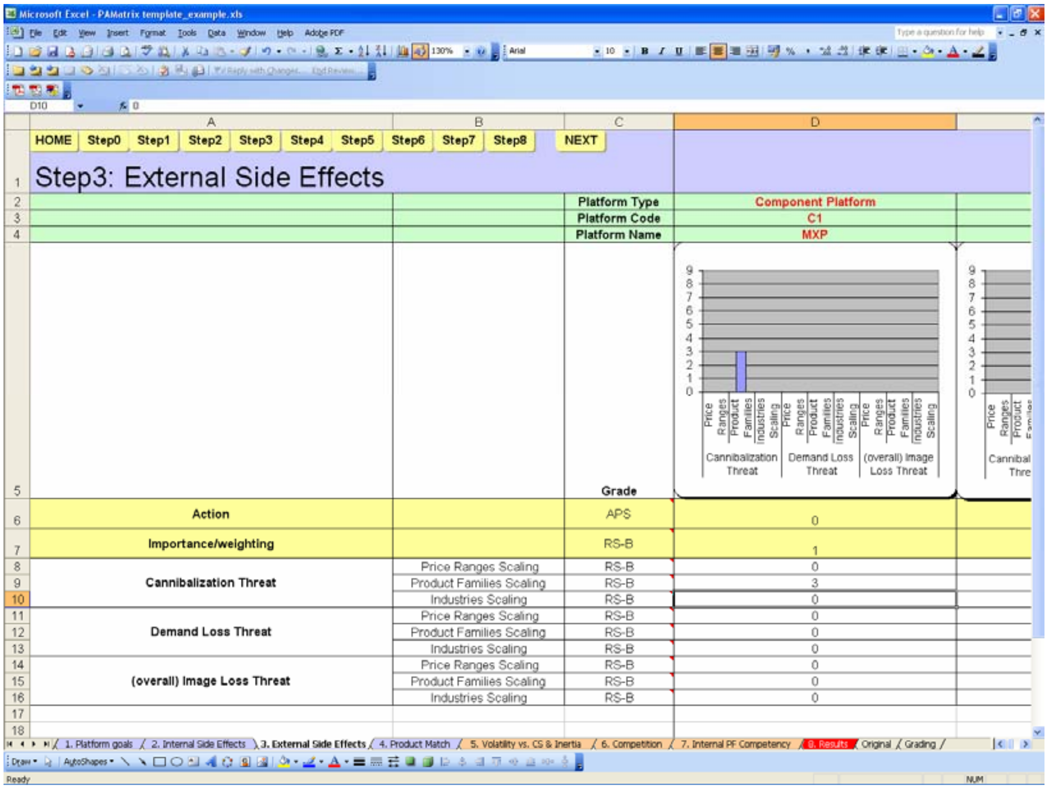

Figure 4-13: External side effects are assessed in Step3 by evaluating the threat of unwanted cannibalization, the threat of demand loss, and the threat of overall image loss.

Step 4: Product Match Viewpoint

In the final viewpoint used to describe the effect that a platform has on its surroundings, the match of a platform to the products that use it is assessed. For some of the products the platform might have a correct match in regards to the target *values* that the company seeks to give the customer with a specific product, while for other products, the match might not be optimal; either as it does not meet the required target level, or as it offers too much.

In Table 4-3, eight attributes are listed that have been identified as giving a holistic view of how a customer reviews a product.

Table 4-3: The list of attributes used to determine the platform match to products

Attribute	Description
Functionality	This attribute determines whether or not the platform enables the product to match its target functionality
Fulfillment of Competitive Advantage Strategy (CAS)	This attribute determines to what extent the platform contributes to the fulfillment of competitive advantage strategy of the product
Quality	This attribute determines whether or not the platform enables the product to match its target quality
Cost	This attribute determines whether or not the platform enables the product to match its target cost
Volume	This attribute determines whether or not the platform enables the product to match its target volume
Emotional Appeal	This attribute determines whether or not the platform enables the product to match its target emotional appeal
Maintenance & Repair	This attribute determines whether or not the platform enables the product to match its target maintenance & repair
Overall Competitive Importance	This attribute determines how important the platform is in terms of overall competitive importance

As with the viewpoints, one can argue whether the chosen attributes are optimal. For demonstrating the method however, they are adequate. They have been identified through a literature study and with the assistance of the industry in an iterative improvement process[55].

The grading scales used are RS-B, and RS-E, and APS (Table 4-1). In Figure 4-14, we can see a sample of how this match is registered in the PAMatrix. The rating scale E (RS-E) is used in evaluating six of the attributes; here 0 is given for a correct match, a negative score is given in the case that the platform does not enable the proper fulfillment of the attribute, and a positive score is given where the platform provides too much. Offering too much does not necessarily have to be good for the company, as it might e.g. cause

[55] This process is described more thoroughly in Chapter 5.

unwanted product cannibalism. Furthermore, for two of the attributes, the rating scale B (RS-B) is used. In this case a high grade is positive while a low grade is negative. As an example, in Figure 4-14, the platform is considered of being of medium competitive importance for the product shown, while the platform offers a correct match in regards to functionality.

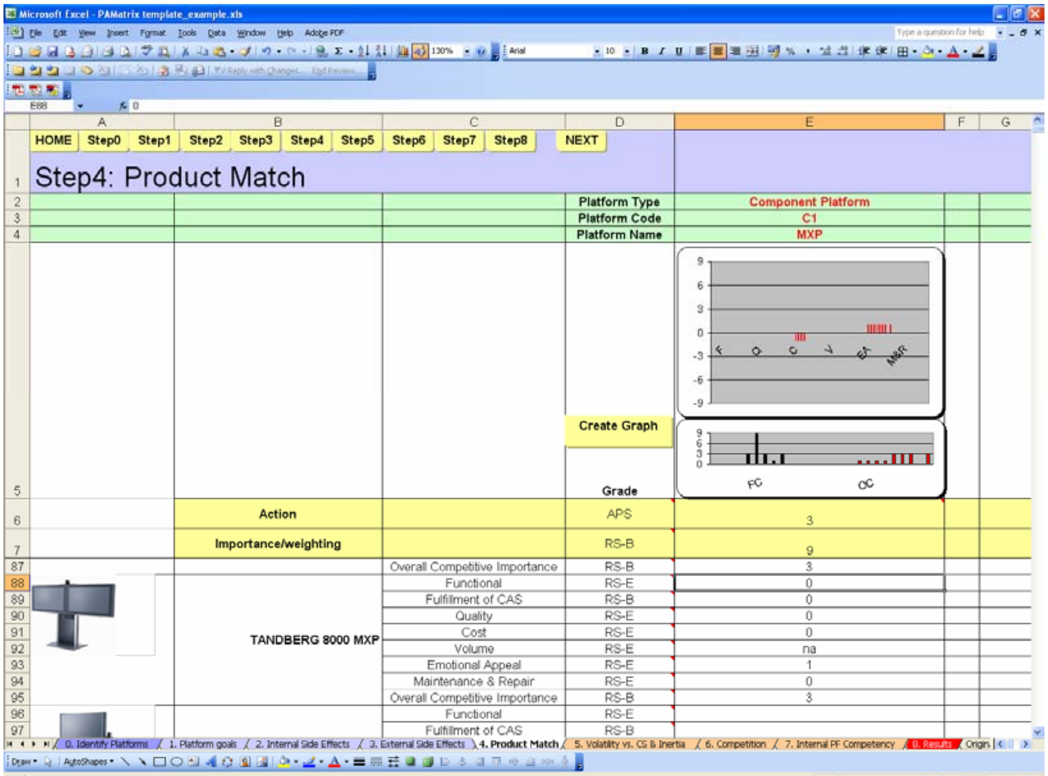

Figure 4-14: In Step4 the platforms match the derived products target attributes are assessed

4.6.2 Viewpoints Demonstrating the Surrounding's Effect on the Platform

In Steps 5 to 7, the viewpoints demonstrate the effect that the surroundings have on a platform. This can be thought of as viewpoints describing the *positioning* of platforms, i.e. the potential of a platform to continue to be a strong enabler of competitive advantage.

Step 5: Market volatility vs. clockspeed & inertia Viewpoint

> For high-technology companies, the most important judgment for senior executives pondering their product development portfolio is, "What is the remaining life cycle of our primary product platforms?" – McGrath [42]

In this viewpoint, the dynamics of the market are considered in terms of the platform. The factors looked at are the *clockspeed* and *inertia* of the platform, as well as the platform's *market volatility level* and *maturity level.* In addition, the matrix captures the main driver of the inertia, i.e. whether it is due to financial reasons (e.g. due to large investments) or/and Time-To-Market (product launch deadlines) or/and know-how (level of knowledge) or/and standards (need to follow standards). Furthermore, to create a reference point, the main competitor's clockspeed and inertia in terms of his comparable platform (if it exists) is registered. Finally, the method captures whether the function that the platform fulfils is a threshold-, performance-, or excitement function, in according to the Kano Model of Customer Satisfaction (see e.g. [96, 100], Figure 4-6 and Chapter 4.4 for further information). The grading scales used are RS-B, IRS, MLP, ASP, and the clockspeed is measured in the maximum amount of years that a company will use it (starting from time of initial use).

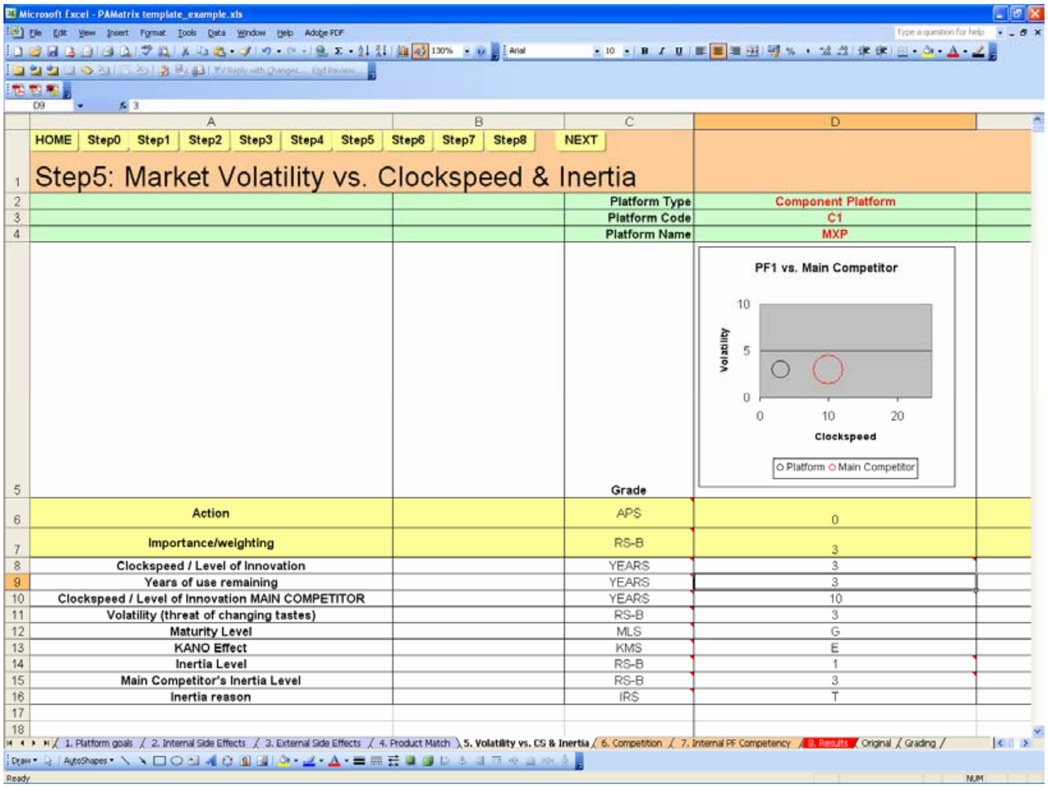

Figure 4-15: In Step5 the dynamics of the market are assessed

In the graph in Figure 4-15, the bubble is positioned according to clockspeed and estimated level of volatility, where the size of the bubble represents the inertia level. The blue bubble represents the assessment for a companies own platform while a red bubble represents the assessment for the main competitor.

Step 6: Competition Viewpoint

The company exists in a specific industrial context. In the PAMatrix, this context is assess by estimating how the platform complies with the given industry situation. Figure 4-16 demonstrates how the industry forces for each of the company's platforms are captured in the PAMatrix.

There are six factors considered, always in relevance to the specific platform. These factors are *Rivalry Rate, Barriers to Entry, Bargaining Power of Buyers, Bargaining Power of Suppliers, Substitution Threat,* and *Disruptive*

Technology Threat. In essence, Porter's Five Forces Model [55] in addition to Christensen's theory of disruptive technologies [98] are used to capture the industry forces which affect the platforms[56]. For each factor, a grading is given according to how strong the forces are. The grading scales used are RS-B, RS-C, and APS (Table 4-1). If e.g. the *Bargaining Power of Buyers* is high in reference to a particular platform, the grading would be set as 9. Figure 4-16 demonstrates that high scores indicate a tough industry situation for the platform.

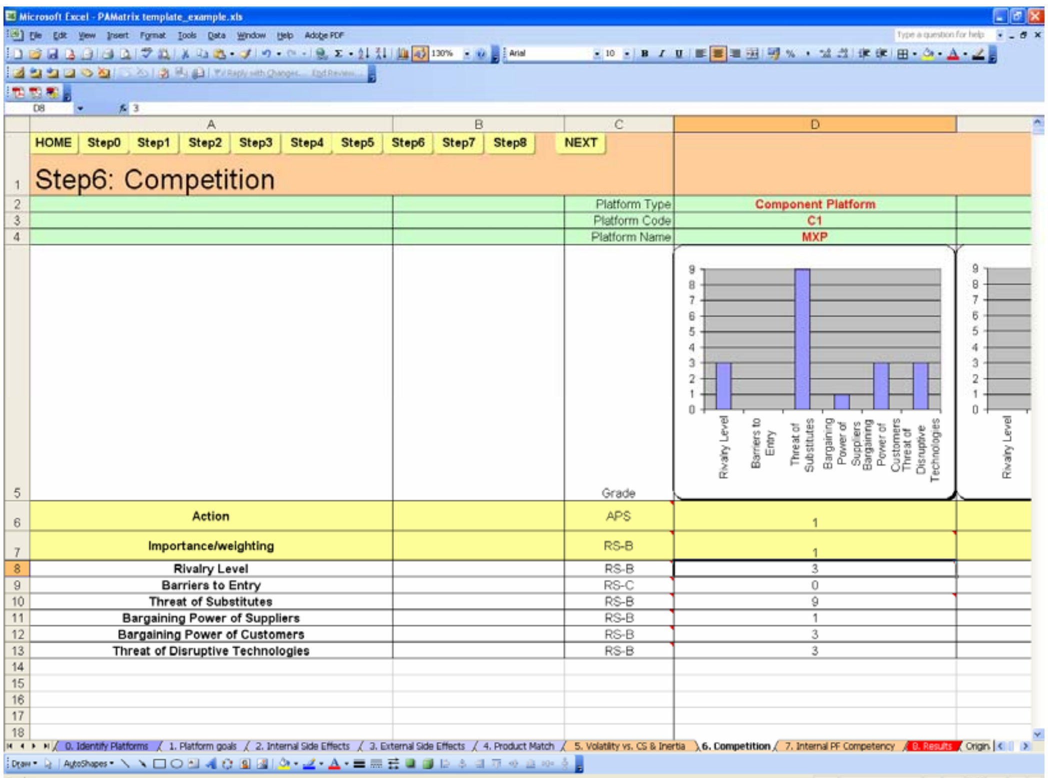

Figure 4-16: In Step 6 the competitive scenario is assessed

Step 7: Platform Competency Viewpoint

The final viewpoint in the PAMatrix is used to assess the competency of the company in regards to the platform. Companies have a number of platforms that they use to support their overall competitive advantage strategy. A

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[56] It is important to notice that the analysis is applied on platform level and not on the product level.

company is unlikely to have the good fortune to be able to deliver world class performance in regards to all platforms. In Figure 4-17 an example of how this step is executed is demonstrated. As an example, the companies assessed competency in regards to improving/changing the platform is considered to being *high*. The grading scales used are RS-B, RS-D, and APS.

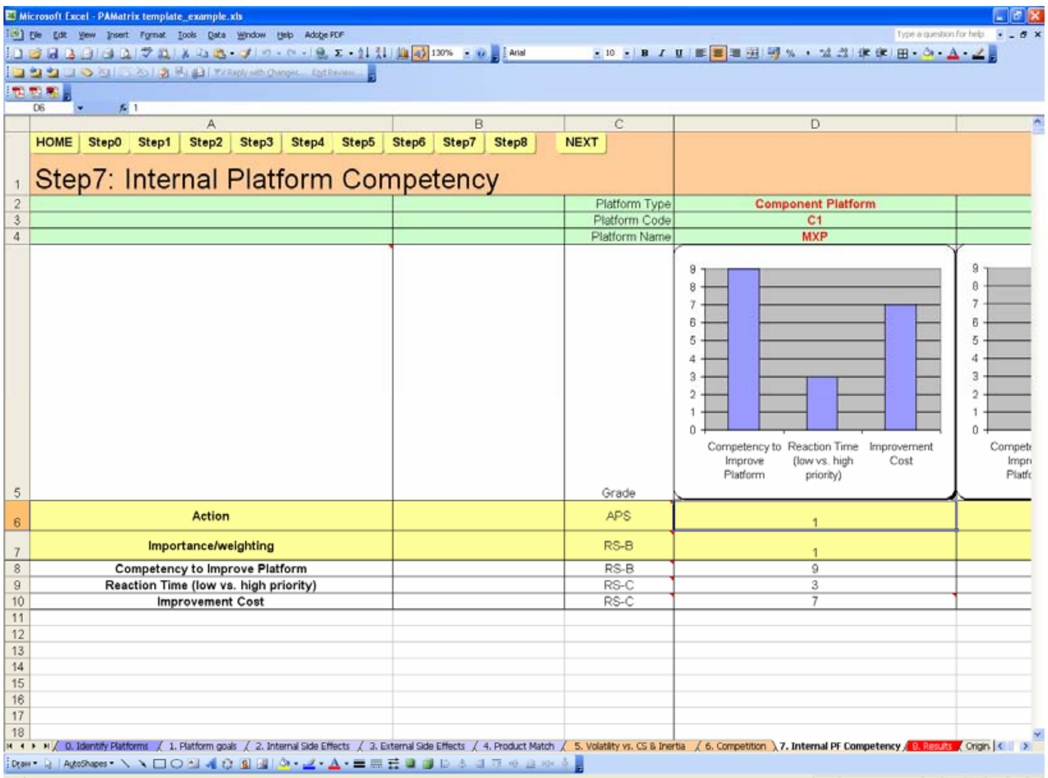

Figure 4-17: In Step7 the company's competency in regards to the platform is assessed.

Step 8: Results

In the last step of the process, the entered data is summarized and visually displayed. According to the evaluation results, along with the overall impression of the stakeholder, a final assessment is made with regards to the:

- Overall support of the platform to the company-wide competitive advantage strategy,
- Overall need to change the platform,
- Overall importance of platform in general, and finally
- A final action plan is recommended

The grading scales used are RS-B and APS.

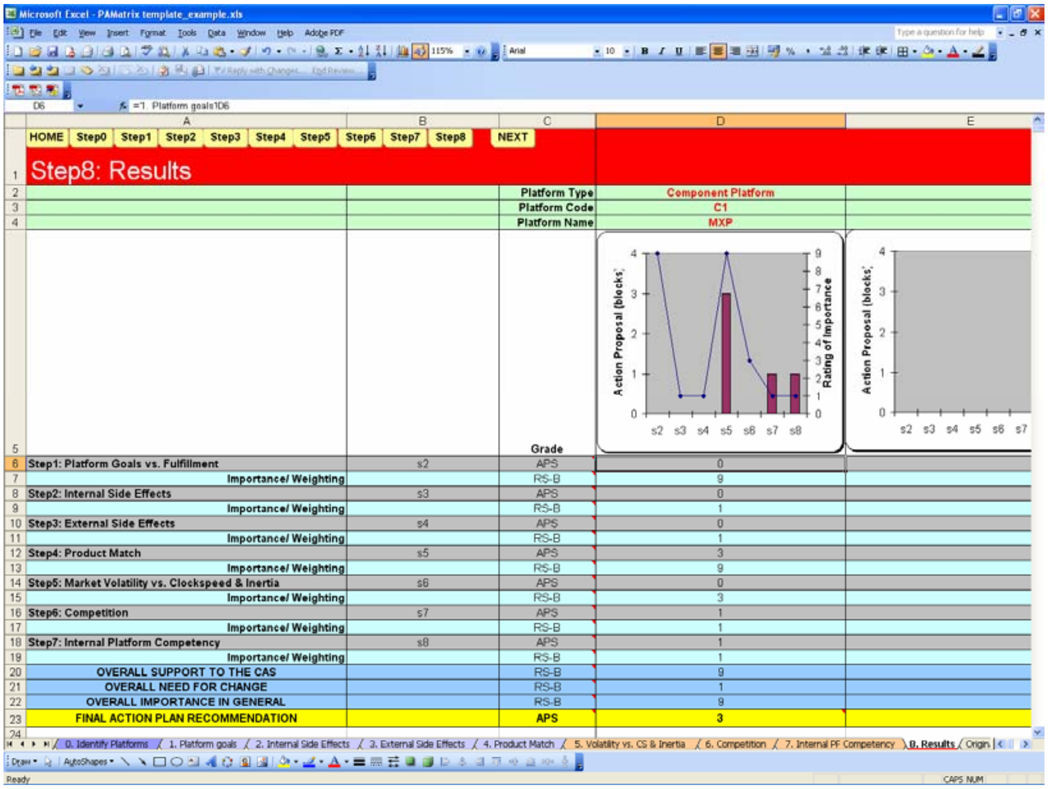

Figure 4-18: In the Step8, the findings for steps1-7 are summed up.

After the completion of the individual interviewing, the combined results are then graphically interpreted and presented.

4.7 Joint Results

After having completed the individual interviewing process, the results are graphically combined and presented in a large graph displaying both the individual grading and comments, along with graphs visualizing the collective results (Figure 4-19).

The moderator presents the results step by step, highlighting on the way differing opinions of the stakeholders and promoting discussion. It is of grave importance here that the moderator competently steers the conversation without interfering with the discussion. Conflicting understanding of the platform must be brought up, discussed and a mutual understanding created. The discussion should build the feeling of common ownership of the platform.

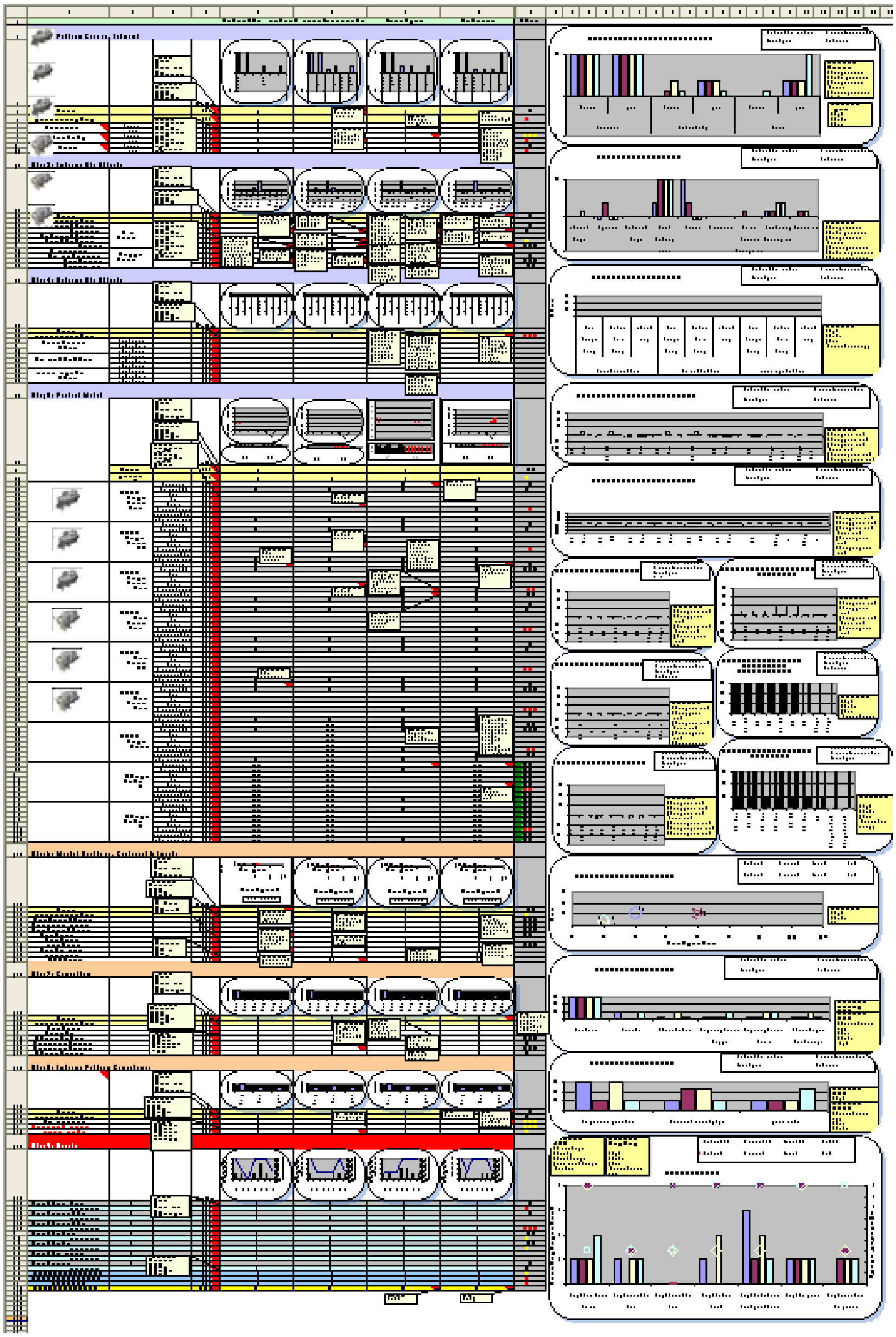

Figure 4-19: Example of PAMatrix summary. The graph is intentionally obscure to conceal company data.

As the individual grading in themselves are subjective, it is necessary to discuss the results and what they actually mean to each individual stakeholder. As an example a score of -1 for one stakeholder, might be a -3 for another, without them actually disagreeing in the platform evaluation.

The comments are displayed as callouts and are an important part of the method to raise points of interest. What is said in individual interviews is often not something the stakeholders would, from themselves, share in public and therefore a meaningful piece of data to capture to be able to reach some kind of consensus.

In presenting the results, the graph presented in Figure 4-19 is merely meant as background material. For a quick assessment it is too complicated. The moderator should present the main results for each viewpoint in a format which highlights the main findings. This could e.g. be done by creating an illustration as seen in Figure 4-20.

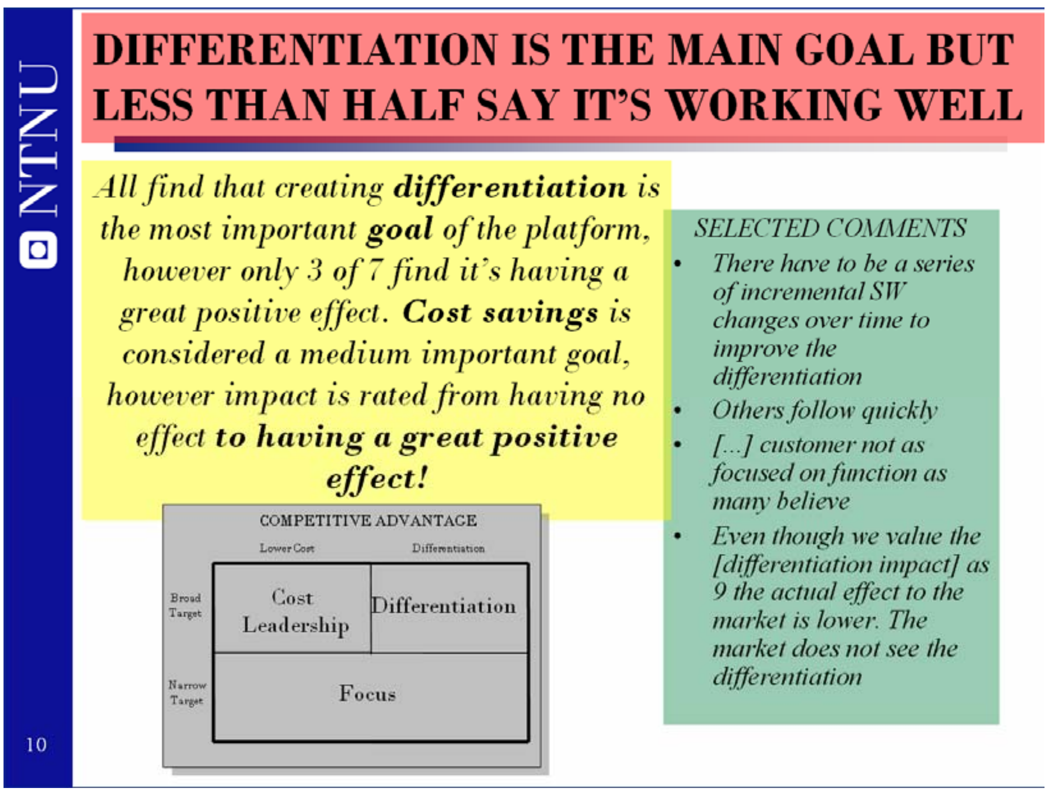

Figure 4-20: An example of summed results for Step 1

5 CASE STUDIES

5.1 Introduction

In this chapter, the industry case-studies on using the PAMatrix are described. The purpose of the studies was first and foremost to iteratively improve the PAMatrix method, and second of all, to assess the value of the method for the studied companies.

In Chapter 4, the PAMatrix was presented. In a nutshell, a group of cross-functional stakeholders first individually grade a chosen platform based upon a series of viewpoint (Steps 1 to 7 in Figure 4-4), and then mutually discuss the findings – first reaching a common understanding of the platform status and then deciding upon a strategic action plan to follow in regards to the specific platform.

5.2 Case studies

Three companies were chosen for the study: TANDBERG Video Conferencing, Rolls Royce Marine and Marel Ltd. (Table 5-1). All of the companies develop highly engineered products, however within quite different industries. Furthermore, they all have broad product family ranges.

Table 5-1. An overview of the companies used in the case study

Company	Location	Platform	Contact person	Industry
TANDBERG Video Conferencing	Oslo, Norway	MXP Codec	Market Research Manager	Stand-alone Video Conferencing equipment
Rolls Royce Marine	Ulsteinvik, Norway	Helicon-X	Technical Manager	Marine Propulsion
Marel Ltd.	Gardabaer, Iceland	3D Computer Vision	Head of Research and Development	Food processing equipment for fish, poultry, and meat

5.2.1 The Case Study Process

At each of the companies, a contact person was identified that had a good strategic understanding of their company's products and the authority to assemble a cross-functional focus group. The contact person along with the researcher chose one platform for the study; the choice criteria being that the platform had to be of key importance for the company to create a competitive advantage, in addition to its use for a range of products.

Individual interviews of members of the focus group were held in closed settings at company locations. Each interview lasted for approximately two hours. In that time period the interviewee first got a brief introduction to the method before advancing to the interviewing. Each viewpoint was graded and weighted and the results directly entered into the Excel-based PAMatrix computer program. Any ambiguousness was clarified during the process. Special precaution was put into the interviewer not influencing the interviewee's grading.

Later, the combined results were presented for the group via a video projector. For each viewpoint the results were presented and deviances highlighted and discussed. Figure 5-1 shows a graph from the PAMatrix demonstrating the opinion of a number of stakeholders in regards to the platform goal and actual impact.

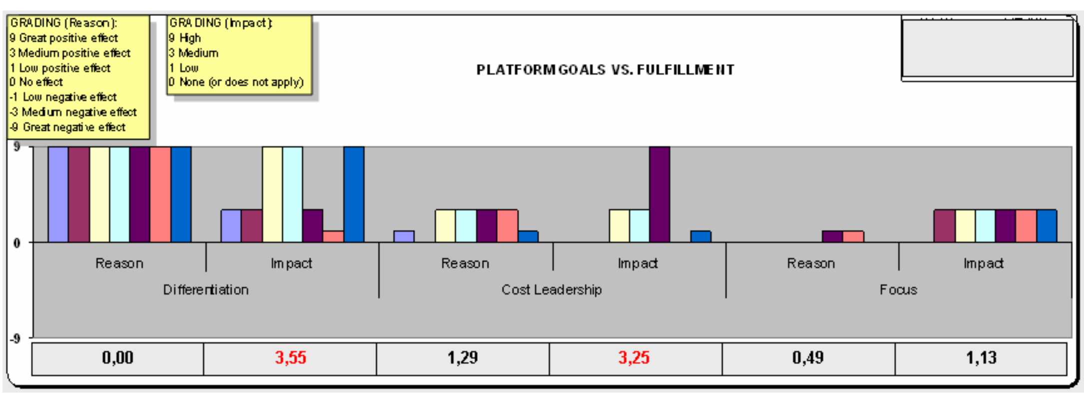

Figure 5-1: An example of joint results on Platform Goal vs. Fulfillment.

As an example of how to interpret the illustration: All agree that the main reason for creating the platform was to create differentiation, while there is a mixed conception of the impact it has had. In the graph a standard deviation was used to point out large discrepancies in opinion; where the level of discrepancies was color coded: black symbolizing minor discrepancy, yellow symbolizing medium discrepancy, and red symbolizing major discrepancy[57]. In addition to such graphs, the comments of the stakeholders in regards to each viewpoint are presented.

During the presentation the interviewer/moderator stimulates a discussion to clarify disagreements – actively using comments and the results to fuel the talks.

After the completion of the study, a 2-page survey with 10 questions (Chapter 5.3) is sent by e-mail to the participants to be filled out and returned also by e-mail.

In the following sections the studies at each company are described and discussed.

5.2.2 TANDBERG Video Conferencing, Norway

TANDBERG Video Conferencing is a leading global provider of video systems and services that help companies and organizations fill the visual communication gap that exists today.

Together with the contact person, “MXP” was chosen as the platform to observe for the study. The MXP platform includes a state-of-the-art MXP codec hardware that supports a *feature-rich environment*, the TRC3 Remote Control, screen interface, and proprietary software based on established standards (Figure 5-2). The MXP platform had been launched a few months prior to the study.

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[57] The standard deviation is not to be taken as an exact measure, but rather a way to roughly categorize levels of discrepancies. The absolute numbers are uninteresting in this case.

Figure 5-2. The MXP platform includes the interface to the customer, i.e. screen layout, remote control, codec hardware and proprietary software based on established standards

The MXP platform was at the time of the study used in 8 products – illustrated in Figure 5-3; the 770 MXP, 880 MXP, 990 MXP, and 3000 MXP are aimed for medium sized groups, while the 6000 MXP, 7000 MXP, 8000 MXP, and the Maestro are aimed for large groups.

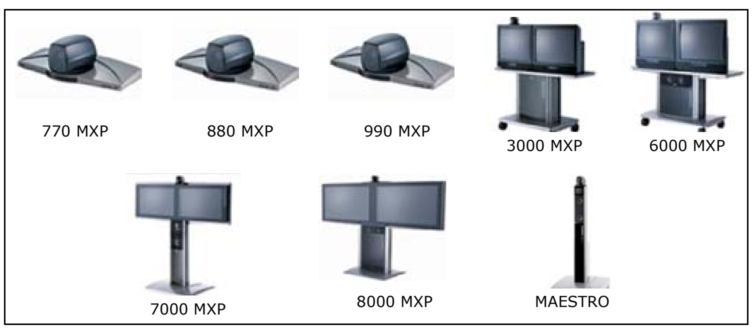

Figure 5-3. An overview of the products using the MXP platform at TANDBERG

The case study took place at the TANDBERG headquarters in Oslo. Seven stakeholders (five men and two women) were first individually interviewed, after which a workshop was held with all participants. The focus group originated from product development, customer service, training, and sales & marketing – all working in one geographic location. As manufacturing is outsourced at TANDBERG, no representatives originated from logistics, operations, or procurement.

Observations during the interviewing process

- As many of the concepts used in the method were new to the interviewees, the interviewer had to clarify and explain these. This was time consuming.
- A great deal of difficulty/confusion became apparent in assessing the MXP platform as it has two quite deviating clockspeeds, one clockspeed for HW and one for SW.
- Difficulty to assess weighting of importance of viewpoint for the overall assessment of the specific platform was noticed.
- Some of the questions were obviously very difficult for the stakeholders and it appeared that they had (in most cases) not considered them previously.
- An interesting aspect identified was that the individuals had differing opinions of the importance of platform as a sales argument to sell the product. The method did not pick up this input.

Workshop

Due to the busy schedules of the participants of the study, the workshop was first held 5 weeks after the interviewing. In the workshop, the results were presented and discussed. A good deal of the discussion focused on the match of the platform to the product range. Here it became apparent that most of the stakeholders believed that the platform did not manage to differentiate well enough between the products aimed for medium sized groups and the products aimed for large groups. Furthermore, that the main differentiation between mid and high range was found to be due to aesthetics, unrelated to the platform. Interestingly, there were quite split opinions of the importance of the platform in general. One stakeholder found that it was difficult to evaluate the platform in such an abstract and isolated manor; the whole product had to be considered. The common strategic action step to follow was assessed as being to continue to do *incremental* changes.

Survey

In Chapter 5.3 the results of the survey are shown. Some of the comments regarding the method are listed below:

- *It was useful that the group consisted of a mix of people with different responsibilities and tasks.*

- *The group was probably not optimal for the study; it might have been more useful for a group with direct impact on R&D development, cost evaluation, production strategy etc.*
- *The PAMatrix method made me more aware of the other aspects around the platform, i.e. not just the features, functions and benefits.*
- *For the method to be better in supporting concrete decision making, design and "emotional appeal" are of key importance. This would give a better holistic picture.*
- *This was not an activity I do often so it was kind of new and maybe little bit out of my league – compared to my job. But it gave me lots of new views and awareness on our platform.*
- *Some of the questions were too complex.*
- *I had some difficulty in understanding the method.*

Conclusion

There was some confusion as the platform contained software and hardware elements that had different clockspeeds/lifecycles. This caused some uncertainty regarding how to respond.

⇨ A platform should only contain assets with similar clockspeeds. Alternatively, in questions regarding clockspeed, it must be made clear which asset is being referred to, and this asset should then be consistently focused upon.

As participants from manufacturing were missing from the study, the mix of people for the study was sub-optimal. To answer the questions in the method, some background material was needed. It turned out that the 5 weeks break between the interviewing process and workshop was too long; the participants had almost forgotten the background details and therefore had a harder time discussing the viewpoints.

⇨ The focus group should contain members from the whole value-chain.

⇨ The time between the interviewing process and the workshop should be kept short.

⇨ The method should possibly be simplified.

Originally there were nine viewpoints used but two viewpoints were found not to be value adding.

⇨ The two viewpoints were cut out and partly integrated into other viewpoints. The original viewpoints can be seen in the appended Paper D.

The participants had differing opinion of the importance of the platform as a “sales argument.” This was not captured in the PAMatrix.

⇨ Changes were made in “Step 4: Product Match,” where the attribute “Overall Competitive Importance” was added.

The stakeholders found that the greatest benefit of the method was in being able to view the platform systematically and to improve cross-functional cooperation; 50% characterized their understanding of the platform as “slightly improved understanding”, while 50% as “much improved understanding.”

5.2.3 Rolls Royce Marine, Norway

Rolls-Royce Marine is a global leader in marine propulsion, engineering and hydrodynamic expertise, with a broad product range and full systems integration capability.

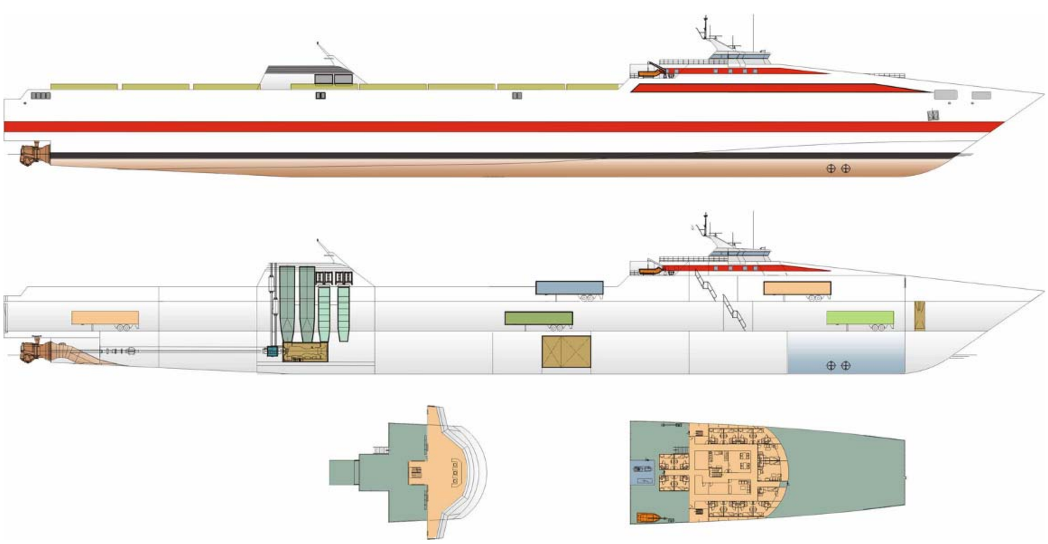

Figure 5-4: An example of a high speed vessel using equipment from Rolls Royce Marine.

Together with the contact person “Helicon-X” was chosen as a platform to observe. The Helicon-X platform is a remote control system for propulsion systems (Tunnel Thrusters, Azimuth Thrusters, and Main propulsion pods) and gears. It supports functions such as pitch control, RPM control, load control, and fixed pitch reductions. In Figure 5-5 we can see an overview of the system. It includes hardware and software[58] and the panel interface in the bridge and engineer control room.

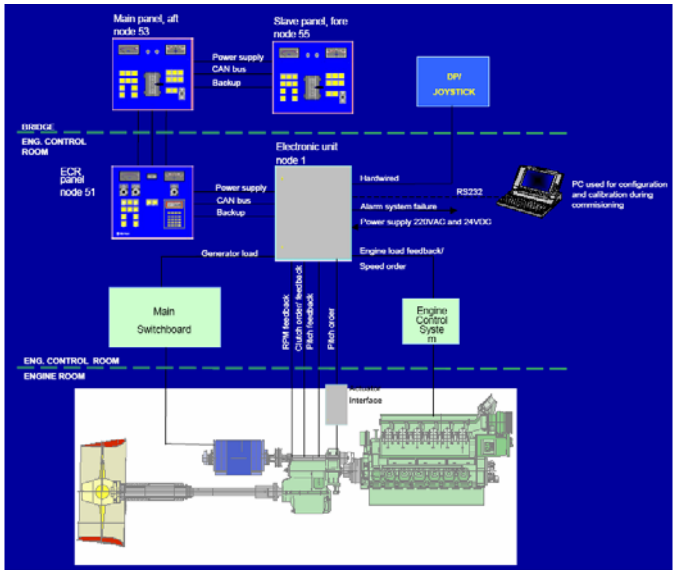

Figure 5-5. A schematic overview of the Helicon-X platform

In contrary to the MXP platform at TANDBERG, the Helicon-X platform is used simultaneously for a number of products. In Figure 5-6 an overview is provided of some of the products/product families that use the platform – ranging from tunnel thrusters to gears.

[58] Unlike the case and TANDBERG however, the clockspeed refers to HW.

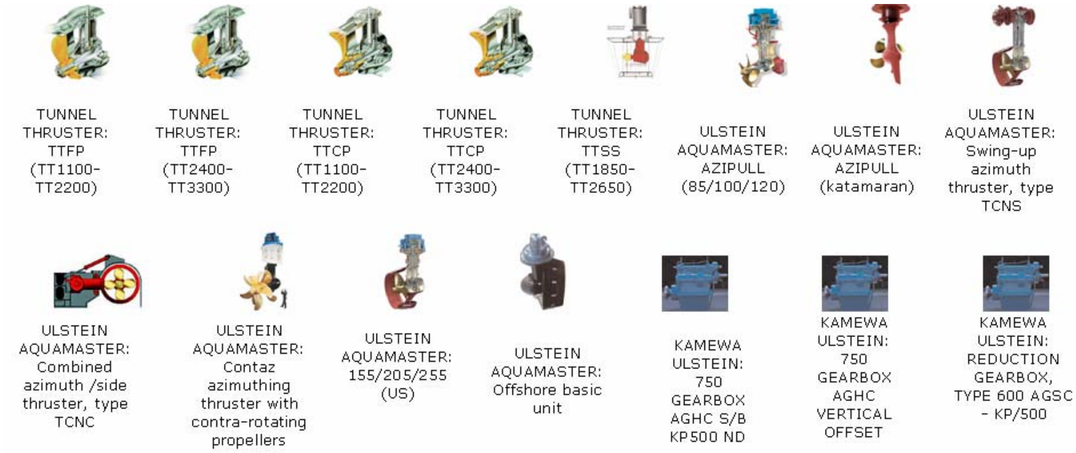

Figure 5-6. An overview of products that use the Helicon-X platform

The case study took place at two Rolls Royce Marine sites on the Norway's west coast, in Ulsteinvik and Longva. Eight stakeholders (six men and two women) were first individually interviewed, after which a joint workshop was held. The stakeholders originated from research, product development, manufacturing, internal sales, and service. Unlike the study at TANDBERG, the participants were geographically spread out, increasing the difficulty to communicate.

Observations during the interviewing process

- As many of the concepts used in the method were new to the interviewees, the interviewer had to clarify and explain these. This took quite a long time of the process. The same observation was made at TANDBERG
- In some cases the participants seemed afraid to state their actual opinion and grade accordingly. This led to the suspicion that at least in some cases it might be beneficial to hide the identity of the stakeholders in the presentation of results
- Difficulty to assess weighting of importance. The same observation was made at TANDBERG
- The grading scale for Step 2: Internal Side Effects" is perhaps sub-optimal

Workshop

In the workshop, the results were presented and discussed. Many were surprised of the level of agreement of issues. Amongst the focus points in the discussion where that the Helicon-X interface was considered by some as out dated – *"it had a 70's look and feel to it*."

Furthermore, the platform is more important for segments that require dynamic positioning, e.g. offshore, and less important for steady long journeys, e.g. cargo transport. This could possibly cause some frustration for segments requiring simple solutions.

A phase-out of the platform was already in the pipelines and the method caught the imagination of the stakeholders to map the planned future platform as well as other existing platforms. The production manager even suggested using the method to assess the tools used in assembly.

As the decision had already been made to shift out the platform, this also was the consensus based action step.

Survey

In Chapter 5.3 the results of the survey are shown. Some of the comments regarding the method:

- *The method gives a possibility (or forces you) to structure and to be concrete at a rather visible level.*
- *The method improves the communication and interfaces between the different stakeholders.*

Conclusion

Five of the seven participants felt that the ability to communicate the platform was better than before. This was ranked as the main benefit of the method. In the beginning of the study a great deal of skepticism towards the method was observed. However, after completing the study, this skepticism was replaced by overall acceptance and approval.

The participants originated from different sites and fields and compared to TANDBERG, there was a greater benefit in terms of being able to cross-functionally discuss the platform.

Slight iterations were made as the interviewer found that the method did not sufficiently identify the need to change platforms based on the viewpoints. This was perhaps due to the fact that competition was not well known and the platform was by many not considered a creator of competitive advantage. Therefore, for many, it was not considered being a crucial platform to sell the products.

⇨ A KANO effect evaluation was added to the “Step 5: Market Volatility vs. Clockspeed and Inertia”-viewpoint. This enables a better understanding of the potential that the platform can deliver to the customer in regards to “excitement”[59].

The rating scale in Step 2 was found to be ambiguous as no absolute reference was made available.

⇨ In Step 2, the grading scale was changed on the bases of feedback.

5.2.4 Marel, Iceland

Marel manufactures *solutions* for use in all major sectors of the food processing industry. The product range includes scales and graders, flow-lines, intelligent portioning machines and software systems as well as turn-key solutions for larger plants.

Figure 5-7: An example of a portioning, weighing, and grading flowline from Marel.

Together with the contact person, “3D Computer Vision” was chosen as the platform for observation. 3D Computer Vision includes 1 or 2 cameras, hardware and proprietary software. It automatically evaluates each piece (poultry, fish or meat) before cutting, and then calculates the most economic cut configuration based on parameters pre-selected by the production manager.

[59] The Kano effect evaluation had been present in an earlier version of the method but deemed not value adding in the TANDBERG case and therefore removed.

The platform is used in a range of portioning machines for the different industry segments (fish, poultry, and meat). In addition it is planned for use for two grading machines (Figure 5-8), as well as a machine not included in the paper due to confidentiality reasons.

Figure 5-8. An overview of the products using the 3D Computer Vision

The case study took place at the Marel headquarters in Iceland. Four stakeholders (all men) were first individually interviewed, after which a joint workshop was held. The focus group originated from research & product development, manufacturing, sales, and service. Furthermore, the participants all work in the same geographic location and have little difficulty to meet. Although the sample of focus group attendees was quite small, it represented a good cross-functional spread.

Observations during the interviewing process

- As many of the concepts used in the method were new to the interviewees, the interviewer had to clarify and explain these. This took quite a long time of the process. Similar experience was gathered from the other two studies.
- The perception was that the products were highly similar, however differentiating enough where it mattered.
- Difficulty to assess weighting of importance.
- The focus group members had quite limited time for the study.

Workshop

Unfortunately, only three stakeholders from Marel were present at the workshop, limiting perhaps the level of discussion.

In the workshop the results were discussed. Two points were of special interest: 1) the functionality of the platform was suboptimal for meat-cutting, and 2) using the platform for a certain product[60] might cause unwanted cannibalization.

The participants found that the method was useful to evaluate the potential for new products. One of the participants specifically requested a simpler version that did not require the background knowledge – this being useful for decision makers at all levels.

The common strategic action step to follow was assessed as being to continue to do *incremental* to *drastic* changes.

Survey

In Chapter 5.3 the results of the survey are shown. Some of the comments regarding the method:

- *Seems to be helpful to decide how good a platform is.*
- *I thought the method was a bit to complex first time around at least. Especially deciding upon Importance/weighting. This would probably change after having used the method a couple of times.*
- *[The method] is comprehensive and includes many issues. It gives a good overview of the current situation.*
- *The method would be beneficial for companies like Marel to support decision making on the products [based on a platform].*

Conclusion

Marel is expanding rapidly and has not had time to think of platforms in a strategic way before. The method therefore addresses a need to better understand the platform; e.g. in terms of the importance of differentiation and the threat of cannibalization.

Although issues regarding product cannibalism and lack of match for one segment had been tacitly identified by some of the participants, using the method "forced" an open discussion of these issues – it *brought the issues out* and made them easier to discuss.

[60] At the time, the product was still in the concept development phase. Due to confidentiality reasons the product is not included in the study.

5.3 Survey Results: Effect of Using the PAMatrix

After the study, a survey was sent to all participants via email as an attachment. In this section the results of the survey are presented. The objective of the survey was to obtain an understanding of how this arguably limited number of participants considers the use of the method.

Summarized, 50% (3 of 6) of TANDBERG's participants[61], 72% of Rolls Royce's participants (5 of 7), and 33% of Marel's participants (1 of 3) found that the method increased platform understanding "Slightly", while 50% of TANDBERG's participants (3 of 6), 14% of Rolls Royce's participants (1 of 7), and 67% of Marel's participants (2 of 3) found that it increased platform understanding "Much." 14% of Rolls Royce's participants (1 of 7) found that it increased platform understanding "Greatly."

Regarding the potential of making platform related decisions, 17% (1 of 6) of TANDBERG's participants, and 57% of Rolls Royce's participants (4 of 7), and 67% of Marel's participants (2 of 3) characterized it as "Better" or "Much better" than before.

The ability to "communicate the platform" was found by 34% of TANDBERG's participants (2 of 6), and 86% of Rolls Royce's participants (6 of 7), and 67% of Marel's participants (2 of 3) to be "Better" or "Much better" than before.

While most were not surprised by the level of disagreement regarding the platform, quite a few were "A bit" or "Somewhat" surprised with the level of agreement.

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[61] Here "participants" is understood as those that filled out and returned the survey. In total 7 participants from TANDBERG took part in the study, whereof 6 answered the survey. At Rolls Royce Marine, 8 participated in the study, whereof 7 answered the survey. Finally, at Marel there were 4 participants of the study, whereof 3 answered the survey.

17% of TANDBERG's participants (1 of 6), and 72% of Rolls Royce's participants (5 of 7), and 33% of Marel's participants (1 of 3) found the benefit of the method "A lot" or "Huge."

While TANDBERG found the methods main benefit lay in *creating a systematic way to discuss the platform*, Rolls Royce found that its main benefit lay in *facilitation of cross-functional cooperation*. Marel found that the main benefit is *improving the understanding of the platform, and improving decision making regarding the platforms*, as well as in *getting people to cooperate cross functionally.*

Most found the time needed for the method "As expected," however the complexity of the method was deemed by 67% of TANDBERG (4 of 6) to be "More than expected," 72% of Rolls Royce (5 of 7) as "As expected," and finally at Marel, the complexity was considered from being "Less than expected" to "More than expected."

Further detail on the survey can be found in Appendix B: Survey results.

5.4 Results and Comments

In all cases the participants of the studies found that there was an improved understanding of the platform by using the method – although the degree of increased understanding was debated. Depending on the company, the method promoted different focus areas. While one company centered the main discussion on the match of the platform to its derived products, another company focused the discussion mainly on the threat of cannibalization if a low cost version would be introduced based on the same platform.

In one case the platform investigated was, in the opinion of the stakeholders, of little importance as the decision had already been made to phase it out; instead the method captured the imagination of the participants to be used for a potential platform and even to investigate the use of a range of tools.

While one company found that the main benefit was that it enabled cross-functional stakeholders to communicate better, another company found that the main benefit was its novel approach to systematically observe a platform.

In response to the feedback from the participants of the study, some iteration was made to improve the method. This included e.g. the removal of two non-value adding original viewpoints–that were then partly included into other viewpoints and partly discarded.

It was found that as the method is quite complex, it is important to have the workshop a relatively short time after the interviewing process. It is e.g. likely that TANDBERG did not experience the same amount of benefit from the method as Rolls Royce due to the large time gap between the interviewing process and the workshop.

Summarized, while the PAMatrix was found to be useful, there were differing opinions of (a) how useful it was and (b) what the main benefit was. Different industries have differing needs, and the method could definitely be refined and improved. The concept though is sound and novel for the industry. For one of the companies, there was a great deal of anticipation around the method. It immediately captured the imagination of the participants of the study and there was a proposal to further use the method for other platforms. For the other two companies, the use was positive but there was no immediate request to continue using the method for other platforms.

Only three companies were used in the case study. Future research is needed to test the method for a greater amount of industries, as well as for more abstract platforms, i.e. knowledge platforms.

6 SUMMARY AND CONCLUSION

A man should look for what is, and not for what he thinks should be.
– Albert Einstein

In this section, the main findings and conclusion of the dissertation are presented along with a discussion of issues regarding the research questions. Furthermore, limitations are discussed and further research suggested.

6.1 Summary: Main Findings

Companies have had difficulties with managing platforms – e.g. to decide which products should be based on which platforms, and what lifetime/clockspeed the platforms should have. They have lacked a practical method to fully understand the holistic effect that the platform has on the company, as well as what forces affect the platforms potential to further develop.

Most methods that exist to create or assess platforms, have been found to only consider a small range of metrics – neglecting numerous crucial factors needed to depict a genuinely holistic context-oriented assessment. Furthermore, through an extensive review of literature on the topic "platforms" in the context of engineering design (i.e. manufacturing industry), it has been found that they vary both in scope and context. This makes it difficult for companies to use a standard method to assess them. In this dissertation a platform is defined as "a set of core asset that are reused to create a competitive advantage" – where *assets* can be components, processes, knowledge and/or people & relationships. This definition has been found useful as it enables companies to "put their finger on" the assets that actually create value – to *bundle together* the assets that are logically connected and observe them as one entity.

The method developed in this dissertation (PAMatrix) has the purpose of increasing a company's holistic understanding of its product platforms by cross-functionally evaluating dissected views of the platform. A key assumption is that by improving the understanding of the platform, it is possible to increase the likelihood of creating competitive advantage. There are basically three steps in the method: 1) define the platforms to be viewed, 2) cross-functionally view the platform from a set of mutually exclusive and all inclusive viewpoints[62], and 3) make consensus based decisions on strategic platform action steps based on a presentation of the results from step (2).

The method was iteratively improved in three companies operating in three different industries. Furthermore, a basic evaluation of the level of platform understanding before and after the use of the method was carried out. The limited amount of studies did not provide a basis for external/universal validation; however a validation of the methods usefulness for the participants of the case studies was made. In general the level of platform understanding was increased and in all cases, the method was found to be useful – although the stakeholders differed in comprehension of what the main benefit of the method was.

Basically, the method was found to be important for companies as it facilitated the management of their platforms – e.g. helped them to make better decisions on what products to use a specific platform, for how long to use a platform, and what changes to make on a platform. Uniquely, the PAMatrix considers a number of holistic metrics by cross-functional stakeholders. It systematically uses the already available tacit and explicit knowledge in the organization to support decision making.

It is apparent that the industry generally has a very vague and ambiguous understanding of what a platform is. It is therefore quite understandable that a holistic evaluation of platforms is quite unusual, and studies showed that stakeholders were not accustomed to such an approach. There was however an agreement that the PAMatrix method was beneficial for different reasons: To systematically view a platform, to increase the understanding of platforms, and to increase the level of cross-functional cooperation. It is however difficult

[62] In theory this has been the aim, although in praxis it has been impossible to achieve, i.e. if one views the set covered by the viewpoints there is some overlapping and also some missing areas.

to evaluate the direct benefits of such a method, as the sample size is quite small.

6.2 Addressing the Research Questions

RQ1: Is it possible to define the term *platform* in a way that embodies the core essence of the multiple current definitions from the academia?

Yes, defining a platform as "*a collection of core assets that are reused to achieve a competitive advantage"* embodies the core essence of the multiple current definitions. This was found after analyzing an extensive literature review of the many different definitions of product platforms – varying in context (from operational to strategic) and in scope (from narrow to broad). The main idea for the term was not to find a common denominator per say, but rather to identify the *core essence* of the meaning. The assumption was made that the goal of using platforms in the manufacturing industry is to create a competitive advantage, either by facilitating the creation of differentiation, by lower cost, or by enhancing the ability to focus on specific market segments. This assumption was justified after having examined the goals of using platforms in a number of different industries; e.g. shorten time to market or improve reliability, and finding that all goals could be linked to the three generic strategies to create competitive advantage as defined by Porter [55], i.e. differentiation, cost leadership, or focus.

RQ2: How can a platform be viewed to create a holistic understanding of its current state?

The basic idea was to divide the analysis of a complex object (i.e. platform) into a number of viewpoints – each one contributing with a piece of information that could increase the understanding of a platform. To create a holistic assessment, a platform was looked at as both affecting a number of internal and external factors, as well as being affected by a number of internal and external factors.

A framework was created that looked first at the *effect that the platform had on its environment* – first by questioning how well the platform fulfilled its original goal, then by considering its side-effects, and lastly by considering its *match* to the products using it. With regards to the *factors that influence the platform*, the competitive situation, the market situation, and the internal competency were identified. From this framework, seven viewpoints were derived – four demonstrating how the platform influences its surroundings, and three demonstrating how the platform is influenced by its surroundings.

RQ3: Can a cross-functional assessment of a platform facilitate and stimulate discussion, common understanding, consensus based decision making, and common ownership, with regards to the platform?

After validating the method for a sample of companies the conclusion to RQ3 is that it is possible to facilitate and stimulate discussion, common understanding, consensus based decision making, and common ownership, in regards to the platform by using a cross-functional assessment.

The viewpoints identified in RQ2 were used as a basis for a method – the Platform Assessment Matrix (PAMatrix). To ensure a holistic assessment, it based on information gathered from a group of cross-functional stakeholders that are knowledgeable within the platform field. Each stakeholder subjectively assesses the state of the platform seen from the seven identified viewpoints. This is done in closed settings. Later, the results are combined together and presented for all the participants, specially focusing on deviances in opinion, individual comments, and problem areas. Through a confrontation of the broad range of holistic issues raised in the matrix, the stakeholders create a mutual understanding of the platform, discuss and debate differences, and finally create a common understanding and ownership.

In the DRM framework, iteration loops from the Descriptive Study II to Prescriptive Study as well as from the Descriptive Study II to the Descriptive Study I are integrated (Figure 3-1). In the research, both of the iteration loops were used, i.e. both to modify the viewpoints used as well as the method itself.

6.3 Conclusions

Platforms are in their nature rigid and difficult to change – investments are high and a lot of time goes into their development. It is therefore vital for companies to be able to better understand how their platforms affect their surroundings and furthermore how the dynamics of the surroundings affect the potential of the platform to perform and change – both before the introduction of the platform, as well as during the lifetime of the platform.

The PAMatrix method is a tool that improves the holistic understanding of a company's product platforms. As the method uses the expert opinions of a group of cross-functional stakeholders, and then later presents these opinions in a joint forum, PAMatrix facilitates the creation of common understanding and ownership.

The objective of the case studies was twofold: First of all, to iteratively improve the method based on feedback, and second of all to validate whether the users felt the method managed to improve their understanding of the platform. After trying the method in three companies and interviewing 19 people, the key conclusion is that the suggested method to evaluate platforms is novel and considered useful by the industry.

It is clear that it still has a large potential for improvement – perhaps it should be made less complex, perhaps the background material should be lessened, perhaps it could be visually improved to facilitate the comprehension of data, or perhaps it could consider other viewpoints. This was outside the scope of the dissertation. The aim was rather to demonstrate that by using viewpoints in general to create a holistic picture of a platform, and furthermore to use cross-functional stakeholders to first objectively state their opinion and later jointly discuss the results, a better understanding of the platform could be achieved.

As mentioned in Chapter 1.4, Ulrich & Eppinger [26] argue that a design methodology is a procedure for completing activities, and is valuable for three reasons: 1) the decision process is made explicit, 2) important issues are not forgotten, and 3) a record of the decision-making process is created. The

PAMatrix method can be said to do just this, i.e. make explicit the decision process, systematically assess important issues, and document the decision making process.

6.4 Validation

The method has construct validity as the collected empirical information accurately captures the concepts contained in the theoretical model being investigated – the theoretical model in this case is the general concept of viewing a platform from a holistic set of viewpoints by a cross-functional group of stakeholders.

In terms of internal validity, history/leniency and maturation are not a threat as the results of the individual interviews are openly and jointly discussed by the group later on – enabling the clarification of such errors. The selection of the group however, is of key importance, and it is likely that the TANDBERG group was not optimally chosen in terms of background knowledge and cross-functional spread. At Marel, the group could have been larger; however the individuals represented a good cross-functional selection. The threat of the interviewer biasing the grading is quite high as there is a strong interaction between the interviewee and interviewer. This threat is highest during the initial use of the method, as it is in this phase that the metrics have to be explained in great detail and exemplified.

The inherent logic of the method should make it universal, i.e. usable for most companies; whether they sell physical products or services. In terms of external validity however, the method has only been tested in three industries and can therefore not be deemed universally valid. The findings suggested that the method proposed different value for different companies (and for different stakeholders).

Reliability is a measure of whether the research can be replicated and the *same* findings found. By following the research procedure it is likely that quite similar findings could be obtained. This is a qualitative study, where a mixed group of individuals give their expert opinion. There is always the danger of leniency-, central tendency-, and the halo effect error. However, as mentioned, the findings are discussed openly amongst the group and therefore a clarification and elimination of such errors is possible.

6.5 Discussion

The time frame of doctoral dissertations at NTNU is in most cases three years. This led to the use of literature and deductive reasoning in the first phase of the study rather then direct involvement of the industry. Later on however, the industry played a crucial part in iteratively improving the method based both on direct feedback and observations.

It has been shown that industries are often not knowledgeable about what fundamentally platforms are – and academia has not been consistent in explaining the concept. The approach in this dissertation reflects this, and a considerable amount of time and effort has been used to define what fundamentally a platform in the context of engineering design is, in order to be of practical use.

Although the method has been well received by the industry, we can ask whether it is the method itself that has led to better platform understanding or merely the “forced” dialog between stakeholders. Would the same effect be achieved by using e.g. quality function deployment (QFD) or using the Balanced Scorecard method?

The responses indicate that the method is far from perfect and still needs improvements, but nevertheless it offers a considerable improvement in terms of enabling companies to practically and systematically view their platforms – by involving a group of cross-functional stakeholders, and by forcing a debate and discussion on a wide range of holistic issues.

6.6 Limitations

The dissertation is based on extensive literature reviews, interviews, workshops, and personal findings. Due to the time frame, only a number of iterations have been made to improve the method. Furthermore, only a few industries were tested and external validation is therefore outside the scope of this dissertation.

6.7 Further Research

Future research could focus on further improving the method. One important aspect is to examine whether and how a number of platforms interact with each other and what effect this has on a products attractiveness. Another research area could be to assess whether the method can be used universally, i.e. external validation for all industries. It might be interesting to view whether different industries promote different weightings of viewpoint importance. Furthermore, companies might themselves want to create a set of viewpoints that best fit their particular context. Finally, a longitudinal study might be of interest in observing how the view of a focus group towards a specific platform changes as time goes by.

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Appendix A: Appended Papers

Introduction to the Appended Papers

Paper A The term platform in the context of a product developing company

In this paper, a sample of the use of the term platform in the academia is shown – mainly focusing on the term product platform. Furthermore a definition of the term is suggested so that all platforms can be objectively assessed.

Paper B A Framework for Evaluating Platforms in Product Developing Organizations

In this paper, a framework is proposed for a discussion-based evaluation method for platforms. Such a method would serve as a support tool for stakeholder to quickly comprehend the nature of the diverse platforms used in a company, and so make better decisions on explicit strategic action plans for each individual platform.

Paper C Platform strategy: a study of influencing factors

In the paper, the following factors are found to be of importance when creating a platform strategy: the competitive advantage strategy of the company, the industrial situation, the market situation, and the internal core competencies of a company. Furthermore, each of these areas is examined and examples given of how they influence the platform strategy.

Paper D PAMatrix: a method to assess platforms in product developing companies

The purpose of the paper is to propose a method that enables an assessment of a company's platforms in reference to the industry-, market-, and company intrinsic context, as well as in reference to the company's chosen competitive advantage strategy. Furthermore, an important objective is to keep the method easy to use, and base it on explicit or tacit data that already exist in the company. A basic assumption is that companies have a great deal of valuable data, in regards to platforms, that isn't utilized; it has to be documented and presented in a way that converts it to useful information.

Paper E Using the Platform Assessment Matrix (PAMatrix) in Praxis: Empirical Studies

The objective of this paper is to iteratively improve the PAMatrix method by using it in a sample of companies. Furthermore, the usefulness of the method is validated for these companies.

Paper A

INTERNATIONAL DESIGN CONFERENCE - DESIGN 2004
Dubrovnik, May 18 - 21, 2004.

DESIGN 2004

THE TERM PLATFORM IN THE CONTEXT OF A PRODUCT DEVELOPING COMPANY

Arnar H. Kristjansson, Tormod Jensen, and Hans-Petter Hildre

Platform definition, product development

1 Introduction

The term platform means different things in different circumstances; an oil platform, a platform in a railway station, a platform as a declaration of principles in politics – all these ways of using the term are frequently practiced and have a relatively clear meaning. Within the context of a product developing company however, the term is more vague – used in different contexts and scopes – and often causes misunderstanding and confusion. Due to the vagueness of the terminology, it has proven difficult to evaluate and benchmark different platforms.

In this paper, we present a sample of the use of the term *platform* in the context of product development – mainly focusing on the term *product platform*. Furthermore – in this context – we suggest a definition of the term so that *all* platforms can be objectively characterized.

2 The use of the term platform in product developing companies

A range of different platform terms are used in the context of product developing companies; *product* platform, *technology* platform, *brand* platform, *global* platform, *modular* platform, *process* platform, *customer* platform, *integral* platform, *scalable* platform, and *high-tech* platform are all commonly used terms to describe different types of platforms. Unfortunately, there are also a number of different definitions for the *same type* of platform. Furthermore, the general term *platform* means different things to different people, i.e. there is a general lack of precision in its usage.
According to [Moore et al. 1999][1] a *platform* is *a foundation for a range of individual product variation,* i.e., *something that is developed once and used in multiple applications*. [Ericsson & Erixon 1999][2] similarly find that a *platform* refers to a *common base* from which a number of predefined models can be built. [Gonzalez-Zugasti et al. 2001][3] include *interfaces* into the concept and define a *platform* as *the set of elements and interfaces that are common to a family of products*. These definitions are very similar to definitions of *product platforms,* as we will later see[4].

Moving on to the term *product platform*, we find differing meanings in the literature depending on the scope and context of its use; it can refer to the sharing of *functions*, the reuse of a *physical frame* that is constant over time, a collection of *modules which can change* over time, or even in some cases it might be a *strategic tool*. Let us look at definitions of product platforms from some of the leaders within engineering design- and marketing research.

[1] Work within the field of business and marketing
[2] Work within the field of engineering
[3] ibid
[4] Although not specified it is likely that the authors use the term *platform* synonymously to the term *product platform*.

In its most simplistic form, a product platform refers merely to the sharing of physical components over a range of products. [Meyer & Lehnerd 1997][5] define a product platform as a set of common components, modules, or parts (especially the underlying core technology) from which a stream of derivative products can be efficiently created and launched. [Sawhney 1998][6] finds that a product platform is set of subsystems and *interfaces* that form a common structure from which a stream of derivative products can be efficiently developed and produced. This is very similar to [Gonzalez-Zugasti et al. 2001] definition of a *platform* mentioned earlier.

Adding the term *design* to the concept, [Meyer & Utterback 1993][7] and later [Nayak et al. 2000][8] argue that a product platform encompasses the design as well as the components which are shared by a set of products. Similarly, [de Weck et al. 2003][9] find that a product platform is a set of *design variables or components* that is commonly shared across the product family.

A different perspective is seen from those who find that the reuse of *technology* is the main factor of a product platform. [Maier & Fadel 2001][10] define a product platform as *the technology that all the members of the product family have in common* and upon which different product variants are designed (or "instantiated") by individually adding technology to the platform. Similarly [McGrath 2001][11] and [Siddique et al. 1998][12] argue that *a product platform is the lowest common denominator of relevant technology in a set of products or a product line*[13].

[Robertson & Ulrich 1998][14] include all of the above into their definition of a product platform – finding that it is *the collection of assets that are shared by a set of products*. These assets can be divided into four categories, consisting of components, processes, knowledge, and people and relationships.

[McGrath 2001] furthermore finds that a product platform is *a collection of common elements, particularly the underlying technology elements, implemented across a range of products*. At the same time he emphasizes that a product platform is *primarily a definition for planning, decision making, and strategic thinking*; it is the set of *architectural rules* and *technology elements* that enable multiple product offerings and defines the *basic value proposition, competitive differentiation, capabilities, cost structure, and life cycle of these offerings*. Here it is clear that the platform encloses the core competency of the organization; that *certain something* that gives the organization a competitive advantage.

Significantly different is the definition from [Farrell & Simpson 2001][15] of a product platform, as it is not a steady, unchangeable foundation or basis, but rather a *design architectural* concept that can change[16]. They argue that the product platform provides the basis for the product family, which is derived through the addition, *substitution, or exclusion* of one or more modules from the platform or by scaling the platform in one or more dimensions.

[Sudjianto & Otto 2001][17] move from viewing a product platform as mainly being *a collection of physical assets* to being *a set of shared functionality across multiple products*. In the case of the use of multiple brands, *a product platform is a set of functions shared across multiple products each within a*

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[5] Meyer works within management
[6] Works within management of electronic commerce and technology
[7] Utterback works within management and innovation
[8] Work within the field of engineering
[9] ibid
[10] ibid
[11] Works within strategic management
[12] Work within the field of engineering
[13] It is important to notice however, that in many cases concepts such as *technology* and *design* mean different things to different people.
[14] Work within the field of information- & product development
[15] Work within the field of engineering
[16] As an example in the automotive industry a platform can include interchangeable modules [Muffatto 1999]. The chassis may even have different lengths as long as the same stamping dies are used.
[17] Work within the field of engineering

different brand. It is clear in this case that the definition has a different character, as there is no certainty of reuse of components although we reuse functions[18]. Furthermore, they define a brand platform as *the set of shared brand signatures and modules* over a range of products. Here a brand signature is a function or aesthetic element made common to a brand's offerings, to maintain brand identity.

From what we have read, we see a gradual increase in *scope* in the *product platform* definition – from including only physical components and modules, to including technology, human resources, design, and functionality.

According to [McGrath 2001] *technology platforms* are managed differently from product platforms in that product platforms are a market-facing construct, and, although developed collaboratively with R&D, they are managed by a business unit. Technology platforms are in a sense, a core competency for technology-based companies. They do not lend themselves to the building block modules and interface structure of product platforms – whereas the key technical issues for a product platform revolve around the design of *the element integration and the architecture* – for technology platforms, they are more complex; they include road-mapping of relevant product platform elements and predictable, on-schedule technology delivery. Finally make-buy decisions are different for a product platform as they are made at the element level, while for a technology platform, make/buy and licensing decisions are made at the technology, patent, and portfolio level.
[Ulrich & Eppinger 2000][19] find that a platform product is built around a pre-existing technological subsystem (a technology platform). As an example, the tape transport mechanism in the Sony Walkman, the Apple Macintosh operating system, and the instant film used in Polaroid cameras. A technology platform has already demonstrated its usefulness in the marketplace in meeting customer needs. Furthermore, they find that platform products are very similar to technology-push products in that the team begins the development effort with an assumption that the product concept will embody a particular technology. [Gawer & Cusumano 2002][20] find that a high-tech platform is an evolving system made of interdependent pieces that can each be innovated[21].

The concept of *platform thinking* is defined by [Sawhney 1998] as the process of *identifying and exploiting the shared logic and structure in a firm's activities and offerings* to achieve leveraged growth and variety. It can be applied to the firm's products, brands, target markets, geographical markets, and business processes. He finds that each of these dimensions is a vector for growth and variety creation, and together these dimensions enable firms to achieve leveraged high variety. He describes five types of platforms to facilitate the analysis of the firm's activities and offerings, i.e. a *product platform*, a *global platform*[22], a *customer platform*[23], a *process platform*[24], and finally a *brand platform*[25].

We see that there exist numerous types of platforms within the context of a product developing companies. Furthermore, a definition of the same *type* of platform can vary considerably as the example of a *product platform* in Table 1 shows. Finally, we observe that in some cases greater precision is needed in what is meant by the term platform.

Table 1. A summary of the product platform definitions displayed in the paper

[18] Even if we assume a one-to-one matching between the physical components and the functional elements – i.e. what e.g. [Ulrich 1995] refers to as modular architecture – we cannot assume the reuse of components.
[19] Work within the field of product development
[20] Work within the field of management
[21] In this case a platform can be thought of as a standard
[22] Consisting of a core offering that is common across global markets and customized elements that enable speedy and cost-effective localization of the firm's offerings to country-specific conditions and customer preferences
[23] The *beachhead* that the firm chooses as its point of entry into a new market can be conceptualized as the firm's *customer platform*
[24] E.g. manufacturing processes, design work-steps, assembly procedures, and logistics handling procedures
[25] Platform thinking applied to brand management allows a firm to exploit synergies among brands, to minimize overlap among brand identities, and to achieve coherence and clarity of poritioning across the product family

		Strategic thinking tool	Planning tool	Decision making tool	Reuse of knowledge	Reuse of functionality	Reuse of design/ design variables	Reuse of architectural rules	Reuse of people and relationships	Reuse of processes	Reuse of a product foundation/ basis	Reuse of technology/ technology elements	Reuse of interfaces	Reuse of modules/ subsystem	Reuse of components/ elements	Reuse of single monolithic part
1	[Meyer & Lehnerd 1997]													X	X	
2	[Moore et al. 1999]										X					
3	[Ericsson & Erixon 1999]										X					
4	[Gonzalez-Zugasti et al. 2001][26]												X		X	
5	[Sawhney 1998]													X		
6	[Meyer & Utterback 1993]						X								X	
7	[Nayak et al. 2000]						X								X	
8	[de Weck et al. 2003]						X									
9	[Maier & Fadel 2001]											X				
10	[Gonzalez-Zugasti & Otto 2000]													X[27]		X[28]
11	[Robertson & Ulrich 1998]				X				X	X					X	
12	[McGrath 2001]	X	X	X				X				X			X	
13	[Sudjianto & Otto 2001]					X										
14	[Farrell & Simpson 2001]													X		

3 A definition of the term platform in the context of product development

How can we define a platform in the context of a product developing company in a way that captures the core meaning of all different types of platforms? We argue that this is only possible if we set the scope of the term in a way that it is compatible with an *accepted* body of definitions as the lowest common denominator. Based on our findings we define a *platform* as[29]:

a collection of core assets that are reused to achieve a competitive advantage

Here *assets* is adapted from [Robertson & Ulrich 1998] and defined as **components** (e.g. part designs of a product, the CAD tools needed to make them, the circuit designs, software, and product function), **processes** (e.g. the equipment used to make components or to assemble components into products, and the design of the associated production process and supply chain, and material), **knowledge** (e.g. design know-how, material know-how, technology applications and limitations, production techniques, mathematical models, and testing methods), and finally **people and relationships** (e.g. teams, relationships among team members, relationships between the team and the larger organization, relationship with a network of suppliers, and alliances). The term *core* indicates that the company believes that the asset enables a competitive advantage for the company; in most cases core assets are proprietary, engineered by the members of the organization; the expertise of use of specific material, the concept of differentiating the final product after first phase quality control, the secret multi-step process of manufacturing a SiC semiconductor wafer, or for that matter the secret mixture of the Coca Cola syrup, are all examples of an organizations reuse of core assets.

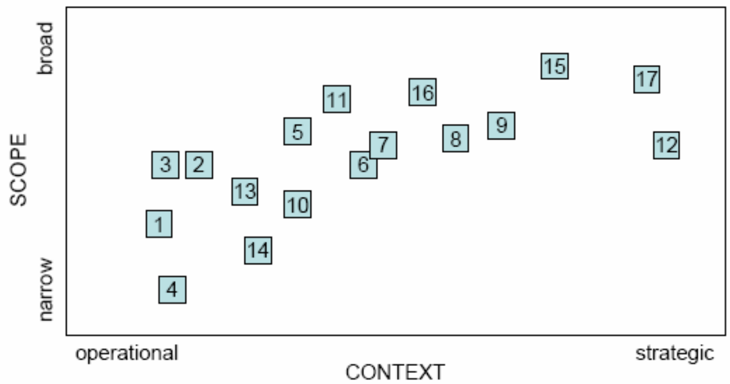
The platform definitions discussed in this paper are summed up in figure 1. We find that although a number of similarities exist we see that there are large deviances both in scope as well as context.

[26] We assume that their use of the term *platform* is synonymous with the term *product platform*

[27] Modular platform

[28] Integral platform

[29] The definition is influenced by [McGrath 2001], [Sawhney 1998], and [Robertson & Ulrich 1998]



#	AUTHOR(S)
1	[Meyer & Lehnerd 1997]
2	[Moore et al. 1999]
3	[Ericsson & Erixon 1999]
4	[Gonzalez-Zugasti et al. 2001]
5	[Sawhney 1998][30]
6	[Meyer & Utterback 1993]
7	[Nayak et al. 2000]
8	[de Weck et al. 2003]
9	[Maier & Fadel 2001]
10	[Gonzalez-Zugasti & Otto 2000]
11	[Robertson & Ulrich 1998]
12	[McGrath 2001]
13	[Sudjianto & Otto 2001]
14	[Farrell & Simpson 2001]
15	[Gawer & Cusumano 2002]
16	[Ulrich & Eppinger 2000]
17	[Sawhney 1998][31]

Figure 1. The platform concepts vary in scope and context[32].

4 Conclusion and further research

In the overview of the *platform* concept, we have not attempted to list all definitions of platforms, but rather analyzed the context and scope of a representative sample of literature. We argue that 1) there exist a number of different types of platforms, 2) within the same type of platform, there often exist ambiguous nuances, and 3) the term *platform* is understood differently by different people, i.e. there is a lack of precision in the use of the term.

Based on the findings we propose that if one wants to objectively evaluate and benchmark platforms, one has to first define the platform term in a way, which includes platforms in all scopes and contexts[33]. This we do by defining a platform as *a collection of assets that are reused to achieve a competitive advantage.* Although this is a broad definition, it serves as the *lowest common denominator* for the platform concepts we have presented in this paper.

Further research has been carried out to identify a set of *viewpoints* that can be used to objectively characterize platforms[34] in product developing companies. Future research aims to varify the feasibility of using these viewpoints as well as understanding their dynamics in terms of platform strategy. Finally – building on this research – a methodology to assess the performance of platforms is in the making.

[30] Definition of product platform
[31] Concept of platform thinking
[32] The concepts are not accurately placed in the figure, but rather qualitatively according to the views of the authors.
[33] Within the context of a product developing company
[34] A set of such viewpoints is suggested in the paper "PLATFORM CHARACTERIZATION: a method to view the reuse of core assets in product developing companies" by A. Kristjansson and H.-P. Hildre. Published at the 7th Workshop on Product Structuring – Product Platform Development, Chalmers University Of Technology, Göteborg, March 24-25, 2004

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Paper B

7TH WORKSHOP ON PRODUCT STRUCTURING – PRODUCT PLATFORM DEVELOPMENT
CHALMERS UNIVERSITY OF TECHNOLOGY, GÖTEBORG, MARCH 24-25, 2004

A FRAMEWORK FOR EVALUATING PLATFORMS IN PRODUCT DEVELOPING ORGANIZATIONS

Arnar H. Kristjansson and Hans-Petter Hildre

Abstract

Platforms have grown in importance as product developing companies strive to be competitive by simultaneously increasing product variants and lowering internal costs. Sometimes platforms have been beneficial but in other cases they have not been. The questions are why is this so and how can we evaluate platforms in general. Furthermore, it is of interest for companies to be able to take general strategic action plans to improve the performance of their platforms.

Numerous platform definitions exist, ranging in context and scope. Due to their diverse nature, platforms are difficult to interpret, discuss, and evaluate. We define a platform as a set of core assets that are reused to achieve a competitive advantage. The term is arguably broad, but we find that it has the advantage of capturing a company's variety of reused heterogenic assets that are in effect the core enablers of competitive advantage for the company

In the paper we propose a framework for a discussion-based evaluation method for platforms. Such a method would serve as a support tool for stakeholder to quickly comprehend the nature of the diverse platforms used in a company, and so make better decisions on explicit strategic action plans for each individual platform.

Keywords: platform evaluation, decision support, platform terminology, platform strategy, asset management

1 Introduction

With the advent of globalization and a higher level of competition, companies are striving to remain competitive by both decreasing internal costs, as well as increasing customer satisfaction [1] – meeting the customer's expectations in terms of technical performance, innovation and time of delivery. This has caused great managerial challenges, where a partial remedy has been found in the use of platforms.

Platforms have in many cases been successful in creating a match between fulfilling market demand and creating internal benefits [2-6]. Other research however has indicated that they have at times not been beneficial [7]. This raises the question of what exactly it is that makes a platform successful and how can they be evaluated in general. This again raises the fundamental question of just what a platform is.

A literature review on platforms in the context of product developing companies has shown that vast amount of definitions exist, in different contexts and scopes [8, 9]. Based on the review, we boil down the core essence of the term and define a platform as *a set of core assets that are reused to achieve a competitive advantage.* Here, a competitive advantage can both be created inside the company (e.g. within design and production) as well as externally (e.g.

due to more attractive products leading to higher sales). The advantage with this arguably broad definition is that it enables stakeholders to capture a variety of reused heterogenic assets that are de facto the core enablers of competitive advantage for the company.

Many methods exist aimed at assessing platforms [4, 10-12], each of them doubtlessly beneficial for their particular context and scope, but arguably not appropriate for our broader definition of the term. Furthermore, we argue that the methods often are quite complex to use (see e.g. de Weck et al. [12]) and require a great deal of information that is hard/tedious to acquire. This in effect makes them unattainable for many potential users.

We find that there is great need for an alternative method – based on already available explicit and tacit information and data – which enables a company to evaluate all platforms in a standard way. In today's praxis, managers and other stakeholder make decisions regarding platforms based on intuition, multi-tasking ability, and cognitive juggling of numerous parameters.

2 Theoretical background

To be able to create a framework to evaluate platforms in product developing companies, the platform definition itself has to be clear. There exist numerous definitions of platforms, existing in different contexts and scopes. According to Moore et al. [13][1] a *platform* is a foundation for a range of individual product variation, i.e., something that is developed once and used in multiple applications. Ericsson & Erixon [14][2] similarly find that a *platform* refers to a *common base* from which a number of predefined models can be built. Gonzales-Zugasti et al. [15][3] include *interfaces* into the concept and define a *platform* as *the set of elements and interfaces that are common to a family of products*. If we look specifically at the use of the term *product platform*, it can refer to the sharing of *functions*, the reuse of a *physical frame* that is constant over time, a collection of *modules which can change* over time, or even in some cases it might be a *strategic tool*. Meyer & Lehnerd [4][4] define a *product platform* as a *set of common components, modules, or parts (especially the underlying core technology) from which a stream of derivative products can be efficiently created and launched*. A different perspective is seen from those who find that the reuse of *technology* is the main factor of a product platform [5, 16, 17]. Robertson & Ulrich [18][5] include all of the above into their definition of a product platform – finding that it is *the collection of assets that are shared by a set of products*. These assets can be divided into four categories, consisting of components, processes, knowledge, and people and relationships. McGrath [5] argues that a product platform is *a collection of common elements, particularly the underlying technology elements, implemented across a range of products*. At the same time he emphasizes that a product platform is *primarily a definition for planning, decision making, and strategic thinking*; it is the set of *architectural rules* and *technology elements* that enable multiple product offerings and defines the *basic value proposition, competitive differentiation, capabilities, cost structure, and life cycle of these offerings*. Here it is clear that the platform encloses the core competency of the organization; that *certain something* that gives the organization a competitive advantage. Significantly different is the definition from Farrell &

[1] Work within the field of business and marketing
[2] Work within the field of engineering
[3] ibid
[4] Meyer works within management
[5] Work within the field of information- & product development

Simpson [19][6] of a product platform, as it is not a steady, unchangeable foundation or basis, but rather a *design architectural* concept that can change[7]. They argue that the product platform provides the basis for the product family, which is derived through the addition, *substitution, or exclusion* of one or more modules from the platform or by scaling the platform in one or more dimensions. Sudjianto & Otto [21][8] move from viewing a product platform as mainly being *a collection of physical assets* to being *a set of shared functionality across multiple products.* In the case of the use of multiple brands, *a product platform is a set of functions shared across multiple products each within a different brand.* It is clear in this case that the definition has a different character, as there is no certainty of reuse of components although we reuse functions[9].

From what we have read, we see a gradual increase in *scope* in the *product platform* definition – from including only physical components and modules, to including technology, human resources, design, and functionality. This leads to an ambiguous use of the term product platform. Such ambiguity is not unique for the term product platform; the authors have also found certain ambiguity in the use of the terms *technology* platforms [23], *brand* platforms [21, 24], *global* platforms [25], *modular* platforms [26], *process* platforms [25], *customer* platforms [25], *integral* platforms [26], *scalable* platforms [27], and *high-tech* platforms [3].

The concept of *platform thinking* is defined by Sawhney [25] as the process of *identifying and exploiting the shared logic and structure in a firm's activities and offerings* to achieve leveraged growth and variety. It can be applied to the firm's products, brands, target markets, geographical markets, and business processes. He finds that each of these dimensions is a vector for growth and variety creation, and together these dimensions enable firms to achieve leveraged high variety. He describes five types of platforms to facilitate the analysis of the firm's activities and offerings, i.e. a *product platform*, a *global platform*[10], a *customer platform*[11], a *process platform*[12], and finally a *brand platform*[13].

From what we have seen, within the context of a product developing company, there exist 1) a number of different types of platforms, 2) each different type of platform has a number of ambiguous definitions, and 3) we argue that the term *platform* is understood in different ways.

How can we define a platform in the context of a product developing company in a way that captures the core meaning of all different types of platforms? We argue that this is only possible if we set the scope of the term in a way that it is compatible with an *accepted* body of definitions as the lowest common denominator. Based on our findings we define a *platform* as:

a set of core assets that are reused to achieve a competitive advantage

Here *assets* is adapted from Robertson & Ulrich [18] and defined as **components** (e.g. part designs of a product, the CAD tools needed to make them, the circuit designs, software, and

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[6] Work within the field of engineering

[7] As an example in the automotive industry a platform can include interchangeable modules [20]. The chassis may even have different lengths as long as the same stamping dies are used.

[8] Work within the field of engineering

[9] Even if we assume a one-to-one matching between the physical components and the functional elements – i.e. what e.g. Ulrich [22] refers to as modular architecture – we cannot assume the reuse of components.

[10] Consisting of a core offering that is common across global markets and customized elements that enable speedy and cost-effective localization of the firm's offerings to country-specific conditions and customer preferences

[11] The *beachhead* that the firm chooses as its point of entry into a new market can be conceptualized as the firm's *customer platform*

[12] E.g. manufacturing processes, design work-steps, assembly procedures, and logistics handling procedures

[13] Platform thinking applied to brand management allows a firm to exploit synergies among brands, to minimize overlap among brand identities, and to achieve coherence and clarity of positioning across the product family

product function), **processes** (e.g. the equipment used to make components or to assemble components into products, and the design of the associated production process and supply chain, and material), **knowledge** (e.g. design know-how, material know-how, technology applications and limitations, production techniques, mathematical models, and testing methods), and finally **people and relationships** (e.g. teams, relationships among team members, relationships between the team and the larger organization, relationship with a network of suppliers, and alliances). The term *core* indicates that the company views the asset as an enabler of competitive advantage; the expertise of use of specific material, the concept of differentiating the final product after first phase quality control, the secret multi-step process of manufacturing a SiC semiconductor wafer, or for that matter the secret mixture of the Coca Cola syrup, are all examples of an organizations reuse of core assets. According to Porter [28], a company can achieve a competitive advantage by following one of three generic strategies: Differentiation, Cost Leadership, or Focus (Figure 1). However, a company should only focus on one of the competitive advantages: *being "all things to all people" is a recipe for strategic mediocrity and below-average performance, because it often means that a firm has no competitive advantage at all* [28]. If a company wants to have a competitive advantage for a number of segments (broad target), it can either aim to achieve *cost leadership* (at the same time achieving proximity or parity in the bases of differentiation relative to its competitors) or *differentiation* (at the same time achieving cost proximity or parity relative to its competitors by reducing cost in all areas that do not affect differentiation). By focusing on cost, a firm seeks a cost advantage in its target segment, while by focusing on differentiation a company seeks differentiation in its target segment. After a company has chosen one of the three generic strategies to create a competitive advantage, it has to align its platform strategy in accordance. In Figure 1 we can see a matrix illustrating Porter's three generic strategies to achieve a competitive advantage.

Figure 1. Porters Three Generic Strategies [28].

Methods exist aimed at assessing the *goodness* of a platform; e.g. Meyer & Lehnerd [4] have defined the *effectiveness* and *efficiency* of platforms by looking at platform engineering cost, derivative product engineering cost, net sales of a derivative product, and development costs of a derivative product. Jiao & Tseng [11] use two commonality indices – one for component part commonality, and one for process commonality – to *understand* product families for mass customization. Similarly, Siddique [10] developed a commonality metric for platform and product family evaluations. These methods are without doubt good for particular contexts and scopes, but arguably not appropriate for our broader definition of the term platform.

3 Research aim and methodology

The primary aim of this paper is to propose a framework for a discussion-based evaluation *method* for platforms. Such a method would serve as a support tool for stakeholder to quickly comprehend the nature of the diverse platforms used in a company, and so make better decisions upon explicit strategic action plans for each individual platform. The method should use qualitative information already available within the company – both explicit as well as tacit – to create awareness of the "as is" status of platforms, as well as the company's need and potential to change them.

In effect, in this paper we are proposing the general fundamental structure for a *future* method, which shall enable companies to map all platforms in the same reference frame, discuss their pros and cons, and make sound decisions on basic strategic action plans for each individual platform.

Not much literature exists regarding platform assessment. We therefore based our research methodology on deductive reasoning, where our starting point was our given definition of a platform, i.e. *a set of core assets that are reused to achieve a competitive advantage*. Based on findings from a body of literature as well as from own insight we then identified a number of characteristics that where common among seemingly heterogenic platforms. These characteristics were then *formed* into basic *steps* that we then used as the main building blocks of the framework.

4 The framework

Using our basic definition of a platform – i.e. a set of core assets that are reused to achieve a competitive advantage – we propose the following framework (Figure 2) to evaluate platforms in product developing companies.

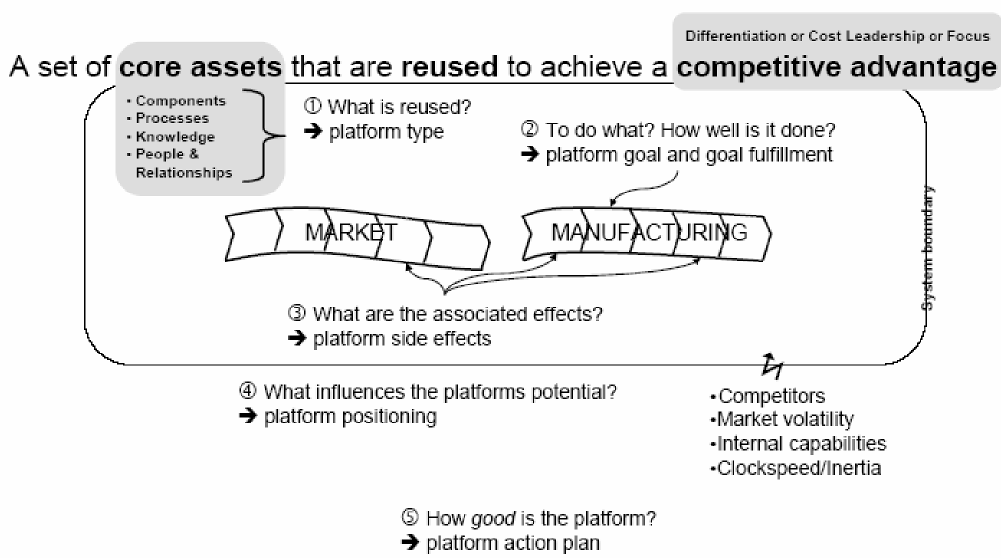

Figure 2. A framework to evaluate platforms with the goal to decide on individual action plans

The framework consists of five steps: 1) platforms of a company are *captured*, 2) their individual goals are identified and goal-fulfilment evaluated, 3) the side effects of the platforms are identified and assessed, 4) factors that influence the potential of the platform are assessed, and finally 5) a total platform evaluation is created and concrete strategic action plans decided.

In Figure 2, we show these steps, and demonstrate how platform goals affect parts of the value chain while side effects can affect other parts. The chain is divided into Market and Manufacturing. *Market* describes any factors / elements of the value chain needed for a new product to reach the market, i.e. any element needed to sell and support the product – e.g. market research, distribution channels, and customer service. *Manufacturing* describes any factors / elements of the value chain needed to design, develop, and create the product – e.g. research, development, procurement, production, and inbound logistics. Furthermore, we distinguish between inside and outside the system boundary. Inside the system boundary we illustrate the "*as is*" situation of the platform; *what it is, how well it fulfils its goals and what its side effects are*. Outside the system boundary are elements that influence the *potential* of the platform to maintain/improve its current value; *how skilled is the company in regards to the platform, how does competition affect its value, and how well does it match market volatility*.

In this section we will explain each step of the framework, how it was derived, and why it is important.

4.1 Step 1: Platform type

In the first step of the framework, we *capture* the platforms of a company. In general, platforms are difficult to grasp, conceptualize, and put into words. The term *capture* in this case then indicates the identification and naming of a set of core assets that stakeholders within the company consider logical and practical to group together.

As an aid for this task, we use the fact that platforms consist of a set of assets: components, processes, knowledge, or/and people & relationships. We argue that platforms can be divided into four different platform types depending on their dominant source of assets, i.e. into *component* platforms, *process* platforms, *knowledge* platforms, and *people & relationships* platforms. The main rule is that a company should define its platforms based upon what it considers to be *a logical and practical grouping*.

In praxis, we suggest working though a company's list of individual products, and for each product identify the platforms it uses – from component- to people & relationships platforms. In the following table we display four different platforms, each one of a different type (Table 1).

Table 1. The list shows a sample of platforms used for a specific product.

Platform	Platform type
J500 Controller (operating system, circuit board design)	Component platform
Prototyping workshop	Process platform
Computer vision technology (image processing)	Knowledge platform
The subsidiary FabriCat produces the cutting machine	People & Relationships platform

4.2 Step 2: Platform goal and goal fulfilment

Every platform has a goal, be it to create savings in the manufacturing, to shorten development time, or to increase the number of variants. In the following table a sample of possible platform goals are presented (Table 2).

Table 2. A sample of platform goals.

• Increase variation • Shorten time to market • Reduce risk • Reduce systemic complexity • Simplify testing	• Improve service levels • Reduce non-value adding work • Create economies of scale • Create economies of scope • Increase ability to mass customize	• Reduce development cost and time • Reduce manufacturing cost • Reduce investments

After having identified the platform goals, their actual fulfilment needs to be assessed. This can be done in different ways, e.g. by using the following table (Figure 3).

Competitive advantage	Platform goal	REASON							IMPACT					EFFECT		
		IMPORTANT			NEUTRAL			UNIMPORTANT	SUPERIOR		AS PLANNED		INFERIOR	POSITIVE	NEUTRAL	NEGATIVE
		7	6	5	4	3	2	1	1	2	3	4	5	1	0	-1
Differentiation	Shorten Time-To-Market (TTM)															
	Increase variation															
	Technology improvement															
	Service level improvement															
Cost leadership	Cost reduction															
	Risk reduction															
	Learning curve utilization															
	Economies of scale															
	Testing simplification															
	Complexity reduction															
Focus	Improve differentiation for niche market															
	Improve cost leadership for niche market															

main goal ⟷ side-effects

Figure 3. An example of how platform goals, along with their fulfilment can be captured.

For a given platform, a rating of the main reason for usage (platform goal) is compiled together with a relative evaluation of the deviation between the impact and expected impact. Finally, the effect is registered as being positive, neutral, or negative[14]. Note as platform goals are rated as less and less important, they change from being *goals* to being expected *side effects*[15]. Furthermore, in the figure we see that a column has been added (first column from left) titled "Competitive advantage." According to Porter [28], a company can choose one of three general strategies to create a *competitive advantage;* by Differentiation, Cost Leadership, or by Focus[16]. We find that it is possible to view each of the platform goals in Table 2 as contributing to one of Porter's three generic strategies to achieve a competitive advantage. Viewing the platform goals in this way can be advantageous, as it enables stakeholder to understand the core strategic value of the platforms. In general a company should follow only one of the three generic strategies. This does not mean that every platform should be aligned to the chosen strategy; it does however mean that their overall combined effect should contribute to the strategy.

[14] A Likert Scale Summated Rating (data: interval) is used to rate the reason of using the platform. To assess the impact of the platform in terms of the specific goal, we use a Comparative Scale (data: ordinal). Finally to rate the general direction of the effect we use a Simple Category Scale (dichotomous; data: nominal). For further information on the rating scales used, please refer to e.g. Cooper & Schindler [29].

[15] It is not within the scope of this paper to go into the specifics of how to use the framework as a concrete method. Here however it makes sense to illustrate how it could be used in praxis.

[16] Please refer to the Technical Background section for more details.

4.3 Step 3: Platform side effects

A platform might fulfill its intended goal adequately but still have a number of negative side effects diminishing its overall benefit. These side effects can appear in any part of the value chain, be expected or unexpected, and range from being positive to being negative.

As an example, if the goal of a platform is to increase the potential of creating variants, a side effect may be that the production process is less efficient; if however the goal of the platform is to create economies of scale in production process, the side effects might be that the platform isn't flexible enough to create the desired variants.

In general we can look at these side effects as being either internal or external.

Internal side effects

The platform can have vast side effects on the internal organization. Throughout the value chain, it dictates work processes, sets restrictions, and generally limits degrees of freedom. On the other hand, it frees up resources and facilitates focus on value adding activities. An example of an internal side effect is the negative effect that using a platform might have on the functionality of a specific product, i.e. where the functionality does not meet the target functionality directly due to the use of a specific platform.

External side effects

External platform side effects are perhaps the most difficult to assess. How does the reuse of core assets affect the customer's perception of the product?

As an example, in a given scenario, a customer is interested in a high price segment product due certain functions. In this case, these functions are directly related to the use of a specific platform. The customer then finds out, that the exact same functions (same platform used) are available in a product in a low price segment. This revelation might cause the buyer to choose the less expensive product (cannibalization) or/and might have a negative effect on the customer's image of the higher priced product (especially in the case of brand differentiation).

It is clear that a basic understanding of the affect a platform has on the customer's perception is important to explore.

4.4 Step 4: Platform positioning

In this step we evaluate factors that affect the platform potential to improve; in contrary to the assessments made in steps 1-3, in step 4 we look into the future and evaluate the platforms *potential/position* to maintain or improve its current value.

Seen from an internal perspective, the general competency a company has in regards to a platform is the most important factor affecting a platform's potential to improve. The level of know how, the number of researchers/developers assigned to the platform, and the quality of the facilities are all factors that affect the general competency.

The most important external factors that influence a platform's position are a) the level of competition within the platform area, and b) how well the platform's clockspeed[17] and inertia match the market volatility. Clockspeed and inertia are useful concepts to describe respectively the speed of evolution of the platforms, and the general resistance to change.

[17] Fine [30] defines the concept *clockspeed* to describe various rates of evolution in industries.

The platform *competition* level is an indicator of how focused a company must be to excel. High platform competition indicates that a company must focus heavily on the platform to create a competitive advantage.

Market volatility is an indicator of how fluctuating the product demand is. In general, if the volatility of the market demand is high, a company should strive to remain flexible in terms of what it can manufacture. As an example, it is ill advisable for a company to develop a platform with a high inertia and slow clockspeed, if a) it highly influences the products it is part of, and b) the demand for the products is unstable.

For each platform, the *clockspeed* and *inertia* can be assessed. Different platforms have different clockspeeds depending on their rate of evolution. As an example, the clockspeed of a CPU component platform can last for a period of 6 months, an automotive component platform for 10 years, and an automotive process platform for up to 15 years. Finally, the platform inertia is an indicator of how much *freedom* an organization has in choosing whether or not to use a specific platform. The inertia can be seen as being due to one or more of the following: *financial* inertia, *development time* inertia, *standard* inertia, and finally *knowledge* inertia[18]. A financial inertia derives from a situation where a company is forced to use a platform due to lack of financial muscle. A development time inertia derives from a situation where the demand to have a short development time forces a company to use a platform. A standard inertia derives from a situation where a company is forced to use a platform as it is a standard. Finally, knowledge inertia derives from a situation where a company is forced to use a platform due to lack of knowledge to do otherwise.

4.5 Step 5: Platform action plan

The framework is meant to be the foundation for a discussion-based evaluation method for platforms; to quickly get up to speed on the status and position of a platform and so support decision making regarding strategic action plans for each individual platform.

In this last step of the process, the findings from steps 1-4 are accumulated to evaluate 1) the need to change the platform, and 2) a company's potential to change the platform. Finally, after evaluating the need and potential to change a platform, strategic action plans are decided upon.

In Figure 4 we see how the action plans derive from an assessment of the need to make changes and an assessment of the potential to make changes. In the former, the need is estimated from an assessment of the platform's goal fulfilment, side effects, and the platform's position in regards to competition and match with market volatility. The assessment of the potential to change derives from a study of the internal competency of the company in regards to each individual platform.

[18] This classification has been found by studying general change resistance forces of platforms.

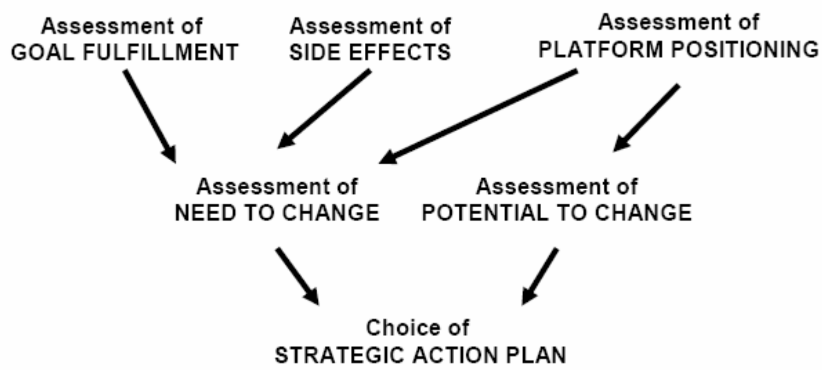

Figure 4. An overview of how the need and potential to change platforms are evaluated and specific action steps derived.

After having completed the process steps, stakeholders should be able to understand the "as is" and positioning of each platform. Based on the results, a limited number of a strategic[19] action plan alternatives can be considered and finally one chosen.

5 Conclusions and further research directions

The framework introduced in this paper was designed to view all *sets of assets* that create a competitive advantage – i.e. platforms – in the same frame of reference. It should create a picture of the "as is" situation of each platform, as well as the need and potential to improve it. Furthermore, all required information and data should be gathered from a group of multi-disciplinary stakeholders in a discussion-based forum/workshop. As the steps of the framework are followed, a more and more accurate *picture* of the platform is created; by identifying them, discussing their goal fulfilment, their side effects, as well as their need and potential for improvement, stakeholders should be able to make better decisions upon concrete strategic action plans for each platform.

The direction of further research is on creating an actual full-fledged method. Each step must be extending in detail and information gathering must be designed to capture best possible estimates of the fulfilment of platform goals, side effects, as well as positioning of the platform. Simultaneously, a row of industry case studies must be conducted to validate the method.

Although we are still in the very beginning of developing a method, we are optimistic that it will be of great value to companies striving to manage a broad range of platforms. We point out that merely "conceptualizing" platforms in the proposed way could be very advantageous – enabling stakeholders to discuss, reflect, and agree upon action plans for each platform.

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[19] With *strategic* we indicate that the plan is not meant to be detailed – it should in general give the direction to follow in regards to the platform. As an example it might be sensible to use five different action plan possibilities:

1. Status Quo (i.e. do nothing)
2. Minor changes / Improvements
3. Major changes
4. Create new platform / Split platform
5. Eliminate platform / Merge platform

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Paper C

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PLATFORM STRATEGY: A STUDY OF INFLUENCING FACTORS

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Platform Strategy, Asset Management, Platform Development, Platform Assement Tools

Abstract

A platform strategy is the overall elaborate action plan a company has to managing its platforms. In general, the use of platforms – what we define as the reuse of a set of core assets to achieve a competitive advantage – has both positive and negative effects, affecting the internal efficiencies and effectiveness of a company as well as the characteristics of a product. In the paper, we find that the following factors should be considered when in the process of creating a platform strategy: the competitive advantage strategy of the company, the industrial situation, the market situation, and the internal core competencies of a company. Furthermore, we examine each of these areas and give examples of how they influence the platform strategy.

1 Introduction

Developing a single product includes numerous complex steps, among them a market analysis, a concept development, a feasibility review, a final design review, a market test review, and a manufacturing feasibility review [Wheelwright and Clark'92]. Developing a platform – upon which a company can derive a number of products over a period of years or even decades – is even more difficult for decision makers; uncertainty of the dynamics of change in markets, technology, the industry, and even the internal status of the company are significant.

A platform strategy is a company's grand plan to manage its platforms – to build a match between creating a family of attractive products for the market and the reuse of core assets within the company. A successful strategy takes into consideration a broad group of factors that either affect or are affected by the company's platforms. The ultimate goal with platforms is to create a competitive advantage, something that at best is a fleeting commodity that must be won again and again [Fine, et al.'02], and the platform strategy has to support this.

2 Theoretical background

The attention to platforms in product developing companies has grown, coinciding with an increased level of competition, more demanding customers, and a shorter lifespan of products. Research activities on platforms have also grown; some indicating that they are beneficial (e.g. [Sanderson and Uzumeri'97]), while other have found out the contrary (e.g. [Hauser'01]). The problem is that in most cases it is impossible to extrapolate such research findings to any situation, as platforms exist in different contexts and scopes.

It is difficult to characterize a platform objectively as people have different ideas of what a platform is, i.e. the platform concept is quite fuzzy. This is due to 1) the existence of a number of different types of platforms, e.g. *product-*, *technology-, brand-, global-, modular-, process-, customer-, integral-, scalable-,* and *high-tech* platforms, 2) ambiguous definition nuances exist within the use of each type, and 3) imprecise use of the term platform. It is not within the scope of this paper to present an extensive literature review of platform types, and we will therefore let be with defining a *product platform* as a collection of assets that are shared by a set of products [Robertson and Ulrich'98] and a *high-tech platform* as an evolving system made of interdependent pieces that can each be innovated upon [Gawer and Cusumano'02]. For a more thorough literature on the term platform in the context of product developing companies, please refer to e.g. [Kristjansson, et al.'04].

Our definition of the term platform is*:* a *set of core assets that a company reuses to achieve a competitive advantage*. The term *core* indicates that the asset is centre in the organizations perception of what is essential for the product to be competitive. In most cases, core assets are proprietary, engineered by the members of the organization. The expertise of use of specific material, the secret multi-step process of manufacturing a SiC semiconductor wafer, or for that matter the secret mixture of the Coca Cola syrup, are all examples of an organizations reuse of core assets. Furthermore, *assets* can be divided into components, processes, knowledge, and people & relationships [Robertson and Ulrich'98].

[Hussay'98] argues that the coming of the portfolio analysis technique in the late 1960s offered a new and superior way to look at the relative strategic importance of the various activities that made up an organization. We find that our definition of platforms in the context of product developing organizations offers a similar benefit, i.e. enables an organization to comprehend the various core assets that actually create a competitive advantage.

The basic purpose of platforms is to create a competitive advantage by reusing a set of core assets. How successful a platform is, depends not only on how well it fulfils its main objective/goal, but also on a number of other factors, e.g. how it influences the customers perception of its derived products, how the reuse of a certain technology affects the companies ability to innovate, how the reuse of a certain component affects the uniqueness of a certain product, or how the reuse of a specific material affects the chance to move into a new market segment.

In Figure 1 we can see two graphs illustrating the difference between following a single product development strategy and a platform based product development strategy. Both graphs contain the same utility curve of a particular market, while the curves for demand, price, and cost are different. The basic assumption of the *Theory of Consumer Behavior* is that the consumer maximizes utility, given a limited income [Henderson and Quandt'58].

A company, which develops a single product, decides a target level of features and quality for a specific market. We illustrate this in Figure 1a. The increased amount of features/quality (bells and whistles*)* increases the utility for the customer, although the differential decreases as features/quality increases. As an example, most car owners primarily want to get safely between A and B, after which extended features – e.g. air conditioning and a radio – increases the utility. After certain amounts of extra features/quality, the gained utility wanes, and fewer people are willing to pay for the extra features/ quality. This is illustrated in the demand curve in Figure 1a, where the company develops a single product with the level of features/ quality that satisfies most buyers in a segment (one-size-fits all method). In Figure 1b, we can see a scenario where a company uses a platform upon which it develops a group of products. In this case, the demand curve is increased as different market segments can chose between numbers of products that specifically fit the need (mass customization method). Furthermore, the cost for extra features decreases as a large *chunk* of the development cost is distributed over a number of products. Again, the utility curve is the same in the two graphs as we look at the same specific market segment.

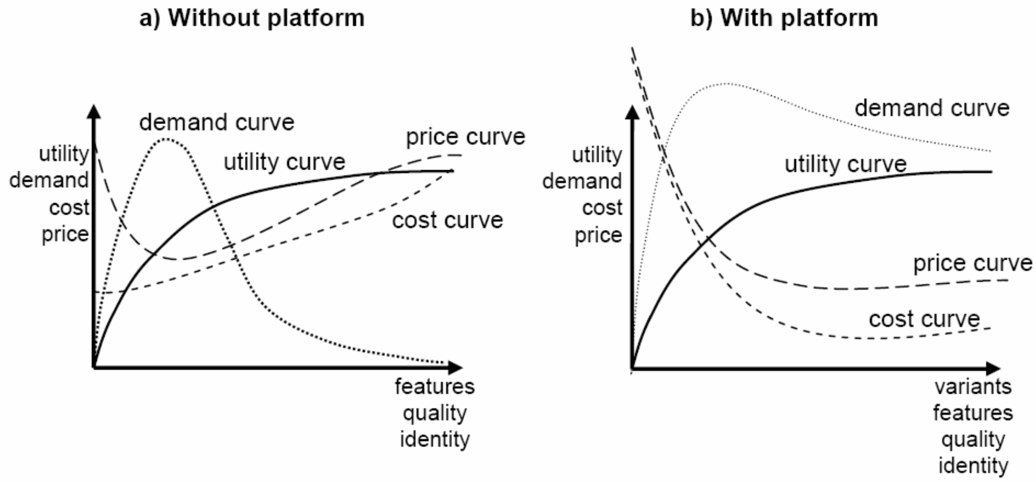

Figure 1. Hypothetical correlation between utility/ demand/ cost/ price and (variants)/ features/ quality. In a) we see a single product offering, while in b) a platform is used for a variety of products.

As with the term *platform*, the term *platform strategy* means different things to different people. [McGrath'01] finds that a *product platform strategy* is the basis for product strategies. He defines a product platform as *a collection of common elements, particularly the underlying technology elements, implemented across a range of products*. At the same time he emphasizes that a product platform is *primarily a definition for planning, decision making, and strategic thinking*; it is the set of *architectural rules* and *technology elements* that enable multiple product offerings and defines the *basic value proposition*, *competitive differentiation*, *capabilities, cost structure, and life cycle of these offerings*. Here it is clear that the platform encloses the core competency of the company; that *certain something* that gives the company a competitive advantage.

[Muffatto'99] argues that a platform can be seen from a *strategic*, an *organizational*, and a *technical* perspective and that the introduction of a *platform strategy* affects product development performances, in particular, cost and lead-time reduction, the international operations and the R&D management strategies of companies. He finds that a platform strategy is strongly linked to the way platform development is organized in relation to the other parts of the whole product and that every company recognizes the platform strategy as a *key issue in their future domestic and international strategy*. Furthermore, he states that a platform strategy affects a number of issues, in particular the relationship between platforms and models and between platforms themselves, the relationship with the supplier base, and the relationship with subsidiaries in other countries and with other companies.

[Meyer and Lehnerd'97] describe different platform strategies in terms of utilizing platforms over different market segments. They identify three strategies in the context of a market segmentation grid (Figure 2). The first strategy is *niche-specific platforms with little sharing of subsystems and manufacturing processes* (Figure 2a).

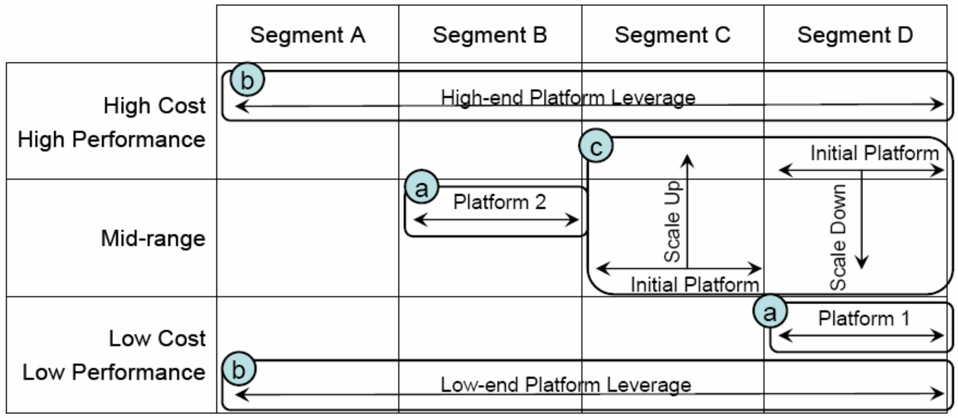

Figure 2. A Market Segmentation Grid with Three Platform Strategies (adapted from [Meyer and Lehnerd'97])

The second strategy is *horizontal leverage of key platform subsystems and manufacturing processes* (Figure 2b). Finally, the third strategy is *vertical scaling of key platform subsystems* (Figure 2c). In addition, they define a *Beachhead Strategy* as being a mix of horizontal leverage and vertical scaling. They suggest a five-step process for companies to define their platform strategy: 1) segment markets, 2) identify growth areas, 3) define current platforms, 4) analyze competing products, and 5) consider future platform initiatives. As we see, their view of a *platform strategy* has to do with leveraging platforms to different market segments.

[Gawer and Cusumano'02] refer to *Platform Leadership* as the objective to drive innovation in the industry. In their opinion, a platform is a standard, e.g. the Microsoft's Windows operating system, or the VHS standard. They look at *platform strategy* as an action plan to become the dominant platform on the market. They suggest a framework – the *Four Levers of Platform Leadership* framework – that managers can use to design a strategy for platform leadership or make their existing strategy more effective. The framework has the following four *levers*: 1) scope of the firm, 2) product technology (architecture, interfaces, intellectual property), 3) Relationships with external complementors, and 4) internal organization.

We can see that these four views of *platform strategy* differ a great deal, depending on – among other things – what the authors puts into the term *platform.*

As we stated earlier, our definition of the term platform is a set core assets that are reused to achieve a competitive advantage. Our definition of the term platform strategy refers then to a company's elaborate and systematic plan of action to manage a group of platforms, both individually as well as in regards to how they work together as a group. A platform strategy includes decisions on how long a platform should exist and the choice of products that are based on each platform.

3 Research aim and methodology

The primary research aim of this paper is to identify general areas/factors which a company must consider before creating a platform strategy. The main contribution is first of all to identify these areas/factors along with appropriate frameworks/tools to analyze platforms in the context, and second of all expand on how these areas/factors potentially affect – or are affected by – the platforms. The findings in this paper will partially be used for a future evaluation method for platforms.

To perform this study, we will look at a sample of how the literature defines *platform strategy*,we examine a body of literature within managment and strategy, and furthermore use our own insight.

4 Influencing factors for a platform strategy

A platform strategy has to support the basic purpose of platforms, namely to create a competitive advantage for the company [Kristjansson, et al.'04]. Competitive advantage can be created in various locations within the value chain, by following one of the general competitive advantage strategies: cost leadership, differentiation, or by focusing on a specific segment [Porter'85]. The context in which a company exists can be divided into being external and internal; the internal context encloses the company's intrinsic functions/departments, while the external context encloses factors that lie outside the company's control. The external context can furthermore be divided into industry and market, where *industry* describes the competitive landscape, and *market* the customers' profiles. Using this context for devising a strategy is in line with the findings of many researchers; e.g. [Gluck, et al.'80] argue that attention has to be given not only to internal aspects but also to what they refer to as *externally oriented planning*, with much more concentration being given to the external environment and to customers and markets.
We propose that in the process of creating a platform strategy, a company should consider the market-, and industry situation, as well as the company's general strategy to create a competitive advantage. Here the *market delivery plan* is included in *market*. The competitive advantage strategy again derives from the industry- and market situation, and the internal core competencies of the company.

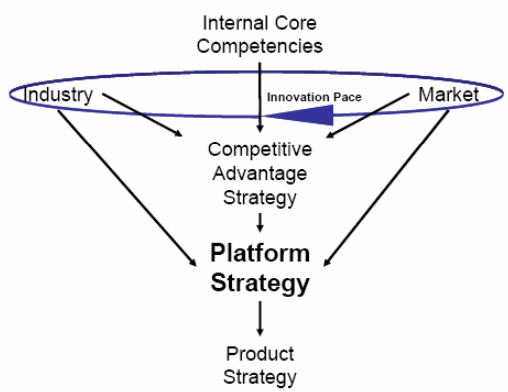

Figure 3. A company derives its platform strategy from the competitive advantage strategy, the industry-, and market situation.

Furthermore, the innovation pace/clockspeed is driven by a complex interaction of industry and market. Finally, the company's product strategy derives from the platform strategy.
In this chapter, we discuss each of these areas and relate them to the platform strategy.

4.1 Internal core competencies

Companies seldom have the opportunity to make decisions based only on the industry- and market situation; in most cases they are bound to use a number of inherent assets, i.e. legacy systems, machinery, housing, staff, technologies, alliances, work processes, and component designs. The core competency of the company is found within these inherent assets and should be exploited when creating a platform strategy.
A company already has a number of platforms. Identifying these platforms is important and here the concept of *platform thinking* is relevant; it is defined by [Sawhney'98] as the process of *identifying and exploiting the shared logic and structure in a firm's activities and offerings* to achieve leveraged growth and variety.

4.2 The industry

The industry situation in which a company competes is important to understand, as it affects the company's competitive advantage strategy as well as its platform strategy. To do this, a company can use Porter's Five Competitive Forces Model (Figure 4), with the forces *threat of new entrants, bargaining power of suppliers, bargaining power of buyers, threat of substitute products or services,* and *rivalry among existing firms.* The five forces determine industry profitability as they influence prices, costs, and a company's required investments.

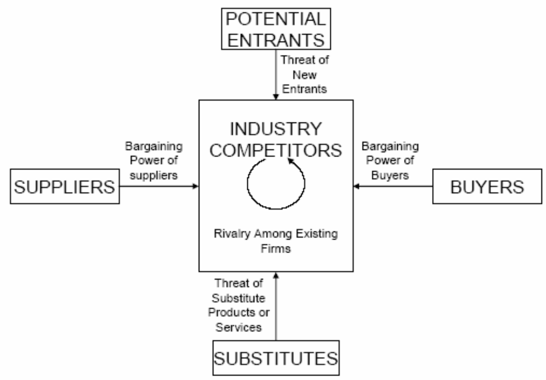

Figure 4. Porter's Five Competitive Forces that determine Industry Profitability [Porter'85]

A company should furthermore assess the *innovation pace* of the industry that it is in and use it as an indicator of what clockspeed the platforms should have. If, e.g., a company in a high innovation pace industry wishes to create a competitive advantage by focusing on differentiation, it should emphasize a high clockspeed amongst the platforms that influence differentiation (for more information on the term *clockspeed* see [Fine'98]). The bottom line is that the platforms of a company have different clockspeeds/ lifecycles, which should be aligned to create competitive advantage – though always keeping in mind that this is a temporary advantage that changes with time. The clockspeed has to be in line with the *innovation pace* of the industry; the pace is derived from a complex interaction of industry and market.

Companies can make their own *proprietary technology / standards, license out, or use open source systems* to quicken development. In high-clockspeed industries, companies might take advantage of open source platforms to quicken the development of e.g. software.

Depending on the industry, the level of competition varies, and so does customer expectation. Typically, as competition levels increase, companies have to find ways to give the market more for less; this is where platforms have been successful, matching more precisely what the customer wants (mass customization) and at the same time reusing internal core assets to create efficiencies. An industry goes through different *maturity levels*: embryonic, growth, maturity, or aging. The maturity level is a good indicator of whether the industry focus is on innovation and technology or on cost reduction. As the industry/technology becomes mature and the demand for greater utility wanes, the innovation pace falls.

Disruptive technologies [Christensen'97] can be thought of as potential substitutes. Presently they might not match the company's technology performance, but have a strong potential to provide similar or greater performance for a lower price.

4.3 The market

With the term *market,* we refer to the buyers of the product. As with the industry situation, the market situation affects both the company's competitive advantage strategy, as well as its platform strategy.

The Kano Model of Customer Satisfaction (Figure 5) divides product attributes into three categories: threshold, performance, and excitement. A competitive product meets basic attributes, maximizes performances attributes, and includes as many "excitement" attributes as possible at a cost the market can bear [Ullman'97]. *Threshold* (or basic) attributes are the expected attributes – or *musts* – of a product, and do not offer an opportunity for product differentiation. *Performance* attributes are those for which more is generally better, and will improve customer satisfaction. On the other hand, an absent or weak performance attribute reduces customer satisfaction. *Excitement* attributes are tacit and unexpected by customers but can contribute to high levels of customer satisfaction. Their absence however does not lead to dissatisfaction. Excitement attributes often satisfy latent needs, i.e. real needs that customers are currently unaware. We adapt the model to platforms instead of functions.

Products can be divided into being *high-or low involvement*. If the customer feels a high level of *risk* in buying a product, then it is considered a *high-involvement* product [Assael'92]. Clothing, stereo-systems, and cars are examples of high-involvement products, while detergent, screws, and recordable DVD disks are examples of low-involvement products.

Finally, *volatility* is an important characteristic of a market. Volatility worsens a company's ability to forecast demand.

Depending on what general competitive strategy is attempted, what the market situation is, and what the industry situation is, a company devises its *market plan*. The market plan encompasses decisions regarding what products, in what quality/price/function, should be launched into which markets.

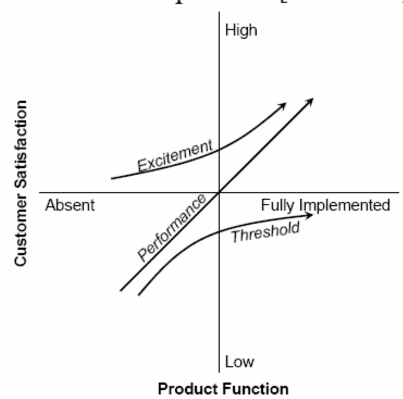

Figure 5. Kano Model

4.4 Competitive strategy

One of the main factors a company should base its platform strategy on is its *competitive strategy*. The competitive strategy includes the company's *market plan*, i.e. into which markets, with what frequency, and which products, the company plans to deliver. According [Porter'85], a competitive advantage is at the heart of any strategy, and achieving it requires a firm to make a choice about the type of competitive advantage it seeks to attain, and the scope within which it will attain it. He finds that a company can follow three generic strategies to attain its desired competitive advantage, Differentiation, Cost Leadership, or Focus (Figure 6).

COMPETITIVE ADVANTAGE

	Lower Cost	Differentiation
Broad Target	1. Cost Leadership	2. Differentiation
Narrow Target	3A. Cost Focus	3B. Differentiation Focus

Figure 6. Porter's three generic strategies: lower cost, differentiation, and focus.

A company should only focus on one of the competitive advantages: *being "all things to all people" is a recipe for strategic mediocrity and below-average performance, because it often means that a firm has no competitive advantage at all* [Porter'85].

If a company wants to have a competitive advantage for a number of segments (broad target), it can either aim to achieve *cost leadership* (at the same time achieving proximity or parity in the bases of differentiation relative to its competitors) or *differentiation* (at the same time achieving cost proximity or parity relative to its competitors by reducing cost in all areas that do not affect differentiation). By focusing on cost, a firm seeks a cost advantage in its target segment, while by focusing on differentiation a company seeks differentiation in its target segment. After a company has chosen one of the three generic strategies to create a competitive advantage, it has to align its platform strategy in accordance.

As the competitive strategy plays a crucial role in the platform strategy, we will describe more thoroughly the three general strategies.

4.4.1 Cost leadership strategy

With this strategy, a company aims to being the low cost provider (for a given level of quality) in the industry. In this case, a company can either sell its products at the same price of the competition – and so gain higher profit, or sell under price to increase market share. In a price-war scenario, the company can still be profitable, while the competition suffers losses. In the long run, the cost leader can better survive price decrease in a maturing industry, remaining profitable over a longer period of time. Usually the cost leadership strategy is used over a broad scope.

Process efficiency improvement, economies of scale, vertical integration, outsourcing, and cutting on unnecessary costs are some of the ways a company can create cost advantages.

A company that wishes to become a cost leader should:

- Have a skilled manufacturing process workforce (incl. engineers)
- Be able to invest in production assets to improve the production process.
- Have efficient distribution channels
- Have a skilled design team to enhance design for manufacturing

Risks following the strategy include technology improvement, disruptive technologies (where other companies may be able to invest in cheaper production technology and still proved the same utility [Christensen'97]), or general improvement of production processes in the industry. Furthermore, focused low cost providers may be able to provide even lower cost alternatives.

4.4.2 Differentiation strategy

In this strategy, a company must create a value proposition for the customer that the competition is unable to meet, either due to a unique offering of products or services that are considered better, or different in a positive way. Due to the differentiation, the company can request a price premium, which should cover extra costs due to the uniqueness of the design. In a scenario where the supplier increases its prices, the company can pass the extra cost over to the customer, as the uniqueness of the product diminishes substitutes.

A company that wishes to become a leader in differentiation should:

- Have a skilled research force or/and have access to leading scientific research
- Have a highly creative and skilled product development team
- Have a high image for innovation and quality
- Have a skilled sales force to communicate the value adding of the products

Risks following the strategy include changing tastes of the market, imitation by competitors, as well as well as focused strategy competitors that even further differentiate for a specific segment.

4.4.3 Focus strategy

The focus strategy attempts to achieve either cost leadership or differentiation in a narrow scope. The idea is that by focusing entirely on a specific segment, a company can better fulfill its needs. A focus strategy company often has a high customer loyalty, and so discourages other companies to compete directly.

A drawback for the focused cost leader is his inability to achieve economies of scale due to lower volumes. On the other hand, the focused differentiator can further increase his uniqueness, and so *pass* higher costs over to the customer, as substitutes are none.

A company that wishes to become a leader with a focused strategy should:

- Have a highly skilled product development team that understands its customers well
- Be able to tailor a broad variety of products

Risks following the strategy include changes in the target segment, imitation, direct competition from a broad cost-leader that modifies his product, and even more focused companies. In Table 1 we sum up the required internal qualities and risks inherited for the generic strategies.

Table 1. Porter's generic strategies require different company intrinsic qualities and bestow different risks (adapted from [Porter'85]).

	Internal Qualities	Risks
Cost Leadership Strategy	• Have a skilled manufacturing process workforce (incl. engineers) • Be able to invest in production assets to improve the production process • Have efficient distribution channels • Have a skilled design team to improve design for manufacturing (DFM)	• Technology improvement • Disruptive technologies • General manufacturing process improvement in the industry • Threat from a focused strategy company
Differentiation Strategy	• Have a skilled research force or have access to leading scientific research • Have a highly creative and skilled product development team • Have a high image for innovation and quality • Have a skilled sales force to communicate the value adding of the products	• Changing tastes of the market • Imitation by competitors • Focused strategy competitor
Focus Strategy	• Have a highly skilled product development team that understands its customers well • Be able to tailor a broad variety of products	• Changes in target segment • Imitation • Direct competition from a broad cost-leader • More focused competitors

4.5 Summary of the influencing factors

Summing up, we find that a platform strategy derives from the core competencies of a company, the industry- and market situation, and the company's chosen competitive advantage strategy. In Table 2 we show this, along with hypothetical examples of how a company might use the status of the factors to reason in regards to a platform strategy.

Table 2. A summarization of the factors that a platform strategy must consider

Areas	Factors	Suggestions regarding the Platform Strategy (Examples)
Core Competencies	Identifying present core competency platforms	*Core competencies must be used; the competencies of a company should be platformed*
Industry Situation	Threat of new entrants	*A company should strive to use platforms in a way that increase barriers to entry*
	Bargaining power of suppliers	*Suppliers should not have too much bargaining power in reference to platforms*
	Bargaining power of buyers	*Bargaining power affects the decision of what to include in platform. If bargaining power is high, platform threshold and performance and focus on excitement add-ons to differentiate.*
	Threat of substitute products or services	*Substitutes are bought either due to cost or differentiation. Platform to minimize threat.*
	Rivalry among existing firms	*If rivalry high, platform the commodity part*
	Clockspeed / Innovation Pace	*Platform low paced assets. Platform mid- and high paced depending on volume and volatility.*
	Proprietary vs. Open Source	*Open source SW platforms might be useful where the need to establish a standard is large*
	Maturity Level	*Usually a high maturity level indicates a focus on cost rather than innovation and technology. Platform commoditiy and differentiate*
	Disruptive Technologies	*If threat of disruptive technologies high, the platform should not contain the as-is technology*
Market Situation	Kano's Model of Customer Satisfaction	*Depending on volatility, platform threshold and possibly performance*
	High- or Low Involvement Products	*Buyers find high involvement products risky. Platforms in high involvement products should decrease the feeling of risk*
	Volatility	*High volatility indicates a need for flexibility. Platform accordingly.*
Competitive Strategy	Differentiation	*Platform threshold assets*
	Cost Leadership	*Platform threshold and performance assets*
	Focus	*Knowledge Platforms of importance*
	Market Plan	*Does company have products in different price segments, industry segments, or family segments. Do not platform differentiating assets*

5 Conclusions and further research

Based on our definition of the term platform in a product developing company, we find that a platform strategy is *a company's elaborate and systematic plan of action to manage a group of platforms, both individually as well as group-wise.* The areas/factors that should be assessed to facilitate a company's platform strategy creation have been identified as deriving from a company's core competencies and chosen competitive advantage strategy, the market situation, and the industry situation. A number of frameworks/tools have furthermore been identified that we propose using for analyzing the platforms in the context of the areas/factors. We argue that by focusing on these areas/factors, stakeholders can make better decisions and create better platform strategies; including decisions on platform market plan, platform life time, and platform usage. The factors were chosen by examining a body of literature as well as from our own insight.

Future research includes creating a method to facilitate a decision making on strategic action plans for each individual platform an organization possesses. For more information please refer to [Kristjansson and Hildre'04].

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Paper D

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PAMATRIX: A METHOD TO ASSESS PLATFORMS IN PRODUCT DEVELOPING COMPANIES

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Platform assessment, platform management, platform development, platform strategy, platform decision making

Abstract

Platforms in the context of product developing companies are used to fulfil a number of different goals. In some cases they have proven to be beneficial, while in other instances they have proven not to be. To understand how well a platform is performing, it has to be assessed in its existing industry-, market-, and company internal context. Furthermore, the platform has to be assessed in line with how much it contributes to the company's specific competitive advantage strategy (CAS).

The purpose of the paper is to propose a method that does this, i.e. assesses a company's platforms in reference to the industry-, market-, and company intrinsic context, as well as in reference to the company's chosen CAS. Furthermore, an important objective is to keep the method easy to use, and base it on explicit or tacit data that already exist in the company. A basic assumption is that companies have a great deal of valuable data that isn't utilized; it has to be documented and presented in a way that converts it to useful information.

The method – which we call the Platform Assessment Matrix (PAMatrix) – consists of a matrix that analyzes the platforms of a company from different viewpoints. By using the method, stakeholders can more easily derive to general strategic action plans for each individual platform.

The method is still in creation, and a number of iterations are still needed. The basis is however in place and a number of industry case studies in the pipeline.

1 Introduction

Over the last decades, the use of platforms in product developing companies has proliferated, coinciding with an increased level of competition, more demanding customers, and a shorter lifespan of products. A platform facilitates a company's effort to effectively and efficiently deliver a variety of attractive goods to the market. In many cases they have been successful

[Sanderson and Uzumeri'97], while in others they have not been worth the effort [Hauser'01]. The problem with such findings is that they apply to specific platforms in specific contexts and cannot be extrapolated to any given situation; an effective platform in one context might be ineffective in another context. Platforms have different *goals* (e.g. to facilitate cost leadership, improve reliability, or to create a standard), and cause a number of different side effects. This raises the question of how we can assess the performance of a platform in a specific context and scope.
We find that there is a great need for a pragmatic and simple method, which holistically and objectively evaluates the performance of platforms in their specific context. Today when managers and other stakeholder make decisions regarding platforms (e.g. regarding their use, maintenance, design, and out phasing), they have to count on intuition, multi-tasking ability, and successful cognitive juggling of numerous factors.

2 Theoretical background

The authors define a platform in the context of a product developing company as *a set of core assets that are reused to achieve a competitive advantage*. This definition has been derived by finding the lowest common denominator of a series of definitions from relevant literature [Kristjansson, et al.'04]. Our working definition of a platform strategy is *a company's elaborate and systematic plan of action to manage a group of platforms, both individually, as well as group-wise*. [Kristjansson and Hildre'04b].
A number of methods exist to construct platforms from scratch (see e.g. [Siddique'00] and [Gonzalez-Zugasti and Otto'00]), few however aim to rate the performance of already existing platforms. [Meyer and Lehnerd'97] have defined the *effectiveness* and *efficiency* of product platforms by looking at platform engineering cost, derivative product engineering cost, net sales of a derivative product, and development costs of a derivative product, and [Gonzalez-Zugasti, et al.'01] attempt to value platforms by using options. These methods are undoubtedly appropriate for specific contexts and scopes, but arguably not appropriate for our broader definition of the term platform. [Kristjansson and Hildre'04a] propose using the following framework to evaluate platforms with the attention to create action plans (Figure 1).

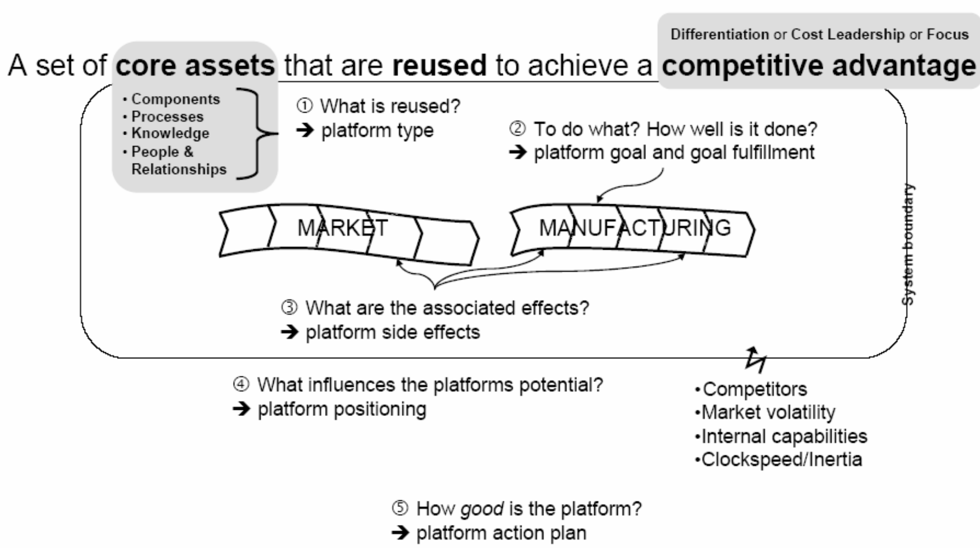


Figure 1. A framework to evaluate platforms with the goal to decide on individual action plans

3 Research aim and methodology

The primary aim of the paper is to propose a discussion-based evaluation method fo platforms. The method should serve as a support tool for stakeholders to quickly comprehen the nature of the diverse platforms used in a company, and so make better decisions upo explicit strategic action plans for each individual platform. It should use qualitativ information already available within the company – both explicit as well as tacit – to creat awareness of the "as is" status of platforms, as well as the company's need and potential t change them. Furthermore, it should be relatively easy to use so increase the likelihood o actual utilization.

In this paper we only aim to describe from a pedagogical standpoint how the method works.

We base our research on previous work that describes a framework for platform evaluatio [Kristjansson and Hildre'04a] and a study of factors influencing platform strateg [Kristjansson and Hildre'04b].

4 The Platform Assessment Matrix (PAMatrix)

The method builds on a sequence of steps; first systematically registering the company' platforms, then assessing each platform in reference to a set of specific "factors", and finall summing up and deciding upon specific action plans.

In Figure 1 we see an illustration of the PAMatrix. Horizontally we line up the company' platforms, while vertically a number of factors are listed that either influence or are influence by the platforms. The factors are divided into "as is" – i.e. factors that describe the curren *performance* of the platform – and "positioning" – i.e. the potential to improve/maintain th current value of the platform. For each step graphical representations are used to facilitate th comprehension of the collected data. After each step, a strategic action plan is recommended.

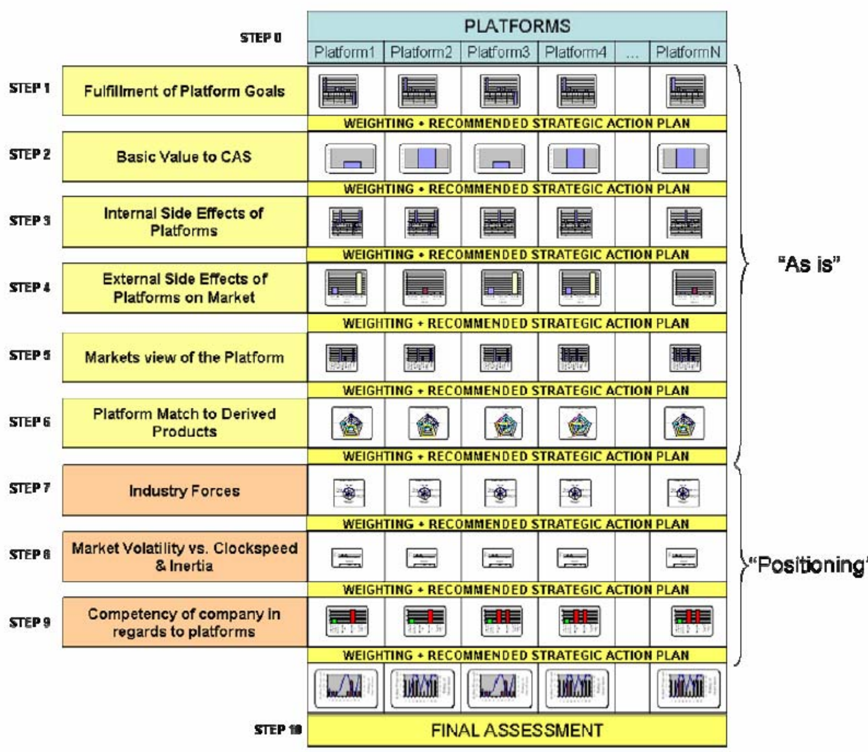


Figure 2. An overview of the PAMatrix method.

The factors are assessed qualitatively by stakeholders most often from within the company.

In this section we describe step by step how the method should be used. In steps 1 to 6, we look at forces that describe the "as is" situation of each platform while in steps 7 to 9, we examine each platforms "positioning." With that we refer to how easy it is for the company to improve/maintain the platforms value proposition.

4.1 Grading and weighting

In the grading process, a number of different scales are used, designed to capture the values of each step in an appropriate way for the given context. In general, rating scales are used to judge properties of objects without reference to other similar objects [Cooper and Schindler'03]. In Table 1, the grading scales used in the PAMatrix are displayed. Common to all steps is that they are ended by recommending a strategic action plan, rated with an APS scale. In addition, the importance of each step for a particular platform is weighted. In this way a platform might perform poorly in regards to a specific factor/step, but at the same time the factor/step might be rated as being of low importance. The rating scale RS-B is used for registering the weighting (Table 1).

Table 1. Grading scales used in the PAMatrix

Rating Scale A (RS-A)	-9	Great negative effect
	-3	Medium negative effect
	-1	Low negative effect
	0	No effect
	1	Low positive effect
	3	Medium positive effect
	9	Great positive effect
Rating Scale B (RS-B)	0	None (or does not apply)
	1	Low
	3	Medium
	9	High
Rating Scale C (RS-C)	0	High
	1	Medium
	3	Low
	9	None (or does not apply)
Rating Scale D (RS-D)	1	Low
	3	Medium
	9	High

Inertia Rating Scale (IRS)	F	Financial
	T	Time To Market
	K	Know-How
	S	Standard
Maturity Level Scale (MLS)	E	Embryonic
	G	Growth
	M	Maturity
	A	Aging
KANO Scale (KMS)	T	Threshold
	P	Performance
	E	Excitement
Action Proposal Scale (APS)	0	Status Quo
	1	Incremental Change
	2	Drastic Change
	3	New / Split
	4	Eliminate / Merge

We will now explain each step of the method. In Figure 3 we can see an example of steps 0 to 5 and in Figure 4 an example of steps 6 to 10.

4.2 Step 0: Identification of the company's platforms

Step 0 of the method is to identify the platforms used in a company. To help with this step, we find that platforms can be categorized into being component-, process-, knowledge-, or people & relationships platforms (derived from [Robertson and Ulrich'98]). We suggest going through a company's products, and for each one, identifying the component-, process-, knowledge-, or people & relationships platforms. The identified platforms are then lined up horizontally into the PAMatrix. See Figure 3 for an example.

4.3 Steps 1 to 6: Assessing the "as is" status of the platforms

4.3.1 Step 1: The fulfilment of the platforms goal

Every platform has one or more goals, be it to create economies of scale or to shorten product development time. In the PAMatrix we register for each platform what the *main goal* is by using Porter's three generic strategies as a framework. For each strategy we assess the expected impact as well as the actual impact the platforms have. The grading scales used are RS-A, RS-B, and APS. See Figure 3 for an example.

4.3.2 *Step 2: Basic value to the competitive advantage strategy (CAS)*

Porter defines three generic strategies that a company can follow to achieve a competitive advantage: differentiation, cost leadership, or focus [Porter'85]. A company should have only one general strategy to follow. Depending on the chosen strategy, the company has to align its platforms accordingly. This however does not mean that platforms not supporting the general strategy should be discarded – the company must however be aware of the impact the platform has.
In step 2 of the process, the basic value of the platform for the competitive advantage strategy is assessed. The grading scales used are RS-A, RS-B, and APS. See Figure 3 for an example of this step.

4.3.3 *Step 3: Internal side effects of platform*

The PAMatrix also captures the internal side effects that a platform has on the company. A platform might have positive main effects but negative side effects, diminishing the overall benefits. In the Figure 3 we see how the side effect of a platform are graded depending on the effect it has on the value chain of a company; on the *firm infrastructure*, the *human resources management*, *technology development*, *procurement*, *inbound logistics*, *operations*, *outbound logistics*, *sales & marketing*, and finally *service* (adapted from [Porter'85]).
The grading scales used are RS-A, RS-B, and APS.

4.3.4 *Step 4: External side effects of the platforms on the market*

Depending on its type, and the context which it is in, a platform deviates in its susceptibility to be reused over price-, industry, and product family segments. The factors used are the threat of unwanted *cannibalization*, *demand loss*, and *image loss* for the three different scenarios, where the platform is a) reused *over a price range*, b) reused *over product families*, and c) reused *over industries*.
In the Figure 3 we show how the external side effects of a platform are registered in the PAMatrix. The grading scales used are RS-B, and APS.

4.3.5 *Step 5: Markets view of the platforms*

The objective of a platform is to create internal advantages for the company, and also to provide the buyer with a value proposition. The buyer might or might not be aware of the platform. If he is aware of the platform, he will perceive it according to how well it fulfils certain functions (here functions can also mean identity or/and quality). He will also get (hopefully) some satisfaction from the platform. In Figure 3 we see how the PAMatrix captures the market views for each platform.
The factors used to analyze the markets view of the platform are *Customer Satisfaction*, *Platform Function Implementation*, *Customer Involvement*, *Awareness to the Customer*, and *Value for Customer*. Furthermore, we register whether the function that the platform fulfils is a threshold-, performance-, or excitement function, i.e. according to the Kano Model (see e.g. [Kristjansson and Hildre'04b,Ullman'97] for further information). The grading scales used are KMS and RS-B, and APS. See Figure 3 for an example.

4.3.6 *Step 6: Platform match to derived products*

Platforms are in many cases originally designed for a certain product in mind, and therefore fit well its target functionality, quality, cost, volume, and identity. When however the

platform is used for other products, the match might not be optimal. In Figure 4 we can see how the PAMatrix registers these matches.
The company's products are listed up on the vertical axis and the platforms match graded in terms of functionality, quality, cost, volume, and identity. The rating scales used are RS-A, RS-B, and APS.

4.4 Steps 7 to 9: Assessing the "positioning" of the platforms

4.4.1 Step 7: Industry forces

The company exists in a certain industrial context. In the PAMatrix, we assess how the platform complies with the given industry situation. In Figure 4 we can see an example of how the *Industry Forces Factors* for each of the company's platforms are captured in the PAMatrix.
There are six factors considered, always in relevance to the specific platform. These factors are *Rivalry Rate, Barriers to Entry, Bargaining Power of Buyers, Bargaining Power of Suppliers, Substitution Threat,* and *Disruptive Technology Threat*. In essence we use Porter's Five Forces Model [Porter'85], in addition to Christensen's theory of disruptive technologies [Christensen'97] to capture the industry forces which affect the platforms. It is important to notice that we apply the analysis on each individual platform, and not on the product in whole.
For each factor a grading is given according to how strong the forces are. The grading scales used are RS-B, RS-C, and APS. If e.g. the *Bargaining Power of Buyers* is strong in reference to a particular platform, the grading would be set as 9.
The graph facilitates the comprehension of the results; high scores indicate a tough industry situation for the platform.

4.4.2 Step 8: Market volatility vs. clockspeed & inertia

Platforms have different clockspeeds and inertia, which should be aligned to – among other things – the volatility of the market. In Figure 3 we see how the relationship between market volatility and clockspeed & inertia is captured in the PAMatrix.
The factors looked at are the *clockspeed* and *inertia* of the platform, as well as the *market volatility level* and *maturity level* of the particular platform. In addition, the matrix captures the main reason for the inertia. Furthermore, to create a reference point, the main competitor's clockspeed and inertia in terms of his comparable platform (if it exists) is registered.
The grading scales used are RS-B, RS-D, IRS, MLP, ASP, and the clockspeed is measured in the maximum amount of years that a company will use it (starting from first usage).

4.4.3 Step 9: Platform competency

Companies have a number of platforms that they use to support their overall competitive advantage strategy. Depending on the platform, a company's ability to improve it varies. The company's competency to improve the platform, along with the time and cost needed to do so is assessed. In Figure 4 we see an example of how this step is executed. The grading scales used are RS-B, RS-D, and APS.

4.5 Step 10: Summing up

Finally the scores from all factors are summed up along with their weightings. An overall evaluation is undertaken of *how well the platform supports the competitive advantage strategy (CAS)*, the overall need to change the platform, the overall potential to do so, and the overall importance to do so. Based on the findings, a final recommendation is given towards a strategic action plan. The grading scales used are RS-B and APS.

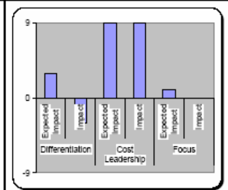
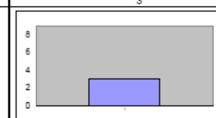
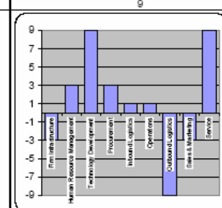
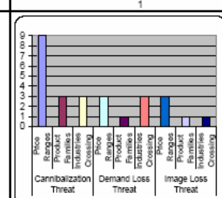
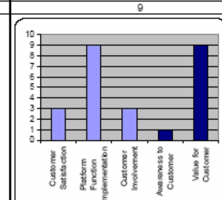
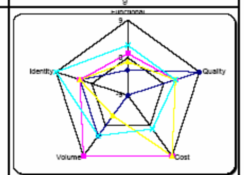
			SCALE	Component platforms
0. PF Type				C1
				J500 Controller (operating system, circuit board design, run-time environment)
1. Fulfillment of Platform Goal	Differentiation	Expected Impact	RS-A	3
		Impact	RS-A	-3
	Cost Leadership	Expected Impact	RS-A	9
		Impact	RS-A	9
	Focus	Expected Impact	RS-A	1
		Impact	RS-A	0
				
	Importance/weighting		RS-B	1
	Action		APS	0
2. Alignment to CAS	Effect on Competitive Advantage Strategy (CAS)		RS-A	3
				
	Importance/weighting		RS-B	3
	Action		APS	1
3. Internal Side Effects of Platforms	Firm Infrastructure		RS-A	-3
	Human Resource Management		RS-A	3
	Technology Development		RS-A	9
	Procurement		RS-A	3
	Inbound Logistics		RS-A	1
	Operations		RS-A	1
	Outbound Logistics		RS-A	-9
	Sales & Marketing		RS-A	-3
	Service		RS-A	9
				
	Importance/weighting		RS-B	1
	Action		APS	1
4. External Side Effects of Platforms on Market	Cannibalization Threat	Price Ranges Crossing	RS-B	9
		Product Families Crossing	RS-B	3
		Industries Crossing	RS-B	3
	Demand Loss Threat	Price Ranges Crossing	RS-B	3
		Product Families Crossing	RS-B	1
		Industries Crossing	RS-B	3
	Image Loss Threat	Price Ranges Crossing	RS-B	3
		Product Families Crossing	RS-B	1
		Industries Crossing	RS-B	1
				
	Importance/weighting		RS-B	9
	Action		APS	1
5. Markets view of the Platform	Kano Model: Threshold, Performance, Excitement		KMS	T
	Customer Satisfaction		RS-B	3
	Platform Function Implementation		RS-B	9
	Customer Involvement		RS-B	3
	Awareness to Customer		RS-B	1
	Value for Customer		RS-B	9
				
	Importance/weighting		RS-B	9
	Action		APS	0

Figure 3. Example for steps 0 to 5 of the PAMatrix. The component platform "C1" is analyzed.

6. Platform Match to Derived Products

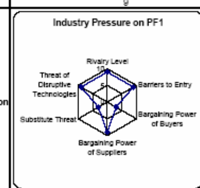
PRODUCT A	Functional	RS-A	-3
	Quality	RS-A	9
	Cost	RS-A	-9
	Volume	RS-A	3
	Identity	RS-A	3
PRODUCT B	Functional	RS-A	1
	Quality	RS-A	3
	Cost	RS-A	9
	Volume	RS-A	9
	Identity	RS-A	3
PRODUCT C	Functional	RS-A	-1
	Quality	RS-A	3
	Cost	RS-A	9
	Volume	RS-A	-3
	Identity	RS-A	3
PRODUCT D	Functional	RS-A	3
	Quality	RS-A	3
	Cost	RS-A	1
	Volume	RS-A	3
	Identity	RS-A	9



Importance/weighting		RS-B	3
Action		APS	3

7. Industry Forces

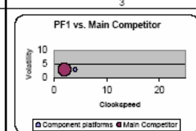
Rivalry Level		RS-B	9
Barriers to Entry		RS-C	9
Bargaining Power of Buyers		RS-B	3
Bargaining Power of Suppliers		RS-B	9
Substitute Threat		RS-B	3
Threat of Disruptive Technologies		RS-B	9
		Industry Situation	



Importance/weighting		RS-B	0
Action		APS	2

8. Market Volatility vs. Clockspeed & Inertia

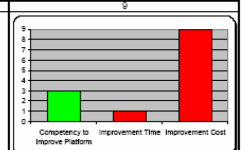
Clockspeed / Level of Innovation		YEARS	4
Main Competitior Clockspeed		YEARS	2
Inertia Level		RS-B	1
Main Competitor's Inertia Level		RS-B	9
Inertia reason		IRS	F
Maturity Level		MLS	Aging
Volatility (threat of changing tastes)		RS-D	3
		Volatitlity / Clockspeed / Inertia	



Importance/weighting		RS-B	3
Action		APS	0

9. Internal Platform Competency

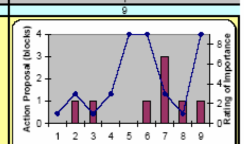
Competency to Improve Platform		RS-B	3
Improvement Time		RS-D	1
Improvement Cost		RS-B	9



Importance/weighting		RS-B	9
Action		APS	1

10. SUMMARY

0. PF Type	0	APS	C1
1. Fulfillment of Platform Goal	1	APS	0
Importance/ Weighting		RS-B	1
2. Alignment to CAS	2	APS	1
Importance/ Weighting		RS-B	3
3. Internal Side Effects of Platforms	3	APS	1
Importance/ Weighting		RS-B	1
4. External Side Effects of Platforms on Market	4	APS	0
Importance/ Weighting		RS-B	3
5. Markets view of the Platform	5	APS	0
Importance/ Weighting		RS-B	9
6. Platform Match to Derived Products	6	APS	1
Importance/ Weighting		RS-B	9
7. Industry Forces	7	APS	3
Importance/ Weighting		RS-B	3
8. Market Volatitlity vs. Clockspeed & Inertia	8	APS	1
Importance/ Weighting		RS-B	1
9. Internal Platform Competency	9	APS	1
Importance/ Weighting		RS-B	9



OVERALL SUPPORT TO THE CAS		RS-B	3
OVERALL NEED FOR CHANGE		RS-B	3
OVERALL POTENTIAL TO CHANGE		RS-B	1
OVERALL IMPORTANCE IN GENERAL		RS-B	3
FINAL ACTION PLAN RECOMMENDATION		APS	1

Figure 4. Example for steps 6 to 10 of the PAMatrix. The component platform "C1" is analyzed.

5 Interpreting PAMatrix

By displaying together a group of platform critical measures, matching them together, and assessing their effect, a relatively strong indicator of platform performance is made possible. The intermediary step-wise action plans facilitate the creation of an overall strategic action plan by breaking down into smaller "pictures" the status for each platform.

Furthermore, due to the classification of platforms, benchmarking is made possible, facilitating the transport of knowledge within the field of platform strategy.

In praxis, the PAMatrix should be used as a discussion-based tool to 1) make the platforms apparent and create common understanding, 2) facilitate a meaningful discussion of the platform's current situation as well as need and potential to change, and 3) derive a strategic action plan based on discussion's and expert opinion.

6 Conclusions and further research

For managers and other stakeholders, the ability to comprehend a large amount of complex information in a relatively short amount of time is of key importance. A company has a number of platforms that are in effect the core foundation of value creation. The industry needs a method to assess the platforms in a standard way, to be able to make better strategic decisions regarding what action plans for each individual platform. This is the main purpose of the PAMatrix method. In essence it has primarily 5 functions:

1) Capture and create a common understanding of a company's diverse platforms
2) Assess a multitude of factors that affect or are affected by these platforms
3) Grade how well the platforms align with the competitive advantage strategy
4) Facilitate an understanding of how the individual platforms should be improved
5) Create an arena for stakeholders to discuss-, create a common understanding of -, and make decisions regarding a company's platforms

The PAMatrix should preferably be displayed in a way that enables all stakeholders to simultaneously view it – e.g. by using a projected or printed graphic representation. Stakeholders should use the depiction as a discussion tool, and be able to cognitively bond findings, modify values, and enter remarks.

An important aspect of the method is that it should not be elusive, but at the same time not so detail oriented that the overview is lost. It is a strategic decision support tool, using the tacit and explicit data and information captured within the company.

The PAMatrix method is still in development. It is an attempt to approach the request of the industry to be able to assess *what* and to which *extent* a company should reuse its core assets. The method is not meant to be a foolproof guide to managing platforms; it will not provide any direct suggestions, but rather should serve as a mapping technique to comprehend a vast amount of information in a systematic way, and so serve as a decision support tool for stakeholders. The basic assumption is made that the company already has a large amount of information regarding the reuse of core assets; it is simply a matter of systematically gathering the information together in a cognitively ergonomic way.

The method has not been validated yet, but a number of case studies in diverse industries are in the pipeline to do this. It will be tested in workshop forums, where a number of cross functional experts will give their qualitative assessment on their company's platforms. We believe that for the purpose of creating a better overview of a company's reuse of assets, it is very useful, and certainly better than using 2-3 simple indicators, cognitively *locked* in the minds of a small group of stakeholder.

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Paper E

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Using the Platform Assessment Matrix in Praxis: Empirical Studies

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Abstract

The Platform Assessment Matrix (PAMatrix) method is developed to increase a company's holistic understanding of platforms in the context of engineering design in order to improve competitive advantage. The basic idea is that by systematically gathering subjective information from a group of cross functional stakeholders, and later jointly discussing the findings, a more insightful understanding is enabled – supporting strategic decision making regarding a platform.

The paper describes studies made in three different companies, where the PAMatrix is used and iteratively modified in accordance to feedback from the users. Furthermore the benefit of the method for the companies is assessed.

A number of iterations were made and we find that while the method still has a need for improvement, the basic concept is both novel and beneficial for the companies that tested it. A majority of the participants in the study found that the method enabled a systematic analysis of the platforms, supported cross-functional communication, and increased the understanding of the platforms – it was an eye-opener to the status of the platform from previously unconsidered perspectives.

Future research is needed to further develop the method in terms of lessening its complexity, and adjusting the viewpoints used for different industries to enable universal use.

Keywords: Product Platform Assessment, Product Platform Management, Product Platform Decision Support, Product Platform Case Studies

1 Introduction

A major part of developing a family of products is in defining the mutual platform they should have. This can be a difficult task as it includes considering a multitude of factors that are in their nature diverse and often contradictory; e.g. that the platform should enable cost savings through economies of scale, but at the same time it should enable the creation of a number of attractive products that entice the customer to purchase. Studies have shown, that companies often lack a profound understanding of their platforms in their specific context [1] and that in general, work on evaluating platforms is restricted to developing a couple focused criteria to assess [2].

The Platform Assessment Matrix (PAMatrix) has been developed to enable companies to increase the understanding of their platforms – in order to support decision making. In Figure 1, the PAMatrix is displayed. In previous papers, the logic for the method [3-5] – as well as a detailed description of the process [6] – have been explained. In a nutshell, a group of cross-functional stakeholders first individually grade a platform based upon a series of viewpoint (steps 1 to 8 in the illustration below), and then mutually discuss the findings – first reaching a common profound understanding of the situation and then deciding upon a strategic action plan to follow in regards to the specific platform.

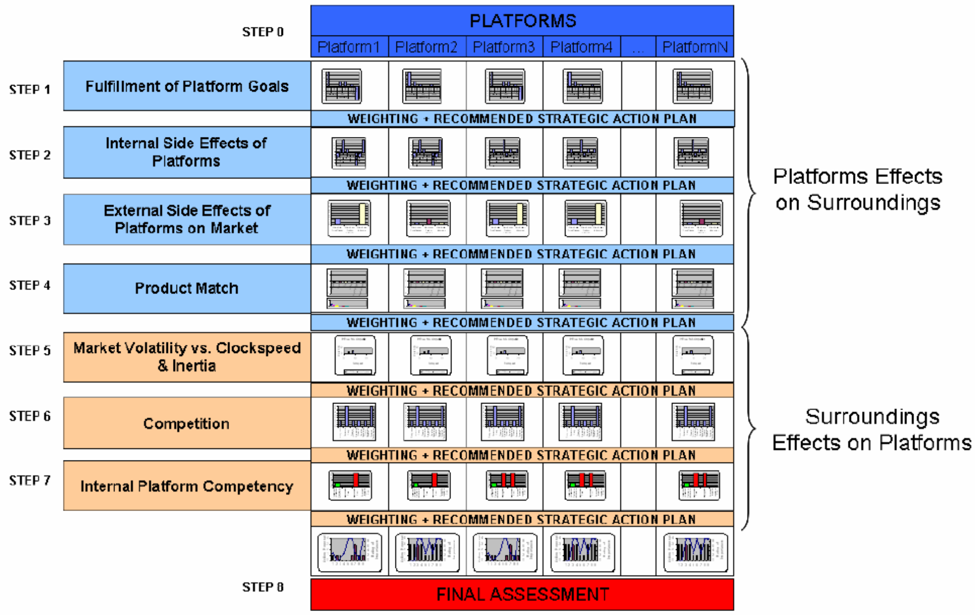

Figure 1. An overview of the Platform Assessment Matrix

2 Case studies

The purpose of the case studies was to iteratively improve the PAMatrix method, as well as assess the value of the method for the participating companies.

Three companies were chosen for the study: TANDBERG Video Conferencing, Rolls Royce Marine and Marel (Table 1). The companies chosen all develop "highly engineered" products and have wide product family ranges.

Table 1. An overview of the companies used in the case study

Company	Location	Platform	Contact person	Industry
TANDBERG Video Conferencing	Oslo, Norway	MXP Codec	Market Research Manager	Stand-alone Video Conferencing equipment
Rolls Royce Marine	Ulsteinvik, Norway	Helicon-X	Technical Manager	Marine Propulsion
Marel Ltd.	Gardabaer, Iceland	3D Computer Vision	Head of Research and Development	Food processing equipment for fish, poultry, and meat

2.1 Preparing the Studies

At each of the companies, contact persons were identified that had a good understanding of their company's products and authority to pull together a cross-functional team of participants. At each company a platform was chosen by the contact person and first author, which was considered of key importance to create a competitive advantage for the company, and that varyingly fulfilled the target criteria (functionality, quality, cost, etc.) of its derived products.

The first author carried out the individual interviews in closed settings at company locations. Later, the results were presented and discussed by the participants. After the completion of the study, a 2-page survey with 10 questions (Figure 7) was sent by e-mail to the participants to be filled out and resent by e-mail.

In the following sections the studies at each company are described and analyzed.

2.2 TANDBERG Video Conferencing, Norway

TANDBERG Video Conferencing is a leading global provider of video systems and services that help companies and organizations fill the visual communication gap that exists today.

Together with the contact person, "MXP" was chosen as a platform to observe. The MXP platform includes state-of-the-art MXP codec hardware that supports a feature-rich environment, the TRC3 remote control, screen interface, and proprietary software based on established standards (Figure 2). The MXP platform had only recently been launched.

Figure 2. The MXP platform includes the interface to the customer, i.e. screen layout, remote control, codec hardware and proprietary software based on established standards

The MXP platform was at the time of the study used in 8 products – listed in Figure 3.

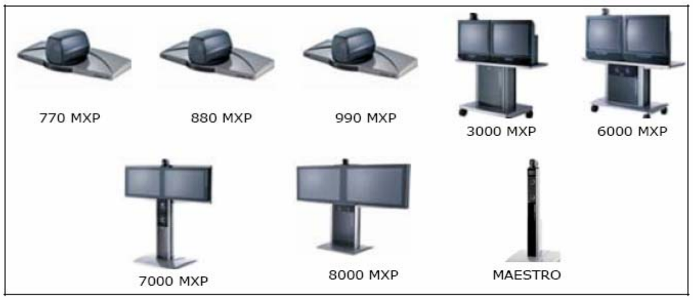

Figure 3. An overview of the products using the MXP platform at TANDBERG

The case study took place at the TANDBERG headquarters in Oslo. 6 stakeholders (4 men and 2 women) where first individually interviewed, after which a workshop was held with all participants. The stakeholders originated from product development, customer service, training, and sales & marketing. As manufacturing is outsourced at TANDBERG, no representatives originated from logistics, operations, or procurement.

Interviewing process:

- As many of the concepts used in the method were new to the interviewees, the interviewer had to clarify and explain these. This took quite a long time of the process.
- Difficulty to assess weighting of importance
- Obviously difficult questions for the stakeholders that they had spared little/no thought previously
- Importance of platform to sell the product was found to be missing and therefore added into “Step 4: Product Match” of the PAMatrix (Figure 1)

Workshop

Due to the busy schedules of the participants of the study, the workshop was first held 5 weeks after the interviewing. In the workshop, the results were presented and discussed. A good deal of the discussion focused around the match of the platform to the product range. Here it became apparent that most of the stakeholders believed that the platform did not manage to differentiate well enough between the low range and mid range products. Furthermore, that the main differentiation between mid and high range was found to be due to aesthetics, unrelated to the platform.

Survey

In Figure 7 the results of the survey are shown. Some of the comments regarding the method:

- It was useful that the group consisted of a mix of people with different responsibilities and tasks
- The group was probably not optimal for the study; it might have been more useful for a group with direct impact on R&D development, cost evaluation, production strategy etc.
- The PAMatrix method made me more aware of the other aspects around the platform, i.e. not just the features, functions and benefits.
- For the method to be better in supporting concrete decision making, design and “emotional appeal” are of key importance. This would give a better holistic picture.

- This was not an activity I do often so it was kind of new and maybe little bit out of my league – compared to my job. But it gave me lots of new views and awareness on our platform
- Some of the questions where too complex

Conclusion

There was some confusion as the platform contained software and hardware elements that had different clockspeeds/lifecycles. This caused some uncertainty of how too answer. As participants from manufacturing were missing from the study, the mix of people for the study was sub-optimal. To answer the questions in the method, some background material is needed. It turned out that the 5 weeks break between the interviewing process and workshop was too long; the participants had almost forgotten the background details and therefore had a harder time discussing the viewpoints.

As mentioned earlier, slight iterations were made.

The stakeholders found that the greatest benefit of the method was to view the platform systematically and to improve cross-functional cooperation. 50% characterized their understanding of the platform as "slightly improved understanding", while 50% as "much improved understanding."

2.3 Rolls Royce Marine, Norway

The Rolls-Royce marine business is a global leader in marine propulsion, engineering and hydrodynamic expertise, with a broad product range and full systems integration capability.

Together with the contact person "Helicon-X" was chosen as a platform to observe. The Helicon-X platform is a remote control system for propulsion systems (Tunnel Thrusters, Azimuth Thrusters, and Main propulsion pods) and gears. It supports functions such as pitch control, RPM control, load control, and fixed pitch reductions. In Figure 4 we can see an overview of the system. It includes hardware and software and the panel interface in the bridge and engineer control room.

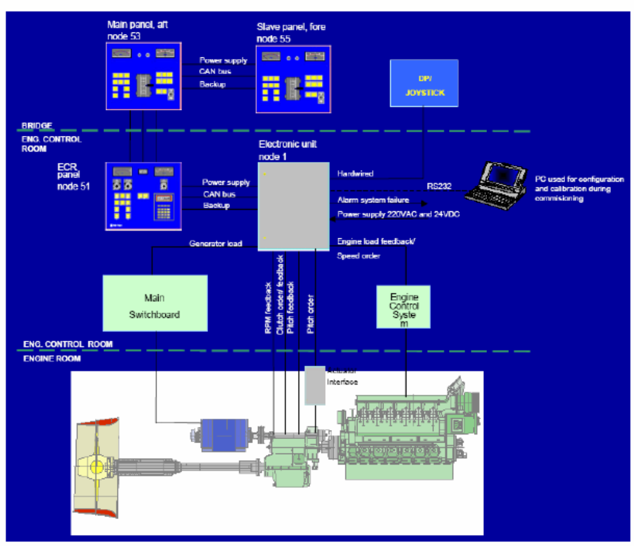

Figure 4. A schematic overview of the Helicon-X platform

In contrary to the MXP platform at TANDBERG, the Helicon-X platform is used simultaneously for a number of products. In Figure 5 we see an overview of some of the products/product families that use the platform.

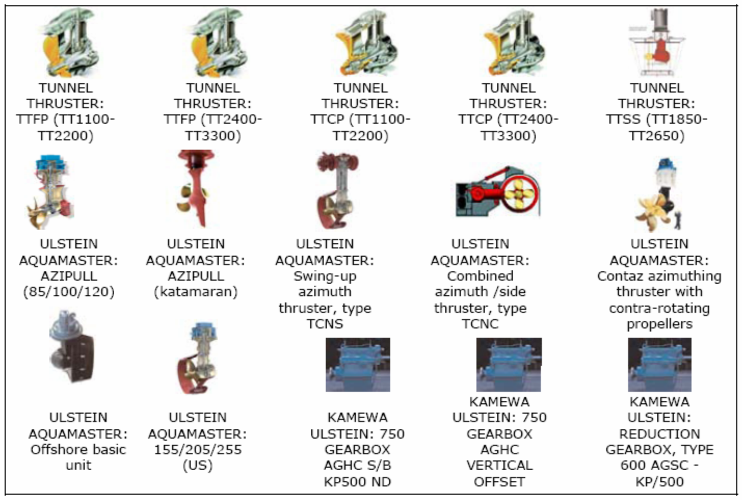

Figure 5. An overview of products that use the Helicon-X platform

The case study took place at two Rolls Royce Marine sites on the Norway's West Coast, in Ulsteinvik and Longva. 7 stakeholders (6 men and 1 women) where first individually interviewed, after which a joint workshop was held. The stakeholders originated from research, product development, manufacturing, internal sales, and service.

Interviewing process:

- As many of the concepts used in the method were new to the interviewees, the interviewer had to clarify and explain these. This took quite a long time of the process.
- Difficulty to assess weighting of importance
- Slight iteration of Step 2: Internal Side Effects" based on feedback

Workshop

In the workshop, the results were presented and discussed. Many were surprised of the level of agreement of issues. Amongst the focus points in the discussion were that the Helicon-X interface was considered by some as out dated – *"it had a 70's look and feel to it*."

Furthermore, the platform is more important for segments that require dynamic positioning, e.g. offshore, and less important for steady long journeys, e.g. cargo transport.

A phase out of the platform was already in the pipelines and the method caught the imagination of the stakeholders to map the future replacing platform and other platforms. The production manager even suggested using the method to assess the tools used in assembly.

Survey

In Figure 7 the results of the survey are shown. Some of the comments regarding the method:

- The method gives a possibility (or forces you) to structure and to be concrete at a rather visible level.
- The method improves the communication and interfaces between the different stakeholders.

Conclusion

72% of the participants felt that the ability to communicate the platform was better than before. This was ranked as the main benefit of the method.

The participants originated from different sites and fields and compared to TANDBERG, there was a greater benefit in terms of being able to cross-functionally discuss the platform.

It was found that the method did not sufficiently identify the need to change platforms based on the viewpoints. This was perhaps due to the fact that competition was not well known and the platform was by many not considered to create a competitive advantage[1], therefore, for many it was not considered being a crucial platform to sell the products. Due to this, a KANO effect evaluation was included into the "Step 5: Market Volatility vs. Clockspeed and Inertia"-viewpoint. This enables a better understanding of the potential that the platform can deliver to the customer in regards to "excitement".

2.4 Marel, Iceland

Marel manufactures solutions for use in all major sectors of the food processing industry. The product range includes scales and graders, flowlines, intelligent portioning machines and software systems as well as turn-key solutions for larger plants.

Together with the contact person, "3D Computer Vision" was chosen as the platform for observation. 3D Computer Vision includes 1 or 2 cameras, hardware and proprietary software. It automatically evaluates each piece (poultry, fish or meat) before cutting, and then calculates the most economic cut configuration based on parameters pre-selected by the production manager.

The platform is used in a range of portioning machines for the different industry segments (fish, poultry, and meat). In addition it is planed to be used for 2 grading machines (Figure 6), as well as a machine not included in the paper due to confidentiality reasons.

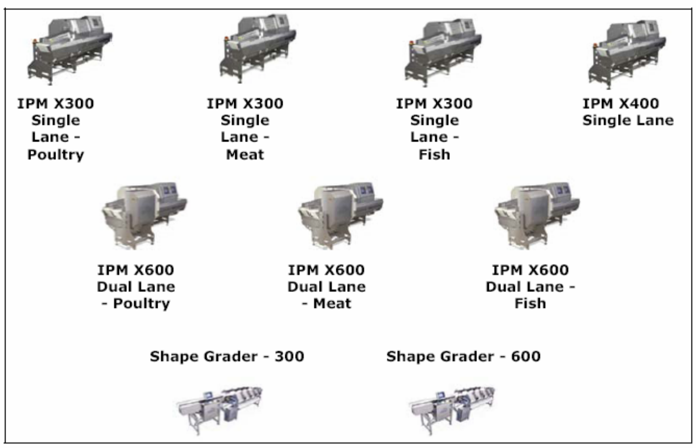

Figure 6. An overview of the products using the 3D Computer Vision

[1] This although the definition of a platform is that it is a collection of assets that are reused over a family of products to create a competitive advantage

The case study took place at the Marel headquarters in Iceland. 4 stakeholders (all men) where first individually interviewed, after which a joint workshop was held. The stakeholders originated from research & product development, manufacturing, sales, and service.

Interviewing process:

- As many of the concepts used in the method were new to the interviewees, the interviewer had to clarify and explain these. This took quite a long time of the process.
- Difficulty to assess weighting of importance

Workshop

In the workshop the results were discussed. Two points were of special interest: 1) the functionality of the platform was suboptimal for meat-cutting, and 2) using the platform for a planned product[2] might cause unwanted cannibalization.

The participants found that the method was useful to evaluate the potential for new products. One of the participants specifically requested a simpler version that did not require the background knowledge.

Survey

In Figure 7 the results of the survey are shown. Some of the comments regarding the method:

- Seems to be helpful to decide how good a platform is
- I thought the method was a bit to complex first time around at least. Especially deciding upon Importance/weighting. This would probably change after having used the method a couple of times.
- [The method] is comprehensive and includes many issues. It gives a good overview of the current situation.
- The method would be beneficial for companies like Marel to support decision making on the products [based on a platform]

Conclusion

Marel is expanding rapidly and has not had time to think of platforms in a strategic way before. The method therefore addresses a need to better understand the platform; e.g. in terms of the importance of differentiation and the threat of cannibalization.

In Figure 7 the, the results from the surveys are summed up. 50% of Tandberg's and Marel's participants, and 72% of Rolls Royce's participants, found that the method increased platform understanding "slightly", while 50% Tandberg's and Marel's participants, and 14% of Rolls Royce's participants, found that it increased platform understanding "much." 14% of Rolls Royce's participants found that it increased platform understanding "greatly."

While TANDBERG found the methods main benefit lay in creating a systematic way to discuss the platform, Rolls Royce found that its main benefit lay in facilitation of cross-functional cooperation, and finally Marel found that its main benefit lay in facilitation of cooperating cross-functionally and also in improving decision making regarding the platforms.

Other results can be found in Figure 7.

[2] Due to confidentiality reasons the product is not included in the paper

Results of Survey of effect of using the PAMatrix:

1. Do you feel that your understanding of the platform has improved after using the PAMatrix?
(PLEASE MARK WITH X)

	TB	RR	M
Not at all			
Slight improved understanding	3/6=50%	5/7=72%	1/2=50%
Much improved understanding	3/6=50%	1/7=14%	1/2=50%
Great improved understanding		1/7=14%	

2. In case you find that the understanding has been improved, how would you characterize your potential to make decisions on the platform now, compare to before using PAMatrix?
(PLEASE MARK WITH X)

	TB	RR	M
The same as before			
Slightly better than before	5/6=83%	3/7=43%	1/2=50%
Better than before	1/6=17%	3/7=43%	1/2=50%
Much better than before		1/7=14%	

3. How would you describe your ability to communicate the platform (i.e. discuss the platform with colleagues)?
(PLEASE MARK WITH X)

	TB	RR	M
The same as before	1/6=17%		
Slightly better than before	3/6=50%	1/7=14%	
Better than before	1/6=17%	4/7=72%	1/2=50%
Much better than before	1/6=17%	1/7=14%	1/2=50%

4. In the following question, please answer whether, and then to what degree, you have thought of the platform in relations to the following factors.
(PLEASE MARK WITH X)

	No	A bit	Some-what	Much	Very much
The main purpose of the platform	0/0/0	1/1/0	2/4/0	1/1/1	1/1/1
The internal side-effects of a platform	0/0/0	3/0/0	2/4/2	0/2/0	0/1/0
The external side-effects of a platform	0/0/0	2/0/0	2/5/2	1/1/0	0/1/0
How well the platform matches the products that use the platform	0/0/0	2/0/0	0/4/1	2/2/1	1/1/0
How well the platform fits the market in reference to market volatility, platform inertia and the platform clockspeed/lifecycle	0/0/0	1/1/0	1/4/1	3/1/1	0/1/0
How competitive the platform is	0/0/0	0/1/0	0/3/0	3/2/2	2/1/0
How competent the company is in improving/changing the platform	0/1/0	1/0/0	0/3/2	2/2/0	2/1/0

5. Did the results come as a surprise to you in terms of:
(PLEASE MARK WITH X)

	No	A bit	Some -what	Much	Very much
the level of disagreement on issues regarding the platform	3/4	2/2	1/1		
the level of agreement of issues regarding the platform	1/1	2/3	3/2	0/1	

6. How would you characterize the benefit of using the method?
(PLEASE MARK WITH X)

	TB	RR	M
None			
Some	5	2	1
A lot	1	4	1
Huge		1	

7. In what respect was the method helpful?
(PLEASE RANK 1-5)

	TB	RR	M
In improving the understanding of the platform	3	3-5	3
In creating a systematic way to discuss the platform	1	3-5	6
In getting people to cooperate cross functionally	2	1	8
In decreasing misunderstanding	4	3-5	5
In improving decision making regarding the platform	5	2	8

8. How would you describe the time needed to use the method?
(PLEASE MARK WITH X)

	TB	RR	M
Less than expected	1		
As expected	5	7	
More than expected			

9. How would you describe the complexity of the method?
(PLEASE MARK WITH X)

	TB	RR	M
Less than expected		1	
As expected	2	5	
More than expected	4	1	

Figure 7. The survey sent to the participants of the case study

3 Results and comments

In all cases the participants of the studies found that there was an improved understanding of the platform by using the method – although the degree of increased understanding was debated. Depending on the company, the method promoted different focuses; while in one company the main discussion was centered on the match of the platform to its derived products, in another company the discussion mainly focused on the threat of cannibalization if a low cost version would be introduced based on the same platform.

In one case the platform investigated was of little interest as the decision had already been made to out phase it; instead the method captured the imagination of the participants to be use for a potential platform and even to investigate the use of a range of tools.

While one company found that the main benefit was that it enabled cross-functional stakeholders to communicate better, another company found that the main benefit lay in its novel approach to systematically observe a platform. A number of stakeholders found the method to be too complex while others found it to be as expected.

In response to the feedback from the participants of the study, some iteration was made to improve the method.

It was found that as the method is quite complex, it is important to have the workshop a relatively short time after the interviewing process.

4 Key conclusions

The aim of the PAMatrix method is to improve the understanding of a company's product platforms. The objective of the case studies was twofold: First of all, to validate whether the users felt the method managed to improve their understanding of the platform, and second of all to iteratively improve the method based on feedback.

After trying the method in 3 companies and interviewing 20 people, we find that the key conclusion is that the suggested method to evaluate platforms is novel and considered useful by the industry. It is however clear that it still has a large potential for improvement – perhaps it might be made less complex, perhaps it could be visually improved to facilitate the comprehension of data, or perhaps it could consider other viewpoints.

Future research could focus on such improvement. One important aspect to examine is whether how a number of platforms interact with each other and what effect this has on a products attractiveness. Another research area would be to assess whether the method can be use universally, i.e. for all industries.

Furthermore, to improve the ability to make concrete decisions on how to manage the platforms, it is necessary to view other platforms used in the products and how they interact with each other.

Although the method has been received well by the industry, we can still ask whether it is the method itself, or merely the "forced" dialog between stakeholders that improves the understanding. Would e.g. using quality function deployment

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APPENDIX B: SURVEY RESULTS

Of the in total 19 participants (7 from TANDBERG, 8 from Rolls Royce, and 4 from Marel), 16 returned in the surveys. One participant did not answer question 4.

Below follow the results from the surveys.

1. ***Do you feel that your understanding of the platform has improved after using the PAMatrix?***

   (Number of participants/Total number of participants)

	TANDBERG	Rolls Royce	Marel
Not at all			
Slight improved understanding	3/6=50%	5/7=72%	1/3=33%
Much improved understanding	3/6=50%	1/7=14%	2/3=67%
Great improved understanding		1/7=14%	

2. ***In case you find that the understanding has been improved, how would you characterize your potential to make decisions on the platform now, compare to before using PAMatrix?***

   (Number of participants/Total number of participants)

	TANDBERG	Rolls Royce	Marel
The same as before			
Slightly better than before	5/6=83%	3/7=43%	1/3=33%
Better than before	1/6=17%	3/7=43%	2/3=67%
Much better than before		1/7=14%	

3. How would you describe your ability to communicate the platform (i.e. discuss the platform with colleagues)?

(Number of participants/Total number of participants)

	TANDBERG	Rolls Royce	Marel
The same as before	1/6=17%		
Slightly better than before	3/6=50%	1/7=14%	1/3=33%
Better than before	1/6=17%	5/7=72%	1/3=33%
Much better than before	1/6=17%	1/7=14%	1/3=33%

4. In the following question, please answer whether, and then to what degree, you have thought of the platform in relations to the following factors.

(TANDBERG/Rolls Royce/Marel)

	No	A bit	Some -what	Much	Very much
The main purpose of the platform	0/0/0	1/1/1	2/4/0	1/1/1	1/1/1
The internal side-effects of a platform	0/0/0	3/0/1	2/4/2	0/2/0	0/1/0
The external side-effects of a platform	0/0/0	2/0/1	2/5/2	1/1/0	0/1/0
How well the platform matches the products that use the platform	0/0/0	2/0/1	0/4/1	2/2/1	1/1/0
How well the platform fits the market in reference to market volatility, platform inertia and the platform clockspeed/lifecycle	0/0/0	1/1/1	1/4/1	3/1/1	0/1/0
How competitive the platform is	0/0/0	0/1/1	0/3/0	3/2/2	2/1/0
How competent the company is in improving/changing the platform	0/1/0	1/0/1	0/3/2	2/2/0	2/1/0

5. ***Did the results come as a surprise to you in terms of:***

(TANDBERG/Rolls Royce/Marel)

	No	A bit	Some-what	Much	Very much
the level of disagreement on issues regarding the platform	3/4/1	2/2/2	1/1/0		
the level of agreement of issues regarding the platform	1/1/0	2/3/2	3/2/0	0/1/1	0/0/0

6. ***How would you characterize the benefit of using the method?***

(Number of participants/Total number of participants)

	TANDBERG	Rolls Royce	Marel
None			
Some	5/6=83%	2/7=29%	2/3=67%
A lot	1/6=17%	4/7=57%	1/3=33%
Huge		1/7=14%	

7. ***In what respect was the method helpful?***

(Ranking of importance – 1 being of higher importance than 5)

	TB	RR	M
In improving the understanding of the platform	3	3-5	1-3
In creating a systematic way to discuss the platform	1	3-5	4
In getting people to cooperate cross functionally	2	1	1-3
In decreasing misunderstanding	4	3-5	5
In improving decision making regarding the platform	5	2	1-3

8. How would you describe the time needed to use the method?

(Number of participants/Total number of participants)

	TB	RR	M
Less than expected	1/6=17%		1/3=33%
As expected	5/6=83%	7/7=100%	2/3=67%
More than expected			

9. How would you describe the complexity of the method?

(Number of participants/Total number of participants)

	TB	RR	M
Less than expected		1/7=14%	1/3=33%
As expected	2/6=33%	5/7=72%	1/3=33%
More than expected	4/6=67%	1/7=14%	1/3=33%