

Congruence between Product Strategy and Manufacturing Strategy

-A framework for collaborative development

A Licentiate thesis

by

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ABSTRACT

Today's industries face an increasing global competition. Decision makers have to deal with different kinds of uncertainty, a complex business ecosystem, a high pace of change, and an unforgiving market when less than best decisions are made. One, among many others, approach that can lead to these better decisions is to have a strategy.

The objective of this research is:

"To design a model that supports the formulation of product strategy and manufacturing strategy in accordance to each other and thereby facilitate and encourage continuous communication and collaboration between product development and manufacturing system development."

To help meet the objective, three chapters of frame of reference are presented; Strategy, development processes and design for X. The frame of reference together with discussions in industry (ITT Flygt) has in an iterative manner lead to a suggested model that supports the formulation of product strategy and manufacturing strategy.

Future research will improve, evaluate and validate both the usability of the model and the results from using it in practise. A method for using the model will be developed.

The research project presented in this licentiate thesis is one of seven parallel research projects with a shared objective – to develop systematic working procedures, a generic decision model and decision sub models that support the practical design of a workshop that supports the business strategy of the company.

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Further, my acknowledgement goes to all participants within the α -program, former and present. To Mårten Tyrén at ÅF for inspiring meetings in the early stages of this research. To my industrial reference group, Kristina Stenberg and Johan Bratthäll and Jan Larsson, thank you for listening to me and your patience. To Patrik Kenger for showing true enthusiasm in doing research, some has really infected me.

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Niklas Tjärnberg

Stockholm, spring 2006

EARLIER PUBLICATIONS

Results of this work have been published earlier in the following media:

Axelson, D., Gröndahl, P., Hägg, A., Jackson, M., Karlsson, K., Milic, M., Sjöberg, M., Tjärnberg, N: *a-Programmet – systematisk utformning av konkurrenskraftiga produktionssystem*, Woxénrapport nr. 39, TRITA-IIP-04-006, ISSN 1650-1888, KTH Royal Institute of Technology (Title in English, The α-program – systematic design of competitive production systems), 2004

Tangen, S., Tjärnberg, N: *Strategin i fokus – del 7, Produktstrategin som konkurrensmedel*, Tidskriften Bättre produktivitet, Nr 1, 2006

CONTENTS

ABSTRACT	I
ACKNOWLEDGEMENT	II
EARLIER PUBLICATIONS	IV
BSTRACT I CKNOWLEDGEMENT II ARLIER PUBLICATIONS IV ONTENTS V INTRODUCTION AND RESEARCH AREA 1 1.1 THE IMPORTANCE OF CONGRUENCE BETWEEN PRODUCT STRATEGY AND MANUFACTURING STRATEGY 1 1.2 PROBLEM DESCRIPTION 4 4 1.2.1 The shortage of support from existing knowledge and methods 4 4 1.2.2 The need for better input in decision making 5 5 1.3 SCOPE OF THE THESIS 7 7 1.3.1 Research objective 7 1.3.2 Research questions 9 1.3.1 Research questions 9 9 1.3.3 Delimitation 9 1.4 DISPOSITION 9 RESEARCH APPROACH 11 2.1 IN THE CONTEXT OF A RESEARCH PROGRAM 11 2.1.1 The a-program 11 2.1.1 The a-program 11 2.1.2 Industrial relevance 12 2.1.3 Academic relevance 12 2.1.4 Structure of the a-program 12 2.2 SCIENCE AND ENGINEERING 13 2.3 RESEARCH METHODS 14 2.3.1 Printed quest	
1 INTRODUCTION AND RESEARCH AREA	1
STRATEGY AND MANUFACTURING STRATEGY 1.2 PROBLEM DESCRIPTION 1.2.1 The shortage of support from existing knowledge and methods. 1.2.2 The need for better input in decision making. 1.3 SCOPE OF THE THESIS 1.3.1 Research objective. 1.3.2 Research questions. 1.3.3 Delimitation.	4 5 7 7
2.1 IN THE CONTEXT OF A RESEARCH PROGRAM 2.1.1 The a-program 2.1.2 Industrial relevance 2.1.3 Academic relevance 2.1.4 Structure of the a-program 2.2 SCIENCE AND ENGINEERING 2.3 RESEARCH METHODS 2.3.1 Printed questionnaire 2.3.2 Semi-structured personal interviews 2.3.3 Action research 2.4 WORKING PROCEDURE 2.4.1 The a-program, its initiation, verification and validation 2.4.2 Project procedure	1112121314141516
3 STRATEGY	
3.1 INTRODUCING STRATEGY	20

3.3.1 Generic competitive strategies	23
3.4 MANUFACTURING STRATEGY	
3.4.1 The content of manufacturing strategy	25
3.4.2 The process of manufacturing strategy	28
3.5 PRODUCT STRATEGY	
3.5.1 Competitive strategy	30
3.5.2 Platform strategies	30
4 DEVELOPMENT PROCESSES	35
4.1 BUSINESS PROCESSES	35
4.2 CHARACTERISTICS OF A DEVELOPMENT PROCESS	36
4.2.1 Development process model	37
4.3 THE PHASE REVIEW PROCESS	40
4.4 PORTFOLIO MANAGEMENT	
4.4.1 Linking strategy to the portfolio	42
5 DESIGN FOR X	44
5.1 CLASSIFICATION OF DFX	45
5.1.1 Design guidelines	45
5.1.2 Stand-alone evaluation tools	46
5.1.3 CAD integrated evaluation tools	47
5.1.4 CAD/CAPP based evaluation tools	47
5.2 DESIGN FOR MANUFACTURING	
5.2.1 Design for existing environment	49
5.2.2 Potential with DFA	
5.3 THE USE OF METHODS IN PRODUCT DEVELOPMENT	51
6 SUGGESTING A MODEL	53
6.1 THE CONTENT OF THE MANUFACTURING STRATEGY	53
6.2 THE PROCESS OF THE MANUFACTURING STRATEGY	54
6.2.1 Analysis of the requirements	55
6.2.2 Analysis of the present state	
6.2.3 Continuous improvement or radical change	55
6.2.4 Analysis of the future state	
6.2.5 Decision of carrying through	57
6.2.6 Project planning	57
6.2.7 Accomplishment	
6.3 THE CONTENT OF THE PRODUCT STRATEGY	
6.4 THE PROCESS OF THE PRODUCT STRATEGY	
6.4.1 Requirements on the product portfolio	
6.4.2 New product proposals	
6.4.3 Product development process	
6.4.4 Product portfolio	
6.4.5 Reengineering or product deleting	60

7 CONCLUSIONS	61
7.1 SUMMARY	61
7.2 CRITICAL REVIEW	62
7.3 FUTURE RESEARCH	63
8 REFERENCES	65

1 INTRODUCTION AND RESEARCH AREA

The purpose of this chapter is to describe the background and objective of the presented research. The chapter starts with pointing out the importance of using strategies when developing products and production systems. This is followed by a presentation of the problem area that leads to the objective, the research questions and the delimitation of this thesis. The chapter is concluded with the disposition of the thesis.

1.1 The importance of congruence between product strategy and manufacturing strategy

Business executives, project leaders and managers have to deal with different kinds of uncertainty, a complex business ecosystem, a high pace of change, and an unforgiving market when less than best decisions are made. The winning businesses in today's innovation economy are those that are able to consistently make faster and better decisions than their competitors. One, among many others, approach that can lead to these better decisions is to have a strategy. One way to think of a strategy is to see it as basically a high level decision on positioning and direction – a decision that establishes a clear framework for subsequent decisions. When looked at it this way, it becomes clear that strategy and decision-making cannot be separated.

On the top level of strategy, business strategy, Porter more than 25 years ago introduced the competitive strategy (Porter, 1998). Competitive strategy is described as taking offensive or defensive actions to create a defendable position in an industry, to cope successfully with the competitive forces and thereby yield a superior return on investment for the company. Porter identified and presented three generic strategies for creating such a defendable position;

Strategic Advantage

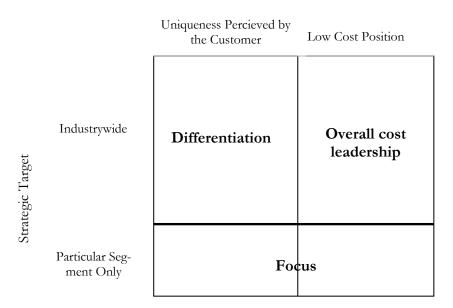


Figure 1 Generic competitive strategy (Porter, 1998)

The three generic strategies are: Overall cost leadership, differentiation and focus. They differ regarding to what strategic advantage and target they are aiming at, which is illustrated in Figure 1 and further discussed in chapter 3. Porter states that a company failing to develop its strategy in at least one of the three directions – a company that is "stuck in the middle" – is in an extremely poor strategic situation.

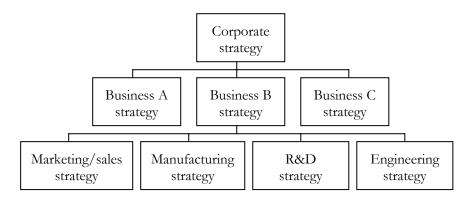


Figure 2 Levels of strategy (modified from Hill, 2000 and Hayes and Wheelwright, 1984)

Both Hill (2000) and Hayes and Wheelwright (1984) define different levels of strategy, see Figure 2. There are some differences between the authors' number of levels and the nomenclature, but common for them is the use of functional strategies, which are found below the business strategy level. There are several areas that need functional strategies, for example: research and development, engineering, marketing and manufacturing. Different functional strategies might be involved depending on the company structure and organisation. To be effective, each functional strategy must support, through a specific and consistent pattern of decisions, the competitive advantage being sought by the business strategy. Companywide debate rarely concerns how the functional strategies fit together. Hill (2000) makes note in this:

"Congruence is assumed and is given credence by the use of broad descriptions of strategy that, instead of providing clarity and the means of testing fit, wash over the debate in generalities"

A generalized formulated strategy gives no direction and could be applied on a random company, and that company could easily strive at a direction no one wants.

It is believed within this research that an increased congruence between product strategy and manufacturing strategy will support companies to be competitive in the long run. Competitiveness can be defined into five more specific dimensions (Ulrich and Eppinger, 2000):

- Improved product quality: Is the product resulting from the development effort robust and reliable? Does it satisfy customer needs? Product quality is ultimately reflected in market share and the price that customers are willing to pay.
- Decreased product cost: What is the manufacturing cost of the product? This cost includes spending on capital equipment and tooling as well as the incremental cost of producing each unit of the product. Product cost determines how much profit accrues to the firm for a particular sales volume and a particular sales price.
- Shorter development time: How quickly did the company complete the
 development effort? Development time determines how responsive the
 company can be to competitive forces and to technological developments,
 as well as how quickly the company receives the economic returns from
 the development efforts.
- Decreased development cost: How much did the company have to spend to develop the product? Development cost is usually a significant fraction of the investment required to achieve the profits.

Increased development capability: Is the company better able to develop
future products as a result of their experience from a development project? Development capability is an asset that the company can use to develop its products more effectively and economically in the future.

Of course there are far more criterions than an increased congruence between product strategy and manufacturing strategy involved. Though, this research is focused on the above with an overall vision that the results will actually stimulate a more long-term view on the companies' competitiveness. This would be achieved by communication and collaboration between product development and manufacturing system development.

1.2 Problem description

As stated in the first section of this chapter, companies stand before many uncertainties and the main issue is to be and stay competitive. One way to reach and maintain the competitiveness is to formulate and work actively with strategies that can be implemented by the functional departments of the company. It is not only vital to have the strategies; there must also be accordance between the different functional strategies. When looking at manufacturing industry environments it is rather clear that the product strategy and the manufacturing strategy are the ones closest to the core area. This problem description is presented in two sections, representing the two main problem areas:

- 1. Shortage of support form existing knowledge and methods
- 2. Need for better input in decision making.

1.2.1 The shortage of support from existing knowledge and methods

Research and industry have for a long time tried to find out how to manage the integration issues. There are many ways to attack the issue of gaining a more integrated way to work. Concurrent Engineering (CE) is a concept that was introduced in the late 1980's. CE is sometimes put equivalent in meaning to integrated product development and in this research it was found that they are more or less two ways of expressing the same thing. CE can be seen as an organizational mechanism to overcome the barriers and induce a collaborative environment (Haque, 2002). One of the most original and most quoted definition of CE is provided by the Institute of Defence Analysis (Winner et al., 1988):

"Concurrent engineering is a systematic approach to the integrated concurrent design of products and their related processes including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life from conception through disposal including quality, cost, schedule and user requirement."

A part of this approach is the development and use of different methods. In the last 25 years research and industry have been trying to put the approach of CE into practice. The number of methods is large and they are varying in focus and degree of applicability. In Haques (2002) in-depth study of three companies the findings were that although the barriers to concurrent new product development were different for each of the three companies, but the organisational factors causing them were more or less the same. The root cause being the organisational factors, resulting in poor integration or concurrence of functions or processes (Haque, 2002).

To aid the product development process some companies have implemented a stage-gate framework, as a high-level representation or the activities required. Such a framework allows the development process to be closely monitored and controlled, using stages of work and review gates. The stage-gate format is quite common in most industries today (Philips et al., 1999). In this research it is believed that this is not enough to help in the continuous collaboration and communication between product development and manufacturing system development, at least not for the kind of companies which is in focus within this research, see further section 1.3.

1.2.2 The need for better input in decision making

Decisions within development are by nature insecure. If someone knew what the future looks like he/she could be unlimited successful. Decisions are made both within projects and by managers being responsible for the project portfolio. As stated earlier, strategy and decision-making cannot be separated. The positioning and direction should be given by the strategy, helping and guiding decision-making.

A company's products have for long been seen as a competitive factor, but it was first in the late sixties that the manufacturing function was mentioned within the academic world as a competitive factor. The article "Manufacturing strategy – missing link in corporate strategy" by Skinner (1969) pointed out the importance of making the manufacturing function a competitive weapon. A manufacturing strategy contains a number of decision areas. When formulating a manufacturing strategy, a pattern of strategic decisions has to be made within these decision areas that align a number of competitive priorities (Skinner, 1969), (Hayes and Wheelwright, 1984), (Hill, 2000). The process of strategy formulation, following a top-down approach, can be described in five steps as shown in Table 1. Derived from the business strategy, the corporate objectives and the marketing strategy are defined in step one and two. To support the development of the manufacturing strategy, also defined as operations strategy (Hill, 2000), the third step is about defining the order qualifying- and winning priorities. The decision is often divided

in structural and infrastructural decisions (Slack et al., 2001), (Hill, 2000) and (Hayes and Wheelwright, 1984). This is where many

strategy researchers conclude their work, but this is not enough though, regarding those who have to design, to plan and to detail the manufacturing system in order to make it a strategic support to the company's way of doing its business. When formulating and implementing a manufacturing strategy in a workshop environment, the existing models tend to be insufficient (Axelson et al., 2004).

Step 1	Step 2	Step 3	Step 4	Step 5
Corporate objec-	Marketing strat-	How do products	Manufacturing strategy	
tives	egy	qualify and win orders in the marketplace?	Process choice	Infrastructure
Growth Survival Return on investment Other financial measures	Product markets and segments Range Mix Volumes Standardization versus customization Level of innovation Leader versus follower alternatives	Price Quality conformance Delivery speed, reliability Demand increases Colour range Product range Design Brand image Technical support After-sales support	Choice of alternative processes Trade-offs embodied in the process choice Role of inventory in the process configuration Make or buy Capacity Size, timing, location	Function support Manufacturing planning and control systems Quality assurance and control Manufacturing systems engineer- ing Clerical procedures Compensation agreements Work structuring Organizational structure

Table 1 Linking manufacturing with corporate marketing decisions (Hill, 2000)

Product strategies involve many different questions and it is hard to be sure that it is complete if only taking one or a couple of aspects in regard, it is multi-dimensional with many links to other strategies. As seen in Table 1, issues concerning the products and their design appear, or should appear, in all of the five steps. Decisions in product development affect different aspects of the manufacturing system, e.g. workshop and cell lay-out, machine and tooling design, control principles, internal and external logistics, competence requirements, product and variant flexibility, and volume flexibility. Of course, decisions during manufacturing system development affect various product characteristics. Aganovic (2004) states, as a topic for future research, exploring this general conceptual dependency and to develop a method for proactive consideration of manufacturing system

issues during product development and vice versa. The word "proactive" is in this research interpreted as being ahead and that's what strategies should be.

1.3 Scope of the thesis

A summary of the problem description is given by the following three critical points:

- Lack of collaboration between product development and manufacturing development in practise
- Lack of support for collaboration on strategic level
- Strategies are often poorly formulated in practise

It is not possible to state that this is a general problem present in all companies and organisations. As an example this research is not focused on automotive industries where product development often includes delivering a complete manufacturing system or at least the assembly line with the new model. Rather this research addresses companies involved in mixed manufacturing, companies dealing with many products and variants shifting in volume and with different kinds of customers. Another characteristic for this kind of company is relatively long product life cycles and that product development is not only concerned with developing new products but also developing existing products further.

1.3.1 Research objective

Given the insight of importance of having, and using, strategies and the difficulties in making accordance between the functional strategies; product strategy and manufacturing strategy, the aim of this research is to explore these aspects. The main objective is:

"To design a model that supports the formulation of product strategy and manufacturing strategy in accordance to each other and thereby facilitate and encourage continuous communication and collaboration between product development and manufacturing system development."

This objective includes that the model should emphasize the requirements on the business strategy of the company to support the formulation of the product strategy and the manufacturing strategy. In this thesis the model will be developed both from the frame of reference, presented in chapters 3-5, and from empirics. Further improvement, evaluation and validation of the framework will be done in the forthcoming doctoral thesis. The objective is also visualized in Figure 3 below.

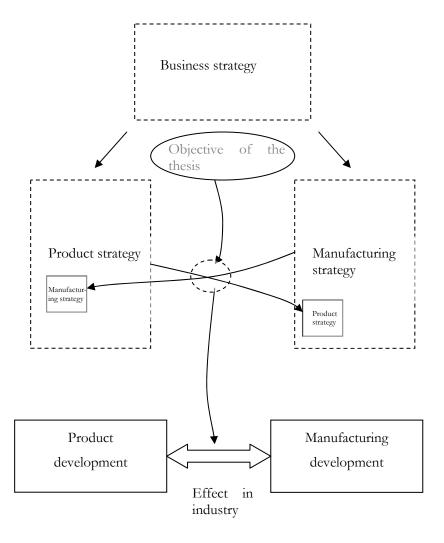


Figure 3 Visualization of the objective of this thesis: To design a model that supports the formulation of product strategy and manufacturing strategy in accordance to each other and thereby facilitate and encourage continuous communication and collaboration between product development and manufacturing system development.

1.3.2 Research questions

In order to fulfil the objective two research questions are formulated. They have been guiding the research and the frame of reference is focused to answer the questions. They are:

Research question 1

What content should a product strategy have to support the formulation of the manufacturing strategy and thereby the manufacturing development function?

Research question 2

What content should a manufacturing strategy have to support the formulation of the product strategy and thereby the product development function?

It is most likely that there will be at least one more research question added in the future research in the doctoral part of the work.

1.3.3 Delimitation

More as given prerequisites than delimitation is the philosophy of concurrent engineering and integrated teams performing in the innovation processes in a company. There are many supporting processes, methods and tools in the area of supporting concurrent engineering. Of course more can be done within that field but this research focuses more on making progress in the input for managers and the integrated team making decisions when conducting development work, i.e. the aim is not to develop a method or tool like those described in chapter 5.

This thesis focuses on the relationships between product strategy and manufacturing strategy. The "chain" of strategies is mentioned only to make a holistic view possible. Further are the issues with *implementing* a strategy left out in this research.

1.4 Disposition

This thesis is divided in 7 chapters, logically collected in 3 parts as illustrated in Figure 4. The first two chapters introduce this research and also provide information about the context of this research, the methods used and the working procedure. The practitioner primarily interested in applications for practise is encouraged to read this initial chapter and then continue directly to chapter 6. Chapter 3 to 5 contains the theoretical frame of reference for this thesis. Chapter 6 and 7 are focused on the results in the licentiate thesis, discussion of the results and plans for future research in the doctoral part of this work.

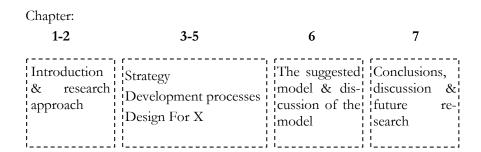


Figure 4 Structure of the thesis

2 RESEARCH APPROACH

The research project presented in this licentiate thesis is one of a number of projects integrated in a research program. The author wants to highlight the difference between the research program and the research project behind this thesis. The initial section is a presentation of the research program and its industrial and academic relevance. Further, the difference between science and engineering is discussed. This is followed by research methods used in this research. Finally the working procedure of this research is presented.

2.1 In the context of a research program

This research project is a part of a larger research program, called the α -program¹. This section will describe the program, involved parttakers and the objective of the program.

2.1.1 The α -program

The program is dealt with by a group consisting of industrial partners and Ph.D. students within WoxénCentrum at the Royal Institute of Technology (KTH) and the Department of Innovation, Design and Product Development (IDP) at Mälardalen University (MdH). Seven sub projects are currently running, focused on different problem areas as well as the generic scope of the research program.

Based on a number of PhD students working in parallel, the objective of the research program is to:

"Develop systematic working procedures, a generic decision model and decision sub models that will support the practical design of a workshop that supports the business strategy"

¹ A full description of the program is published in a Woxén-report (Axelson et al, 2004). It provides a theoretic foundation within manufacturing strategy, an industrial survey, positioning of the program in the research field, the program's common definition of manufacturing strategy and a program description.

2.1.2 Industrial relevance

In order to confirm the industrial relevance of the research program, a survey was conducted to a number of persons, working in manufacturing companies in Sweden. Further, to underline the results from the survey, an in depth interview study has been performed that comprised four companies. The conclusions from the studies are that only a minor part of the companies seems to have an implemented manufacturing strategy. Further, the companies that have one use it only in a limited extent when developing their manufacturing systems. The studies also show that companies seem to need more useful strategies than just "visions on a power point slide". They need strategies that can be communicated down through the hierarchical levels. The studies and their results are described in section 2.3.

2.1.3 Academic relevance

Another study was conducted to see if there are other universities or institutes that deal with the same issues as the α -program. The investigation is not claimed to cover all universities in the world. Still the following points seem to make the program unique:

- The fact that this kind of research is performed at a technical university instead of at a business school, which is most common.
- Strategy formulation within the α-program is based on what information work shop designers need to practise the strategy, not the management.
- The α -program's definition of a manufacturing strategy.

2.1.4 Structure of the α -program

Table 2 gives the supervisors, project manager, PhD students and their sub projects.

KTH = Royal Institute of Technology

MdH = Mälardalen University

Supervisor	Founder/University	Supervising
Peter Gröndahl	WoxénCentrum/KTH	Niklas Tjärnberg, Daniel Axelson, Kenneth Karlsson, Magnus Sjöberg
Mats Jackson	ABB/MdH	Anna Andersson, Anette Brannemo, Milun Milic
Project manager		
Stefan Tangen	WoxénCentrum/KTH	

Student	Founder/University	General project topic	
Niklas Tjärnberg	ITT Flygt AB / WoxénCentrum, KTH	Congruence between product strategy and manufacturing strategy	
Anna Andersson	Volvo Construction Equipment, Components / MdH Design of efficient logistics thr regional collaboration		
Daniel Axelson	WoxénCentrum / KTH Manufacturing system layout organisation design		
Anette Brannemo	Volvo Construction Equipment, Strategic rightsourcing decident Components / MdH Strategic rightsourcing decident within production system		
Kenneth Karlsson	Alfa Laval / WoxénCentrum, KTH	Manufacturing system flow design	
Milun Milic	ABB / MdH	Relationships to information systems	
Magnus Sjöberg	WoxénCentrum / KTH	Automation decisions	

Table 2 The actors in the a-program

2.2 Science and engineering

When performing research within the focus of this project it is essential to have the difference between science and engineering in mind. The difference can be explained in the following way (Braha and Maimon, 1997).

- Engineers are concerned with how things ought to be (normative aspects), while nature science concerns itself solely with how things are (the descriptive aspects).
- Engineering is concerned with synthesis while natural science is concerned with analysis.
- Engineering is creative, intuitive and spontaneous while natural science is rational and analytic.

A complementary, and maybe more comprehensive, view is that improvements must be derived from science and adapted to the practice. When improvements originate from practice, they must be inserted and absorbed into the science.

The research presented in this licentiate thesis can be placed in the borderland between science and engineering, often called applied research. The work has been carried out in collaboration between industry and academy, with an industrial PhD student performing the work. Although this is not a conflict, both interests have to be satisfied. The results must be of practical use for the industry and also of scientific relevance.

The focus in this thesis is to build a frame of reference from which a theoretical decision model can be developed. The literature review is guided by the research

questions provided earlier in chapter 1. The next step in this research, the Ph.D. part, will focus on verifying and validating the model.

2.3 Research methods

In order to reach the objective the need for structure is essential. This section provides and motivates the steps taken in order to reach the objective. This research has been financed by ITT Flygt. They, together with the other industrial parties involved in the α-program identified the need for this research. All along this research project there has been a continuous dialog with the industry, securing that assumptions, results and focuses are aligned with their needs. Of course, since a major part of this thesis is built by a frame of reference, much of the research presented here is based on literature studies. Previous research is reviewed to create a solid theoretical foundation. The studied literature includes books, research papers and journal articles as well as articles in other printed media and on the internet. Another motive for the literature research is to, by reviewing previous research, develop sharper and more insightful questions about a topic (Yin, 1994). Before and in parallel with the literature studies interviews and discussions with industry where held. This was done in order to ensure that this research corresponds to the actual need. The working procedure, going from theory to empirics (within the industry) in an iterative manner is described in section 2.4.

2.3.1 Printed questionnaire

This approach aims to assess and compare responses of questions setup in advance. Questions asked in the questionnaire should be unambiguous and easy to understand. The questionnaire may contain multiple choice alternatives, which should clearly be related to the question (Westlander, 2000).

The printed questionnaire conducted in the α -program was sent to a number of persons within Swedish industry. The purpose with the questionnaire was to indicate the need for this research program. Another purpose was to investigate to what extent manufacturing companies in Sweden formulates and communicate their manufacturing strategies.

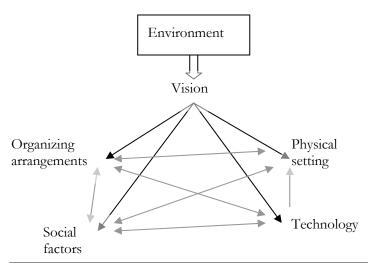
2.3.2 Semi-structured personal interviews

Interview aims at gathering descriptions of reality from the interviewee. Qualitative interviews are primarily made to describe a phenomenon (Westlander, 2000). In the program initiation, verification and validation phase a number of semi-structured personal interviews were conducted in order to strengthen the conclusions drawn in the printed questionnaire. Of course they also gave some deepened information about the interviewees and their company's outlook on manufacturing strategy. Two researchers at each company, writing two subscripts and making

cross-functional comparisons and analysis directly afterwards, performed the interviews.

2.3.3 Action research

Action research as a science is young, but several different approaches within the discipline do exist. Kurt Lewin is regarded to be the father of action research. He formed a research discipline which principal aim was to help the practitioner. Behind Lewins argumentation for action research lays values on a better society, better working life, and the way spells better cooperation (Westlander, 1999). The action researcher is sited in a complex, ever changing and interacting world. As the researcher is a part of this world, he/she affects the results derived from the research. Unlike the natural scientist, he/she can not work with fixed variables in a real life situation. The setting to be studied is built up from several interacting variables; see Figure 5.



Organizing arrangements	Social factors	Physical setting	Technology
Goals	Culture	Space configura- tion	Tools, equip- ment, and ma- chinery
Strategies	Management style	Physical ambiance	Information technology
Structure	Interaction proc- esses	Interior design	Job design
Administrative policies and procedures	Informal patterns and networks	Architectural design	Work flow design
Administrative systems	Individual attrib- utes		Technical expertise
Reward systems			Technical procedures
Ownership			Technical systems

Figure 5 Factors constituting the organizational work setting (Porras & Robertson, 1992)

2.4 Working procedure

The working procedure is illustrated in Figure 6 and further described in the following two sections. The first of them, section 2.4.1, describes the working procedure is illustrated in Figure 6 and further described in the following two sections.

dure in the α -program. After that the working procedure of this research project is presented.

2.4.1 The $\alpha\text{-program},$ its initiation, verification and validation

- 1. Industrial representatives identified the need to be more systematic when designing improved/new production systems. Discussions between academics and industrial representatives initiated a pre study, which resulted in the start up of the α -program.
- The α-program was formed and PhD students where step by step included, both industrial PhD's and classic (employed by Woxéncentrum/KTH). The research objective, research questions and principal deliverables for the program where formulated.
- 3. A literature study on manufacturing strategy was conducted within the program. The purpose was to create the common literature base for the program and to find evidence in the literature that this research topic was academically relevant.
- 4. To find support for the industrial relevance, a questionnaire was conducted.
- 5. In order to strengthen the findings in the survey, an interview study was made at four companies.
- 6. step 3-5 resulted in the final structure of the program, a definition of manufacturing strategy and what role this project has in the common framework (Axelson et al., 2004)

2.4.2 Project procedure

- 7. The founder of the research project behind this thesis (ITT Flygt) identified the need in focusing on the coupling between the product and the manufacturing system. The area was then narrowed down and finally formulated and verified both at ITT Flygt and in existing theory.
- 8. A literature study on product strategy was made.
- In parallel to step 8 and 10, interviews, discussions and workshops on links between product strategy and manufacturing strategy was made/held in order to catch practical experience and issues that are crucial.
- 10. A literature study on the use of strategies in development processes was made.

11. The suggested model gradually evolved from experience captured and also aligned to the literature study.

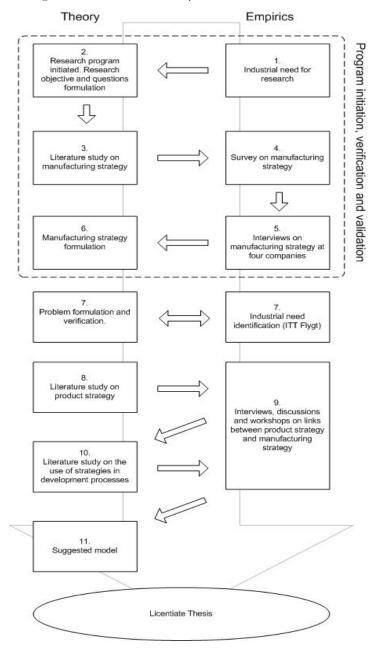


Figure 6 Working procedure

The first chapter in this frame of reference is an attempt to describe strategy, its history, and the functional strategies; product strategy and manufacturing strategy.

3.1 Introducing strategy

To formulate and implement strategies that support corporate objectives and that are in harmony with other prevailing strategies in a company is a complex issue. This work is concerned with the difficulties in making accordance between the functional strategies; product strategy and manufacturing strategy.

After having searched and read a lot of material concerned with formulating and implementing strategies, the following reflection is made. Official stories of strategic issues and the evolution of companies are to a large extent initiated and controlled by top management. Descriptions of how strategy formulation and implementation have been carried out in a goal-oriented and clear-minded way are not unusual. The picture normally presented is one in which the management, with farsighted decisions and strong actions, guides the company toward success. This picture is strengthened by a continuous flow of superficial stories in the commercial press. The same tendency to stress deliberate strategies and create a feeling of managerial potency can also be found in cases and textbooks used in business policy courses.

It is not unlikely that the history of "a success case" is somewhat embellished in retrospect. One could argue whether it really was an explicit decision that was put into action and brought about a deliberate transformation of "the success company". In fact, few would object to call this the pursuit of a strategy. Nevertheless, the notion of strategy certainly does not have an unequivocal definition. Strategy is a subject that has engaged numerous people in writing during at least four decades, academics as well as practitioners. The subject strategy has been given new dimensions over time. The meaning of strategy has undergone a process of evolution where new perspectives on strategy have been added while existing ones have never been possible to leave out of account. As a consequence, there is an abundance of meanings of the notion strategy which in turn has depreciated the value of the concept: to say that something is strategic does not have to mean more than that it is important in general terms. Also, as a consequence for the author of this thesis the collection and sorting of knowledge was very hard and sometimes frustrating.

3.2 The evolution of strategy

From the perspective held in the early works on strategy, a transformation of "a success company" would certainly be seen as a consequence of the intervention of "the visible hand" of management (Chandler, 1962). The assumption made in these accounts is that strategies and consequences are tightly linked, as if managerial intentions can be smoothly translated into organisational outcomes. For example, Chandler (1962) depicts some convincing stories of how prominent industrial leaders have proactively led their companies to successful positions and great earnings. Many such descriptions can be judged as reconstructions where the rational causalities between actions and results are mere ex post rationalisations. Nevertheless, nourished by Chandler and others, the belief in strategy as a management's tool to move a company in a deliberate and desired direction led to the emergence of rigorous strategic planning systems in many companies during the 1960s and 1970s (Weimarck, 2000).

As it became evident that there are discrepancies between planned strategies, i.e. the directions, goals and actions prescribed in strategic plan documents, and realised strategies, i.e. what become the actual behaviour and position of the company, the belief in rigorous strategic planning systems faded. Instead, a view arose in which the future was regarded as difficult to predict and favourable positions unlikely to be reached through purposeful management decisions and actions.

The approach to strategy development and execution has traditionally tended to focus on either positioning or execution – concepts that have formed the basis for the dominant schools of strategic thinking over the past two decades (Fuchs et al., 2000). The positioning groups have been shaped by the competitive analysis school of Porter (see also section 3.2.1) and his followers, while the execution groups reflect the thinking of the resource based, re-engineering and dynamic competency theorists. Strategy is not just positioning or execution. It is both.

Thus, the perspective on strategy, from a theoretical point of view, has changed significantly during recent decades but some things remain clear and constant over time. First, that there is a need for establishing a long-term direction of companies. Second, that managers with a long-term responsibility, which only few do not have, perceive that they are recurrently being confronted with crucial choices between arrays of indistinct and vague alternatives of action, with the future of entire companies sometimes at stake.

3.3 Different views of strategy

Virtually everyone writing on strategy agrees that no consensus on its definition exists. Perhaps as a consequence of the broad scope of strategy research, more or less explicitly and consciously, different authors hold different perspectives on the

meaning of strategy. One spectrum of perspectives on strategy is presented by Weimarck (2000). His discussion is limited to three distinct positions in the spectrum, i.e. the middle and the two extremes.

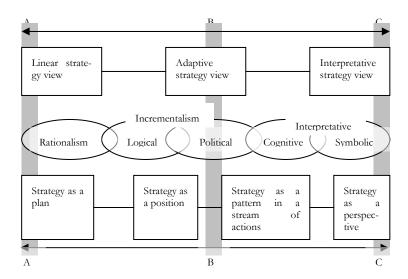


Figure 7 The spectrum of perspectives on strategy (Weimarck, 2000)

Perspective A implies that managers are behaving rational, focusing on making plans. They evaluate possible actions against explicit goals and identify solutions that are likely to achieve these goals. Chandler's (1962) definition of strategy agrees with this perspective:

"Strategy is the determination of the basic long-term goals of an enterprise, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals".

The decision-making process can be described as: managers identify their goals, generate alternative methods to achieve them, weigh the likelihood that alternative methods will succeed, and then decide which ones to implement.

Perspective B sees strategy as a matter of evolution and needs to be understood in terms of the activities that managers undertake to cope with an uncertain and complex environment. Managers are monitoring the environment and making changes simultaneous, i.e. coping with the current situation rather than with an anticipated future.

Perspective C is based on a social contract and assumes that reality is socially constructed and there is no such thing as an objectively observable reality. The interpretative strategist deals with the environment through symbolic actions and

communication. Corporate core values, visions and missions are used to communicate the strategy and should guide the individuals in their daily work.

It is the author's opinion that one can not only use one perspective when dealing with strategy. It is also believed that perspective C is used commonly and that the visions and missions are not always enough guidance for the individuals.

Another way of classifying strategy is the nine main distinct schools in strategic thinking defined by Henry Mintzberg (Ashish & Kemp, 2003):

• The design school – strategy as processes of conception

Strategy is prescribed to be deliberate in nature and strategy formation is regarded as a process of conscious thought. The chief executive officer is responsible; he/she is thereby the main strategist. Strategy formation should be kept simple and informal.

• The planning school – strategy as formal processes

Strategy is prescribed to be the controlled, conscious processes of formal planning, decomposed into distinct steps, each delineated by checklists and supported by techniques.

• The positioning school – strategy as analytical processes

Strategy is prescribed to focus on strategies that are generic, specifically common, identifiable, positions in the marketplace. The marketplace is perceived to be economic and competitive. Analysts play a major role, feeding the result of their calculations to managers who officially control the choices.

• The entrepreneurial school – strategy as visionary processes

Strategy is described to be processes existing mainly in the mind of the leader. Strategies are thereby believed to be specifically about a sense of long-term direction, a vision of the enterprise future.

• The cognitive school – strategy as mental processes

Strategy is described to be cognitive processes that take place in the mind of the strategist. Strategies emerge as concepts, maps, schemas, and frames – that shape how people deal with inputs from the environment.

• The learning school – strategy as emergent processes

Strategy is described to be processes of learning over time, in which formulation and implementation activities are intertwined and indistinguishable in nature.

- The power school strategy as processes of negotiation
 Strategy is described to be mainly shaped by power and politics, whether
 - as a process inside the enterprise itself or as the behaviour of the enterprise as a whole within its external environment.
- The cultural school strategy as collective processes
 - Strategy is described to be processes of social interaction, based on the beliefs and understandings shared by the members of an enterprise. An individual acquires beliefs through a process of acculturation, or socialisation, which is largely tacit and nonverbal.
- The environmental school strategy as reactive processes
 Strategy is described to be mainly about responding in a natural manner with the corporate external environment.

As with any classification, there is a certain danger in trying to put ideas and concepts into a number of boxes. It can lead to oversimplification. However, this classification of strategies hopefully contributes to a deeper understanding of how strategy systems are perceived and how they function.

3.3.1 Generic competitive strategies

Porter's three generic strategies are, as mentioned in chapter 1(see Figure 1):

- Overall cost leadership
- Differentiation
- Focus.

The background to these generic competitive strategies is a structural analysis of industries. When relating a company to its environment, social as well as economic forces must be regarded but the key aspect of the company's environment is the kind of industry or industries in which it competes (Porter, 1998). The intensity of competition within an industry segment is neither a matter of coincidence nor bad luck. Rather, competition in an industry is rooted in its underlying economic structure and goes well beyond the behaviour of current competitors. Porter states that competition in an industry segment depends on five basic competitive forces, shown in Figure 8.

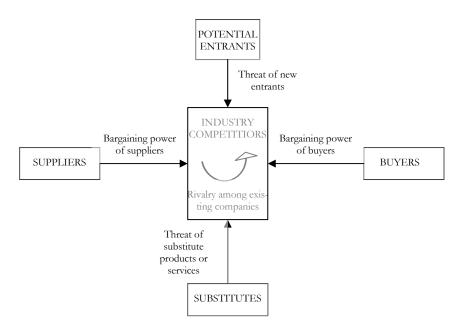


Figure 8 Forces driving industry competition (Porter, 1998)

Porter argues that it is not only the industry that is important, but also the grounds and nature of competition. This competition is provided by rivalry between existing companies, the threat of potential entrants and substitute products and the bargaining power of buyers and suppliers. The generic strategy adopted will offer the organisation three ways of coping with these forces and achieving sustainable competitive advantage. According to the theory, every business needs to adopt one of these strategies in order to compete, and there are real dangers for a company that engages in more than one, or fails to undertake any with authority – i.e. stuck in the middle.

It is questioned if Porters theory on generic competitive strategies is valid. In a case study the theory is tested on the Swedish heavy truck company Scania (Nilsson & Dernroth, 1995). The findings are that Scania can be argued to pursue all of Porter's generic strategies. Advocating any one of these generic strategies as Scania's was easy. What was difficult was excluding the others. In Porter's terms, Scania is definitely stuck in the middle and has been so during a considerable time span. Contrary to Porter's prediction, they perform well above average performance within their kind of industry segment. One can argue that it might be possible to create better generic strategy taxonomy than Porter's by adding dimensions, thus making the net finer. Nilsson and Dernroth (1995) think that this does not address the real problem. The author of this thesis agrees. Making the net finer will just relocate the problem. The real problem is related to the multi-dimensional

characteristic of strategy and when forcing strategy into a "to few-dimensional" net problem occurs.

3.4 Manufacturing strategy

After having given a brief run-through of strategy it is time to move down through the levels of strategy to the functional strategies in focus; manufacturing strategy and product strategy. The concept of manufacturing strategy has earlier been described by others within the α -program, agreeing in its history, its use and formulation of manufacturing strategy has been done in collaboration. Therefore, manufacturing strategy will only be described in short and more space will be given to describe product strategy in section 3.4.

The α -program's definition of manufacturing strategy is:

A company's long-term development plan from a current state to a planned future state, within a specific period. It should further be a written document, containing specified headings and standardised information modules. To be useful, the manufacturing strategy must include at least the following four parts:

- 1. Objectives and constraints
- 2. Current state
- 3. Planned state
- 4. How the planned state will be achieved practically

The basis is that the manufacturing strategy is a practical tool, useable in radical changes or incremental changes which require a revised manufacturing strategy (Axelson et al., 2004).

Notable is the separation into content of a manufacturing strategy and the process of formulating and implementing it.

3.4.1 The content of manufacturing strategy

The content of the manufacturing strategy can be divided into (Dangayach and Deschmukk, 2001):

- Manufacturing capabilities
- Strategic choices
- Best practices

One of the first to pay attention to the importance of manufacturing strategy was Skinner, 1969. He published a well known and quoted article in Harward Business

Review, "Manufacturing – missing link in corporate strategy". His opinion was that manufacturing is generally perceived in the wrong way at the top management level, managed in the wrong way at the plant level, and taught about in the wrong way in the business schools. In his studies he found top executives delegating excessive amounts of manufacturing policy to subordinates, avoiding involvement in most production matters. This led to failing to ask the right questions until the company is in obvious trouble. Skinner explains this pattern to be due to a combination of two factors:

- 1. A sense of personal inadequacy, at the top executives, in managing production.
- A lack of awareness among top executives that a production system inevitably involves trade-offs and compromises and must be designed to perform a limited task well, with that task defined by corporate strategic objectives.

Skinner suggested a top-down approach, meaning that every decision made at lower levels should be based on directives from higher levels in the company, including business strategy.

Competitive priorities

Skinner's concept of the "manufacturing task" has subsequently been elaborated into competitive criteria, competitive priorities, order-winners and other variations on this theme (Spring and Dalrymple, 2000). In this research four competitive priorities are chosen, partly because the same are chosen in the research program (α -program) and partly because they are the ones sustainable in the evolution of competitive priorities (Axelson et al., 2004), (Spring and Dalrymple, 2000), (Garvin, 1993). These are:

- Cost,
- Quality,
- Delivery,
- Flexibility,

Garvin (1993) identified some weaknesses with using only these four competitive priorities; cost, quality, delivery, and flexibility. They are too highly aggregated for direct decision making. He claims they are broad and generic categories with a multitude of possible interpretations. Garvin's integrated framework for manufacturing strategic planning includes a disaggregation stage. This is the process of refining the traditional priorities into narrower, more focused categories. Cost can be divided into initial cost, operating cost and maintenance cost. Quality can be

divided into: performance, features, reliability, conformance, durability, service-ability etc. Flexibility can be divided into three major categories: flexibility to volume changes, to product changes and to process changes. Finally, delivery can be divided into categories as accuracy, speed and ease of ordering.

It is important to point out that when deciding upon which disaggregated priorities to use one should be precise and address the actual customer's needs. For this reason, it is suggested to begin with a market research.

The concept of order-winners and order-qualifiers

As mentioned earlier, it is important to avoid broadly based strategies with unclear statements. Without a certain level of clarity, executives will walk away from the strategy debate with their own idea of which dimension of a particular priority that is the most critical to the business. This argument with Skinner's thoughts of trade-offs is used to express the competitive priorities in order winning criteria and order qualifying criteria (Hill, 2000). He argues that there is a need to distinguish differences as part of the strategy formulation and that it is the manufacturing's task to recognize and apply the concept of order-winners and qualifiers.

- **Qualifiers** are those criteria that a company must meet for a customer to even consider it as a possible supplier.
- Order-winners are those that win the order.

It is argued by many researcher quoting both Skinner and Hill that the concept of order winners and qualifiers is the same as the competitive priorities adopted in much other manufacturing strategy literature. Spring and Boaden (1997) claims the unlike, that they really are different.

Decision areas

A manufacturing strategy also consists of a number of decisions areas. Again Skinner (1969) was the pioneer and described five decision areas, namely:

- Plant and equipment
- Production planning and control
- Labour and staffing
- Product design/engineering
- Organisation and management

Numerous authors have modified his statement. Hayes and Wheelwright (1984) divided the areas (categories as they call them) into structural and infrastructural

decisions. Capacity, Facilities, Technology and Vertical Integration are viewed as structural to their nature because of their long-term impact. They are difficult to reverse or undo once they are in place and they require a substantial capital investment to alter or extend. Workforce, Quality, Production planning/materials control and Organisation are considered more tactical to their nature. They are linked with specific operating aspects of the business and they generally do not require highly visible capital investments.

In Table 1 Hill's (2000) separation into process choice and infrastructure is found, step four and five. Step four provides the appropriate processes to manufacture the company products; step five provides the infrastructure to support the processes.

Within the α -program we have chosen eight decision categories within the scope of research. See Table 3.

Decision categories	Meaning
Facilities	Size, location, specialisation
Capacity	Capacity plan for future demand
Process choice	Equipment, automation, linkages, layout
Vertical integration	Direction, extent, balance
Quality	Prevention of defects, quality tools and methods
Organisation	Structure, salary system, control system
Manufacturing planning and control	Resource planning and control, material planning and control
Introduction of new products and processes	The development of, and linkage between, new products and processes

Table 3 Chosen decision categories within the a-program

3.4.2 The process of manufacturing strategy

In this thesis process is broadly defined as the pattern in which manufacturing strategies are developed. Basically there are two modes of procedure to follow when developing a manufacturing strategy: market based or resource based process. The market approach is the most common and is based on that the production supports the way that the company wins its orders. A well-known method is Hill's (2000) framework, earlier shown in table 1. Advocators to the resource based approach claim that it is more profitable to focus on developing, protecting, and leveraging a company's unique operational resources and advantages in order to change the rules of competition (Gagnon, 1999).

It appears that what the literature offers within this process is mostly broadly defined processes, leaving much out for the reader/user to decide by himself. The author's reflection to this is that the detailed process is very company unique. And even, there may be more than one appropriate process for manufacturing strategy development for one company (Swamidass et al., 2001).

3.5 Product strategy

As the concept of manufacturing strategy the product strategy is very wide and many different views exist regarding what it is. In this thesis the focus is on the physical product and its development, meaning that marketing issues are left out. The thought of finding interaction points between manufacturing and product development has always given direction when wondering whether or not found material; research, papers, articles etc, is essential for this work. A sometimes used term is product plan and it is often related to a process, more explicitly than in literature regarding manufacturing strategy.

The product strategy process takes place before a product development project is formally approved, before substantial resources are applied, and before the larger development team is formed (Ulrich and Eppinger, 2000). In a company investing relatively a lot in product development with many projects running and also many projects waiting to start the product strategy process should be continuous. As with any other investment an organization strives to maximize the effectiveness of its product development efforts. First considering the set of potential projects it might pursue, deciding which projects are most desirable, and then launching each project with a focused mission. When evaluating and prioritizing projects, it is useful to classify projects. The following classification is suggested by Ulrich and Eppinger (2000):

• New product platforms

This type of project involves a major development effort to create a new family of products based on a new, common platform.

Derivatives of existing product platforms

These projects extend an existing product platform to better address familiar markets with one or more new product.

• Incremental improvements to existing products

Adding or modifying some features of existing products in order to keep the product line current and competitive.

Fundamentally new products

Involving radically different product or production technologies to address new and unfamiliar markets

3.5.1 Competitive strategy

A competitive strategy defines a basic approach to markets and products with respect to competitors. When choosing opportunities in product development this strategy can function as a guide. The overall competitive strategy should also permeate the organization and could easily be translated to work in the manufacturing function. Possible strategies are (Ulrich and Eppinger, 2000):

• Technology leadership

When implementing this strategy, a company must place great emphasis on research and development of new technologies and on the deployment of these technologies through product development.

Cost leadership

A strategy which requires the company to compete on production efficiency. This can be done through economies of scale, use of superior manufacturing methods, low-cost labour, or better management of the production system. In product and process development design for manufacturing methods are emphasized.

• Customer focus

When following this strategy, a close connection with new and existing customers is necessary. Customers changing needs and preferences must be fulfilled. This is often done with rapid development of derivative products with new features or functions of interest to customers. This strategy may result in a broad product line featuring high product variety.

Imitative

A strategy which implies following trends in the market, allowing competitors to explore which new products are successful for each segment. When opportunities are identified, the company quickly launches new products to imitate the successful competitors.

3.5.2 Platform strategies

A product platform is the set of assets shared across a set of products. These assets are often components and subassemblies. A benefit from an effective platform is that it can allow a variety of derivative products, created more rapidly and

easily. Platform development projects can take from 2 to 10 times as much time and money as derivative product development projects (Ulrich and Eppinger, 2000). This is why a company cannot afford to make every project a new platform.

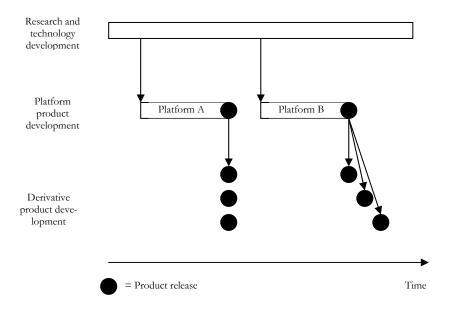


Figure 9 Leverage of an effective product platform (Ulrich and Eppinger, 2000)

The decision whether a project will develop a derivative product from an existing platform or develop an entirely new platform is definitely of high strategic concerns. Technology development is of course closely related to decisions about product platforms since it restrains which technologies to employ in new products. When deciding a projects scope, i.e. deciding between a derivative product and a new product platform, it might be appropriate to structure and analyze the existing product portfolio.

When deciding on when to adopt a new basic technology in a product line it could be of help looking at the Technology S-curve, Figure 10. A new technology has the potential for delivering dramatically better product performance or lower production costs, or both. Figure 10 shows that the performance of a particular product improves rapidly during the period when many alternative design approaches are being tried. With the appearance of a dominant design² product performance

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² A dominant design in a product class is, as defined by Utterback (1996), the one that wins the loyalty of the marketplace, the one that competitors and innovators must adhere to if they hope to command significant market following.

accelerates (Utterback, 1996). After major advances have been made, a period of more incremental and infrequent changes sets in, as indicated by a levelling off of the product performance curve. At the time when a new technology first appears (t_1) , the established technology generally offers better performance or cost than does the new, which is still not fully developed. Eventually, the new technology improves its performance characteristics to the point where they match those of the established technology (t_2) . Then the new technology rockets past the existing and is in a period of rapid improvement.

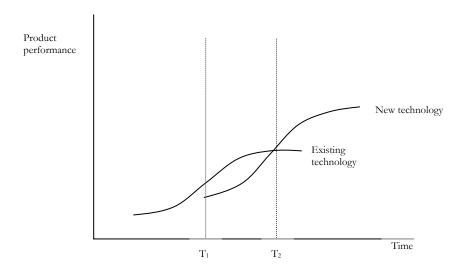


Figure 10 Technology S-curve (Utterback, 1996)

The S-curve illustrates a basic but important concept: Technologies evolve from initial emergence when performance is relatively low, through rapid growth in performance based on experience, and finally approach maturity where some natural technological limit is reached and the technology may become obsolete. The S-shaped trajectory captures this general dynamic. It is of course difficult to predict the future trajectory of the performance curve.

One technique for coordinating technology development with product planning is the technology roadmap (Ulrich and Eppinger, 2000). It illustrates which technology to use in which product platform divided into each functional element in the product.

A platform strategy could have consequences at the production level. It is therefore suggested to define a platform in terms of production processes rather than product architecture.

Modular product design

Decomposing a product design into functional components and specifying the interfaces that define the functional relationships between those components creates a product architecture (Ulrich and Eppinger, 2000). Component interface specifications define, for example:

- How one component may be physically connected to another (the attachment interface)
- How power is to be transferred between components (the transfer interface)
- How signals will be exchanged between components (control and communication interface)

There are two different approaches to defining component interfaces in a product design:

- Conventional product architecture
- Modular product architecture

The two approaches lead to fundamentally different kinds of product architectures (Sanchez, 1996). Table 4 summarises the key differences between conventional and modular approaches to defining, designing, and developing new products.

	Definition	Design	Development	
Conventional product design	product are determined by marketing research. decomposed into components, but component interfaces are determined during component development processes. ar prod- Product is conceived as Modular product archi-		Component designs and product architecture co-evolve in a reiterative process. Product architecture is defined in the final design for the product – i.e., as the output of the development process.	
Modular prod- uct design			Modular product architecture allows component development processes to be concurrent, autonomous, and distributed. Product architecture defined at outset does not change during development.	

Table 4 Differences in product definition, design, and development in conventional versus modular product design (Sanches, 1996)

4 DEVELOPMENT PROCESSES

The second chapter in this frame of reference deals with development processes. Reasons to use processes and characteristics of development processes are presented. Further, a generic development process including tasks and responsibilities is described. Finally, portfolio management and ways to link strategy to the portfolio are explored.

4.1 Business processes

A process is a sequence of steps that transforms a set of inputs into a set of outputs. The result from a development effort can not be seen as random outcome. The organisation and the dynamics in the development process affect the result; therefore it is important to focus on the development work. The development of a manufacturing system is a twofold task:

- 1. Planning of the development
- 2. The actual development (layout) of the manufacturing system.

Using a process to guide the development is a prerequisite for being systematic (Bellgran & Säfsten, 2005).

Business processes can be seen as series of interrelated activities. They depend on the unique ways in which an organisation coordinates and organises its operations to produce valuable products and/or services. The operations of an organisation may include various directly or indirectly value-adding processes which involve creation, communication and the utilisation of material, information and knowledge (Aganovic, 2004). Why are business processes important? Why are organisations moving to adopt approaches to explicitly manage by business processes? Reasons include that the process view (Armistead & Machin, 1997):

- allows increasing flexibility in organisations to meet changing external demands;
- addresses the speed to market of new products and services and the responsiveness to the demands of customers;
- facilitates the reduction of costs;

- facilitates increased delivery reliability; and
- helps address the quality of products and services in terms of their consistency and capability.

Aganovic (2004) points out the importance of having understood the functions that are needed to execute the set of processes when a process organisation is applied. This could be an obvious notice but still of current interest when organisations are striving at meagre organisations and lean concepts.

Processes are part of the philosophy of total quality management (TQM), it requires the identification of processes, the management of these processes with review and targetry, innovation and creativity applied to processes and the management of process change (Armistead & Machin, 1997). Another route that leads organisations to consider their business processes is business process reengineering (BPR) which promotes the radical change of business processes (Hammer & Champy, 1993) (Champy, 1994).

To be structured, business processes can be seen as two categories:

- Core processes. They fulfil companies overall business idea.
- Support processes. They help core processes to deliver correct results.

4.2 Characteristics of a development process

Some organisations define and follow a precise and detailed development process, while others may not even be able to describe their processes. Also, every organisation employs a process at least slightly different from that of every other organisation. Even, the same company may follow different processes for each of several different types of development projects (Ulrich & Eppinger, 2000). The way to execute a development process is often in the form of a project, every new product introduction or new manufacturing system implementation is a new project. One can question if there is a standard development process that will work for every company. That question will be discussed later in this thesis in chapter 6.

Ulrich and Eppinger (2000) have suggested a list of why a well-defined development process is useful:

Quality assurance: A development process specifies the phases a development project will go by and the checkpoints to pass along the way. One way of assuring the quality of the resulting product is to follow the development process, regarding if its phases and checkpoints are wisely chosen.

- Coordination: a clearly expressed development process acts as a master plan which defines the roles of each of the players in the development team. This plan informs the members of the team when their contributions will be needed. It also informs with whom they will need to exchange information and materials.
- Planning: A development process contains natural milestones corresponding to the completion of each phase. The timing of these milestones anchors the schedule of the overall development project.
- Management: A development process is a benchmark for assessing the performance of an ongoing development effort. When comparing the actual events with the established process, a manager can identify possible problem areas.
- Improvement: The careful documentation of an organisation's development process can help to identify opportunities for improvement.

One way to think about a development process is as a funnel: Initial creation of a wide set of alternative concepts, then subsequent narrowing of alternatives and increasing specification of the outcome, e.g. the product, until the product can be reliably and repeatable produced by the production system.

Another way to see the development process is as an information-processing system. The process begins with inputs such as the corporate objectives and the capabilities of available technologies, product platforms, and production systems. The process concludes when all the information required to support production and sales has been created and communicated.

Development processes are often divided into sub-processes, e.g. phases or stages. Decision-making is needed in the interface between phases; has the previous phase been satisfactory completed and can the project move on to the next phase or not? This point, when the decision is made, is often referred to as a gate (Cooper, 1999).

4.2.1 Development process model

Ulrich and Eppinger (2000) suggest a six phases generic development process:

O. Planning: The planning activity is often referred to as "phase zero", that is because it precedes the project approval and launch of the actual product development process. Planning begins with corporate strategy and includes assessment of technology developments and market objectives. Output from the planning phase is a project mission statement which specifies the target market for the product, business goals, key assumptions and constraints.

- Concept development: Here the needs of the target market are identified, alternative product concepts are generated and evaluated, and one or more concepts are selected for further development and testing. A concept is a description of the form, function, and features of a product. It is usually accompanied by a set of specifications, an analysis of competitive products, and an economic justification of the project.
- 2. System-level design: This phase includes the definition of the product architecture and the decomposition of the product into subsystems and components. The assembly scheme for the production system is usually defined during this phase as well. The output of this phase includes a geometric layout of the product, a functional specification of each of the product's subsystems and a preliminary process flow diagram for the final assembly process.
- 3. Detailed design: This phase includes the complete specification of the geometry, materials, and tolerances of all of the unique parts in the product and the identification of all of the standard parts to be purchased from suppliers. Also, a process plan is established and tooling is designed for each part to be fabricated within the production system. The output of this phase is the controlling documentation for the product the drawings or computer files describing the geometry of each part and its production tooling, the specifications of the purchased parts and the process plans for the fabrication and assembly of the product.
- 4. Testing and refinement: This phase involves the construction and evaluation of multiple preproduction versions of the product. Early (alpha) prototypes are built with production-intent parts parts with the same geometry and material properties as intended for the production version of the product. Alpha prototypes are tested to determine whether or not the product will work as designed and whether or not the product satisfies the key customer needs. Later (beta) prototypes are built with parts supplied by the intended production processes but may not be assembled using the intended final assembly process. Beta prototypes are extensively evaluated internally and are also typically tested by customers in their own use environment. The performance and reliability is tested in order to identify necessary engineering changes for the final product.
- 5. Production ramp-up: Here the product is made using the intended production system. The purpose of the ramp-up is to train the work force and to work out any remaining problems in the production processes. Products produces during production ramp-up are sometimes supplied to preferred customers and are carefully evaluated to identify any remaining flaws.

The six phases are shown below, including the tasks and responsibilities of the key functions of the organisation for each phase.

	Planning	Concept development	System-level design	Detail design	Testing and refinement	Produc- tion ramp-up
Marketing	Articulate market opportunity Define market segments	Collect customer needs Identify lead users Identify competitive products	Develop plan for product options and extended product family	Develop market- ing plan	Develop promo- tion and launch materials Facilitate field testing	Place early production with key customers
Design	Consider product platform and architecture Assess new technologies	Investigate feasibility of product concepts Develop industrial design concepts Build and test experimental prototypes	Generate alternative product archi- tectures Define major sub-systems and interfaces Refine indus- trial design	Define part geometry Choose materials Assign tolerances Complete industrial design control documentation	Reliability testing Life testing Performance testing Obtain regulatory approvals Implement design changes	Evaluate early pro- duction output
Manufacturing	Identify production constraints Set supply chain strategy	Estimate manufacturing cost Assess production feasibility	Identify suppliers for key components Perform makebuy analysis Define final assembly scheme	Define piece- part production processes Design tooling Define quality assurance processes Begin procure- ment of long- lead tooling	Facilitate supplier ramp-up Refine fabrication and assembly processes Train work force Refine quality assurance processes	Begin operation of entire production system
Other functions	Research: demonstrate available technologies Finance: provide planning goals General management: allocate project resources	Finance: facili- tate economic analysis Legal: investi- gate patent issues	Finance: facilitate make- buy analysis Service: iden- tify service issues		Sales: develop sales plan	

Table 5: The generic product development process, including the tasks and responsibilities of the key functions of the organisation for each phase (Ulrich and Eppinger, 2000).

Most phases of development are defined in terms of the state of the product. Ulrich and Eppinger (2000) though, pinpoints that the production process and mar-

keting plans are also evolving as development progresses. Aganovic (2004) has reviewed seven development process models; Andreasen & Hein (1987), Ulrich & Eppinger (2000), McGrath (1996), Cooper (1993), Ericsson (2001), Carlsberg (1997) and Scania (1998). He declares that none is regarding the manufacturing system as a separate design object. He admits that all of them involve manufacturing aspects. Though, a new configuration of the manufacturing system, within or outside an existing manufacturing system, is a system of its own and is therefore to be treated as a separate design object. The author wants to point at this as a possible problem when developing just the manufacturing system, independent from any new product release.

4.3 The phase review process

The ideal picture is that a development effort is driven by the decision-making process that determines what products and systems to develop and how development resources are assigned. Through this processes, senior management leads the development, implements the strategy, and empowers projects teams to develop new products and systems.

Despite its importance, this decision-making process is often ineffective and may even slow down rather than drive development (McGrath, 1996). He claims that industry wastes hundreds of millions of dollars making product development decisions too late. Companies may decide to cancel or refocus a product development effort based on information that was actually known, or knowable, much earlier. The reason is not incompetence, in most cases, but a lack of an effective process that enables senior management to do its job and make the necessary decisions.

Though, McGrath (1996) and many other advocators of a "phase-gate" model try to help in the decision-making by describing the gates and its process. The gates precede each stage and can also be called a Go/Kill decision point. Gates serve as quality-control checkpoints, as prioritisation decision points, and as points where the path forward to the next phase of the process is decided. Gates have a common structure, consisting of three main elements (McGrath, 1996):

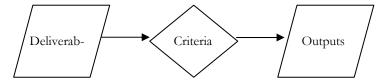


Figure 11 Format of a gate (McGrath, 1996)

Deliverables: a prescribed list of items – results of completed actions – that the project leader must present to the gate.

Criteria: a set of criteria or questions that the project is judged on – to make Go/Kill and prioritisation decisions.

Outputs: a decision; Go/Kill/Hold/Recycle and an approved action plan including timeline, resources and deliverables for next gate.

The purpose of evaluation is to allow ideas to emerge and to select the best concepts with greater certainty (Pugh, 1991). In the beginning of the process there are many project ideas of varied character but only a few of these will become complete projects. The project ideas that pass the first screen undergo a thorough investigation before they reach the development-phase. At each gate, ideas are screened and only the most promising concepts pass. The process therefore resembles a funnel where the number of ideas is narrowed down after each phase (Clark & Wheelwright, 1992), illustrated in Figure 12.

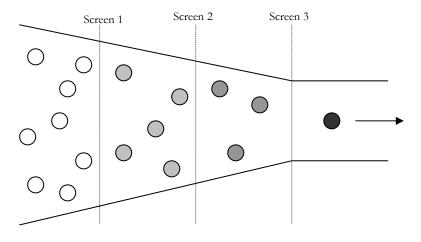


Figure 12. Development funnel (Clark & Wheelwright, 1992)

4.4 Portfolio management

"There are two ways for a business to succeed at new products: doing projects right, and doing the right projects." (Cooper, Edgett & Kleinschmidt, 2001)

Portfolio management, the topic of this section, focuses on the second route – doing the right projects. It deals with issues like how to invest the capital and people resources in the most efficient way. It is also about project selection and strategy, i.e. how to achieve the company's strategy by prioritising between and conducting the right projects.

There are four goals in portfolio management (Cooper, Edgett & Kleinschmidt, 2001):

- Maximising the value of the portfolio
- Achieving balance in the portfolio
- Achieving a strategically aligned portfolio
- Achieving the right number of projects for the limited resources available

In this research the third goal is of most importance since it aims at aligning the portfolio with the strategy. In order to do that one must have a clearly formulated and implemented strategy. The third goal will be further described but first a short look at the others.

The first goal, value maximisation, is achieved by allocating the resources to the projects that are most likely to obtain the highest value of some business objective, for instance long-term profitability. There are a number of methods for achieving this, for instance financial models and scoring models. The result is a rank-ordered list of projects, where the ones with the highest value in terms of the specific objective are ranked until the resources run out.

The second goal, balance, is about creating the right mix of projects in terms of chosen key parameters, for instance low versus high risk projects, long term versus short term projects, market and product categories and projects such as research, maintenance, platforms and new products. The most common tool for achieving a balanced portfolio is some form of chart or diagram where the projects are visualised against certain parameters.

The fourth goal, the right number of projects, is about adjusting the project portfolio in order to obtain balance between available resources and resource demand. One way of obtaining this goal is by undertaking a resource capacity analysis.

Now back to the third goal. Cooper et al. (2001) state the clear connection between strategy and resources and claim that strategy becomes real when you start spending money. Until one begins allocating resources to specific activities strategy is just words in a strategy document. The author agrees with this and includes in it the concept of implementing a strategy.

4.4.1 Linking strategy to the portfolio

When striving at achieving strategic alignment in the portfolio of projects it will be advantageous to consider the strategic fit and the spending breakdown. The first is about asking yourself if the projects are consistent with your strategy. For example, certain technologies or markets are highlighted and in focus of your future, do

the projects fit into these areas? The second is about the money. Does the breakdown of the spending reflect the strategic priorities?

There are two ways to ensure that the portfolio of projects reflects the strategy; top-down and bottom-up approach. The top-down approach starts out from the business's vision, goals and strategy and from this, new project initiatives and resource allocations are decided. The method, the strategic buckets model, requires the management to make forced choices along each of several dimensions. Senior management first develops the strategy for the business. This enables the creation of what Cooper et al. (2001) calls "envelopes of money" or "buckets" destined for different types of projects. Based on the strategy, the management allocates resources across the buckets. Existing projects are then categorised into buckets, which makes it possible to determine whether the actual spending is consistent with the desired spending for each bucket. Finally, projects are prioritised within buckets, which lead to a project portfolio that mirrors the business's strategy. Some common bucket dimensions are market, project type, product line, project size, and technology type. If choosing to use project type and looking at product development, the buckets could be new product projects, platform projects and other, including modifications, improvements and cost reductions. In this case, three different project portfolios are created and managed.

The major strength of the strategic bucket model is that it firmly links spending to the business's strategy. Also all development projects that compete for the same resources are considered.

The bottom-up approach focuses on project selection. Strategic criteria are built into the project selection tools and strategic fit is thereby achieved by incorporating numerous strategic criteria into the go/kill and prioritising methods. The bottom-up approach starts with individual projects and by building in tough screens, the business ends up with a portfolio of strategically aligned projects.

In this third and final chapter of the frame of reference a classification of DFX tools are presented. A "design for manufacturing" method is briefly described. Some "new" approaches are discussed. Finally there is a discussion about the use of methods in industry.

As stated in section 1.2.2 decisions are made both within projects and among projects (portfolio management). In chapter 4 the focus was how to handle the development projects. This chapter is about handling the decisions made within a development project. The decisions made within a project are often not of strategic nature, but about which methods/tools to use. Even though this research is not about developing new supporting methods within design it is somewhat unavoidable to make a short overview of methods used in practice. The purpose with this chapter is twofold; partly to confirm that there actually is a lack of support from existing methods (as stated in section 1.2.1), and partly to explore how methods can be used more effectively.

In order to keep this chapter a chapter and not a book the author has chosen to limit the explored methods to methods often used within product development. Referring to development processes customer need and product specifications are necessary for guiding the concept phase of product development. However, during the later development activities teams often have difficulties linking needs and specifications to the specific design issues they face. This is when many product development teams practice design for X (DFX) methodologies (Ulrich & Eppinger, 2000). Another purpose might be to ensure high product quality while minimising manufacturing cost. DFX highlights optimisation aspects of design: a design has to be created optimised with respect to the aspect X. DFX is a collective term for a number of methods and tools. The X either represents (Tichem, 1997):

- One of all life-cycle phases of the product
- a specific property

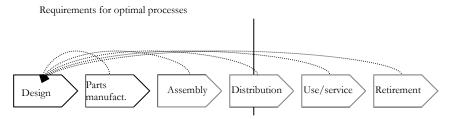


Figure 13 All phases of the product life-cycle give requirement input to the product design process (adapted from Tichem, 1997)

Figure 13 shows the demands on the design from all parts of the product life-cycle. To further narrow the exploration down Figure 13 also shows the limitation in only looking at methods regarding the manufacturing function. This is done since this research is focused on the cooperation between product development and manufacturing system development.

Properties might be cost, quality, lead time, efficiency, flexibility, risk and environmental effect.

5.1 Classification of DFX

Most approaches to DFX support are tools, either to be used by individual designers or by design teams. Tichem (1997) propose four main classes of DFX tools:

- design guidelines
- stand-alone design evaluation tools
- CAD integrated evaluation tools
- CAD/CAPP based evaluation tools

All four classes are described in the following sections.

5.1.1 Design guidelines

Using this approach, a designer is provided with a set of design guidelines. In an easy understandable way the guidelines show the designer examples of good design practise, the do's and don'ts of product design. For example classified according to manufacturing processes, the designer can get good and bad examples of designs when using casted components. Usable for the designer is also a gathering of the capabilities of various manufacturing processes. Pahl & Beitz (1996) provided design guidelines and references to books with guidelines for various processes.

As shown in Figure 14 design guidelines are intended to be used by the designer during design synthesis.

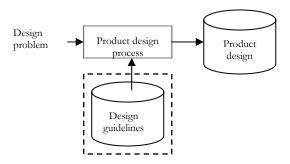


Figure 14 Overview of the design guidelines approach according to Tichem (1997). Compare with Figure 15-17.

Design guidelines are often easy to understand, but this can also be to their disadvantage since they may be too simple for specific design problems. If having all available design guidelines at hand it could be difficult to choose which one to use and follow. Another disadvantage is that there is no support in deciding to implement a guideline or to reject it. Guidelines seldom contain any quantification of the effects reached in applying a guideline; it only gives a recommendation of how to design.

5.1.2 Stand-alone evaluation tools

In design evaluation approaches to DFX, the product design is analysed and the result is fed back to the designer. Compared to the design guidelines, evaluation methods give a systematic approach to design optimisation. Evaluation methods are executed in the following steps, see Figure 15:

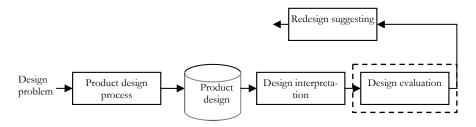


Figure 15 Stand-alone evaluation tools according to Tichem (1997). Compare with Figure 14, 16 and 17.

A frequently cited stand-alone DFMA evaluation tool is developed by Boothroyd & Dewhurst (2002). It consists of a worksheet to document the results of the evaluation and a set of tables used for rating of the difficulty of manufacturing and assembly operations. Both a manual and a computer supported version of the tool are available.

Since cost reductions often are focused the designer must input quantified data about certain product parameters in order to get the cost estimated. This interpretation of the design is left to the designer, which could be a drawback.

5.1.3 CAD integrated evaluation tools

Like the above described evaluation tools, CAD integrated evaluation tools analyse a design and create feedback to the designer. Their extra functionality is to support and where possible fully automate the interpretation of the design, see Figure 16. These approaches also aim to automate the evaluation step as well. In this way the user input is reduced, which may prevent erroneous user input. A possible risk is that the more sophisticated the tool is the more confidence designers have on it. Consequently, erroneous might be more serious if not discovered.

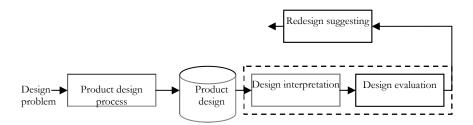


Figure 16 CAD integrated evaluation tools according to Tichem (1997). Compare with Figure 14, 15 and 17.

5.1.4 CAD/CAPP based evaluation tools

In the CAD/CAPP based approach, both a product design and a process plan are used as input to the evaluation, see Figure 17. The process plan is created by a CAPP (Computer Aided Process Planning) module on basis of a product description created in a CAD environment.

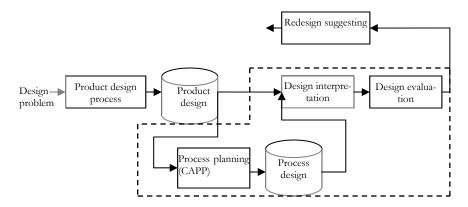


Figure 17 CAD/CAPP based evaluation tools according to Tichem (1997). Compare with Figure 14-16.

This approach is the most sophisticated in the classification. This implies that CAPP methods and tools are developed only for certain aspects of parts manufacturing and assembly. A possible limitation with this approach is that it only suits simple products.

The fast increase of data storage size and processor capacity during the last decade has made the computer aided possibilities far more capable. The classification of DFX in the above sections and Figure 14-17 are based on principle. Even though almost one decade has past since Tichem made the classification it is still valid.

5.2 Design for manufacturing

There are numerous methods available on the topic design for manufacturing. The method chosen to present in this thesis is developed by Ullrich and Eppinger (2000), see Figure 18. Referring to the earlier section presenting different classes of DFX tools, this method qualifies for the stand-alone evaluation tool class. The method basically consists of five steps, and as one can see it is very much focused on cost. Ulrich and Eppinger (2000) states that manufacturing cost is the key determinant of the economic success of a product.

The method gives guidance in all steps, from ways to categorising the elements of manufacturing costs to ideal characteristics of a part for an assembly. Even though the method is focused on manufacturing cost it can also affect product development lead time, product development cost, and product quality (Ulrich & Eppinger, 2000).

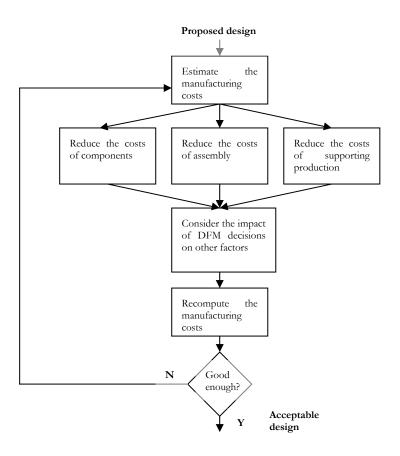


Figure 18 Design for manufacturing method (Ulrich & Eppinger, 2000)

If assuming that most other design for manufacturing methods are at least this easy to understand and probably gives an improved design the question arises whether there really is a lack of support. In this research the opinion is that lack of support lies in direction and guidance for when and which method to use.

5.2.1 Design for existing environment

Taylor et al. (1994) present a technique to design to fit an existing environment (DFEE). The concept of DFEE is a systems integration tool in manufacturing and assembly operations. It concentrates on the benefits associated with designing new products while considering the impact of an entire product mix on a manufacturing process. In a simple experiment Taylor et al. (1994) demonstrates that DFEE in new product design can result in dramatic throughput improvement. General

steps, to be used as a guideline for DFEE implementation is described below (Table 6)Error! Reference source not found..

Step 1.0	Identify the anticipated product mix and process configuration at the scheduled release time.	
Step 2.0	Find the throughput limiting process.	
2.1	Determine if it is possible to redesign the product to off-load work to another process. If possible, continue; otherwise go to step 3.0	
2.2	Establish trade-off rules (for example, five passive devices per active device).	
2.3	Determine the direction of "most probable" maximum improvement and step size.	
2.4	Make the suggested change; go to step 2.0	
Step 3.0	Alternatively add and subtract one period from the target release period.	
3.1	Determine if the cost of changing the release date (charges due to expedition or charges due to lateness) is less than the increased profit from operations. If less, continue; otherwise to to step 4.0.	
3.2	Make the changes; go to step 3.0.	
Step 4.0	Determine if the cost of adding one unit of "bottleneck" capacity is less than the profit from increased sales. If less, continue; otherwise go to step 2.0.	
4.1	Add one unit of bottlened capacity; go to step 2.0.	
Step 5.0	Complete the design process. Strive for continuous improvement.	

Table 6 Guideline for DFEE implementation (Taylor et al., 1994)

DFEE and the planning horizon

Demand variability increases as the planning horizon is extended from operational into strategic decision making. Taylor et al. (1994) divide the planning spectrum into three levels; strategic, tactical and operational.

At the operational level, demand is relatively well known and product designs are mature. Therefore, much of the opportunity to use DFEE concepts has passed, which also Taylor et al. (1994) admits. The tactical planning level is perhaps most interesting in terms of DFEE opportunity for systems integration improvement. At the tactical level, managers must maintain the ability to respond rapidly to strategic decisions regarding production strategies. DFEE concepts can play a key role in helping to ensure minimal disruption by designing the products to take advantage of slack capacity and by suggesting alternative strategies for the timing of release of the product to manufacturing.

At the strategic planning level, a goal is to provide products or services which satisfy the long-term needs of customers. DFEE tools at this level should help in designing new products to fit anticipated capability and capacity. It should also suggest process changes that lead to increased process flexibility. Process flexibility helps to dampen the effects of dynamic environments and extends the useful life

of capital equipment to a greater range of products. Taylor et al. (1994) agrees on the fact that the DFEE technique needs further development to help in the strategic planning level.

5.2.2 Potential with DFA

The DFEE approach gives a systematic way of finding the optimal design of both product and process. It involves development of the manufacturing system to a high degree. Another approach is presented by Bergdahl et al. (2005), introducing a framework including the use of DFA analysis for early start up of assembly system design. The background to their work is that assembly system design and development is characterised by uncertainty resulting in increased lead-times in the design and development process and ineffective assembly system solutions. Explaining this situation Bergdahl et al. (2005) state that companies do not use methods for assembly system design and development in the extent needed, simply because there are no methods applicable. Developers of DFA methods as well as developers of methods for assembly system design assert the importance and possibilities with DFA and assembly system design (Eskilander, 2001).

In the study by Bergdahl et al. (2005) it was found that in companies using DFA production engineers put the information in the desk, not initiating the assembly system design process at this stage. Bergdahl et al. (2005) see the DFA workshop (where the design team analyses the ease of assembly of the design) to be the embodiment of the co-operation between product and assembly system design process. Instead of two parallel pipes for describing the design processes for product and assembly system design, the DFA workshops link the ongoing processes, see Figure 19.

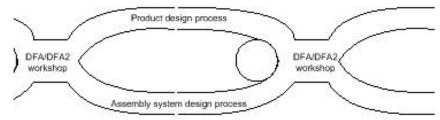


Figure 19 The chain of design process, with the DFA workshop as the body (Bergdahl et al., 2005)

5.3 The use of methods in product development

A relevant question is if industry really uses the methods that actually are available. Carlsson (1996) presents 15 studies of the use of Design for Assembly and Manu-

facturing (DFMA) in Swedish companies. The conclusion (Carlsson, 1996) is that the methods are not utilized to its full potential. This depends on three reasons:

- Ignorance of the methods. The most obvious reason to the low use of the
 methods is lack of knowledge in how they work. Usually there are a few
 specialists (situated in centralised service cost departments) who master
 different kinds of DFMA methods. The knowledge with designers was
 very limited and with production personnel it was non-existent.
- Wrong priorities. The examined products where developed when the
 companies where very successful and made good profits. Product development where then aiming at high quality and high technical performance, but not primarily on a low price. The development efforts where
 wrongly directed, based on a strategy that was obsolete by the time the
 products where finished.
- Work overload. The designers and manufacturing engineers concerned had large burden of work and did not think they where able to consider additional aspects on their work.

Bergdahl's et al. (2005) approach of using an existing method and proposing a new way of using it, supported by a process in a wider range than just the product design, seems a favourable and easy to understand way of supporting both product design and assembly system design and development. Though, it is still the authors' opinion that no matter how good or user-friendly a method is, the results from it is useless if the input of long-term direction, e.g. strategy, is lacking or not understandable, maybe even not communicated.

In this chapter, a model for formulating a manufacturing strategy and a product strategy, in accordance to each other, is presented. The first sections will describe the content and the process of the manufacturing strategy. Further, the same with the product strategy, i.e. the content and the process. The model will be further developed, verified and validated in the forthcoming PhD, including a method for its use.

There has been substantial work done in the three disciplines of strategy, development processes and design methods. The three areas are clearly interrelated and could also be seen as a hierarchic chain; the strategy controls what to be developed and what development processes to use while doing that. What design method to use when and where is controlled by the development process. As a reminder, the objective of this research is to design a model that supports the formulation of product strategy and manufacturing strategy in accordance to each other.

6.1 The content of the manufacturing strategy

As mentioned earlier, the common topic in the α -program is manufacturing strategy. The proposed structure of a manufacturing strategy in this thesis is therefore not a one mans job, it is jointly developed by the researchers within the α -program.

This research uses a relatively broad view of what the content of a manufacturing strategy should be. The reason for that is mainly the vision of a practical useful manufacturing strategy in the development of the manufacturing system. It is also important that a strategy is specified enough and not too overall in its character, else there is a risk of it not being used. A manufacturing strategy should describe a company's long-term plan of development from a known current state to a desirable future state within a specified period of time. The manufacturing strategy should be gathered in a written document containing a number of predetermined headings and subheadings containing information described in a standardised way. In order for the manufacturing strategy to be useful it should at least contain four comprehensive parts:

- 1. The superior strategy, i.e. business strategy or corporate strategy, requirements on the production system.
- 2. A description of the present state of the production system.
- 3. A description of the future state of the production system
- 4. A plan of action, i.e. how the future state can be reached in practise.

A manufacturing strategy containing these four parts is considerably more extensive than what is common in industry today. In the questionnaire and interview study, briefly described in section 2.1.2, it was found that only half of the respondents actually had a manufacturing strategy.

6.2 The process of the manufacturing strategy

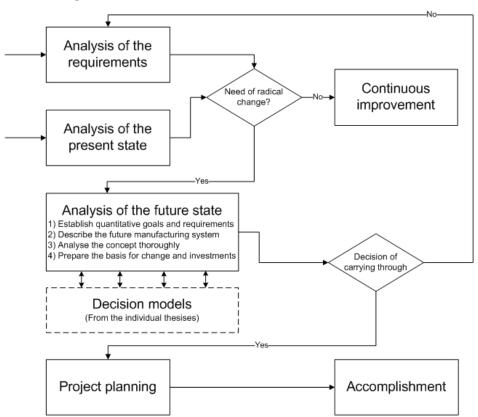


Figure 20 The a-process (adapted from Tangen & Karlsson, 2005)

The process which explains the development of a manufacturing strategy is illustrated in Figure 20 and contains different activities. An important point to bring out is that the process principally turns to companies who in some way need to make a radical change in the production system. In other words, the production system with today's form and layout can not fulfil the requirements from the superior strategy, i.e. business strategy or corporate strategy. Continous improvement work will always be necessary for a manufacturing system to stay competitive, but this differs from what is meant here by radical change. Worth mentioning is that the four activities at the left side of Figure 20 together forms the document which describes the manufacturing strategy.

6.2.1 Analysis of the requirements

The process begins with an identification of the requirements from the superior strategy, i.e. business strategy or corporate strategy. Requirements put on the manufacturing system consist of among other capacity and throughput time, which is the competitive priorities (cost, quality, delivery and flexibility), disaggregated and made concrete. The requirements can also consist of different kinds of limitations put on the manufacturing system, for example; location, budgets and the company's long-term principles and values.

6.2.2 Analysis of the present state

In parallel with the analysis of the requirements an analysis of the present state in the manufacturing system should be done. The analysis of the present state contains of two different parts. The first part describes the present manufacturing system in general, which subsystems and resources and how they are configured. The second part describes different quantitative parameters as; capacity, lead time, quality, security of delivery, productivity etc. A description of the strengths and weaknesses of the manufacturing system is also included.

The description of the present state is an important part of this work whether there is a need for a radical change or not. A basic principle for this work is that it should be described with the same symbols and performance measurements as the analysis of the future state. This is done in order to make a comparison between them possible.

6.2.3 Continuous improvement or radical change

A company working with development of the manufacturing system has a spectrum of possibilities and alternatives. The model in Figure 1 separates two foundations. One of the two alternatives is to carry out a radical change within the manufacturing system. This is done when the present manufacturing system can not fulfil the requirements placed upon it. The other alternative is to work with con-

tinuous improvement in small steps. In other words, if one can establish that there is no need for a radical change, the work continues as normal with continuous improvements. The first of the alternatives, radical change, will arise when:

- A new manufacturing system is to be built in order to increase or decrease the capacity of the system.
- A new product is launched in an existing manufacturing system.
- Management sees it as impossible to continue with continuous improvements in the existing manufacturing system in order to fulfil the requirements from the superior strategy.

Even though a company chooses to work with continuous improvements it could be of great interest to continue with the next activity in the process; Analysis of the future state. For example if management wants to do an internal benchmarking against a manufacturing system developed from blank. This can help to find potential areas for improvements.

6.2.4 Analysis of the future state

The formulation of the future state of the manufacturing system is the most extensive and complicated part of the process. Sketching a wanted future state of the manufacturing system implies a careful description of how the system will look like in the future (approximately in 3-5 years). In resemblance to the analysis of the present state there is a distinguishing between two parts. The quantitative parameters should be appointed, that is capacity, lead time, quality, security of delivery, productivity etc. The other part is about describing how the future manufacturing system looks in general, which subsystems and resources and how they should be configured.

In order to sketch a wanted future state a number of decisions must be made:

- What should be made in-house or outsourced?
- Which flow principle should be used?
- Where should the customer order decoupling point be in the flow?
- Which operations should be manual/automated?
- Etc.

To support this step there is an ambition in the α -program to develop decision models per question above.

Included in the analysis of the future state is also a kind of verification analysis. This analysis should secure the function of the manufacturing system and also show the effect the changes will have.

Finally the basis for the change is formulated. This should summarise what is needed in practise to implement the wanted future state. The basis for the investment is also included.

6.2.5 Decision of carrying through

When a clear vision of how the manufacturing system should be designed in the future is established, the management decision is about implementing or not. If management considers the developed picture of the future state is a wrong way to go one has to go back to the analysis of the requirements. Then a re-evaluation could be appropriate.

6.2.6 Project planning

The aim with project planning is to get a clear plan of action which describes the work to reach the wanted future state. The project plan should include information of what projects and activities to initiate and who's responsible for them. Timetables and budgets for the work are accounted for.

6.2.7 Accomplishment

Finally the plan of action is realised in order for the company to follow their strategy. Feedbacks which compare the results with the defined wanted future state is important. In this way, one can secure that the strategy is followed.

6.3 The content of the product strategy

Similar to the manufacturing strategy the product strategy is about changes. In the product strategy the change is new, reengineered or deleted products. Worth mentioning here is that from this point, in this chapter, the jointly developed part of the research (within the α -program) ends. As with the manufacturing strategy the vision of a practical useful product strategy has been predominant. In resemblance with the manufacturing strategy the product strategy should be gathered in a written document containing a number of predetermined headings and subheadings. In order to be in line with the manufacturing strategy the product strategy should at least contain the following four comprehensive parts:

- 1. The superior strategy, i.e. business strategy or corporate strategy, requirements on the product portfolio.
- 2. A description of the present state of the product portfolio.

- 3. A description of the future state of the product portfolio.
- 4. A plan of action, i.e. how the wanted product portfolio can be reached in practise.

Few companies have clearly formulated product strategies (Deschamps, 1993). A product strategy containing these four parts is a good start to an explicit road map designed to guide a company in its efforts to develop products that build sustainable competitive advantage.

6.4 The process of the product strategy

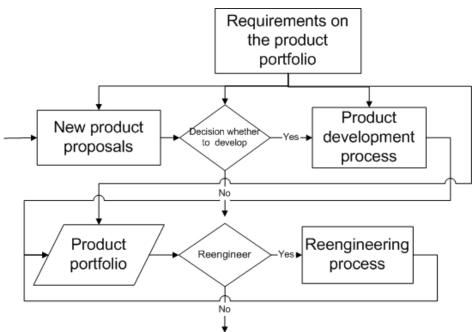


Figure 21 The process of product strategy

As long as a company has projects in the product development process or in the reengineering process it ought to actively work with their product strategy. There is no distinct start or end points in the process of the product strategy. Rather, the process shows the activities which affect the product or an idea for a product. The five steps/activities are described below. Worth to remember is that all steps/activities could itself be a topic for research.

6.4.1 Requirements on the product portfolio

The most central activity in the process is the identification of the requirements on the product portfolio. The requirements should be found both in the superior strategy, i.e. business strategy or corporate strategy, and also in other functional strategies (see Figure 2), i.e. mainly from the marketing/sales strategy. Requirements put on the product portfolio consist of among other range, mix and volumes of products.

Step one to three in Hill's process to link manufacturing with corporate marketing decisions (see Table 1) is one way to ensure the congruence between the product strategy and the manufacturing strategy. Important to keep in mind, though, is to formulate requirements – not solutions. Other activities which should precede the formulation of the requirements are a market analysis where among other things the need of the customer is formulated.

6.4.2 New product proposals

Ideas for new products can arise in different ways; customer, market analysis etc. In this research it is believed that this should be done in a structured and at the same time simple way, to use an idea form. Possible innovators for new products write down elementary information about the idea in a 1 page form. It should contain fundamental descriptions such as contemplated customer for the product, unique features, what is new with the product etc. Consequently, not very much information about the idea is required at this early stage. The purpose of the new product proposal is to capture, visualize and preserve the ideas that are found within and outside the company. Often there is too much preparatory work required in order to get to the first toll/stage gate. This can lead to a too early killing of ideas, risking a shortage of product development projects. The aim of the new product proposals is to attain a more distinct product development funnel as shown in Figure 12, where several ideas are evaluated in parallel.

6.4.3 Product development process

The question raised in section 4.2 whether there is a standard development process that will work for every company is here answered with a simple No. In this model it is suggested to use a phase-gate process (described in section 4.3) fully developed from start by the company or to use a generic development process, like Ulrich and Eppinger's (2000) described in section 4.2.1 and adjust it to suit the company's needs. The product development process should fit the actual company, its products and its manufacturing.

The product development process should also state which design method to use when and why. As found in chapter 5 there is plenty of DFX's. In this model it is recommended that which ones to use are clearly defined in the product develop-

ment process. Worth mentioning is that the chosen DFX's should also be adapted to fit the company's products, competences etc.

6.4.4 Product portfolio

Even though the product development process and the product portfolio are described as separate activities in the process of product strategy they surely influence each other. When making decisions within the product development process it its important to have the product portfolio in mind and vice versa. Therefore it is emphasized in the suggested model that the same group of managers handles both the product development process *and* the product portfolio.

When deciding whether to proceed with a new product proposal and in tollgate decisions some kind of scoring model should be used. The scoring model can consist of categories like; customer value, profitability, market potential, etc. The result should help when making decisions and prioritizing between projects. To make the product portfolio easy to grasp there should be an overview consisting of three parts; all existing products, all ongoing projects and a project status description for each project.

6.4.5 Reengineering or product deleting

All products have a limited life span. Not unusual at companies aimed at in this research is some kind of facelifts of products during their lifetime. New requirements like new features, manufacturing processes, customer needs etc. on a product or product family require a reengineering or the product will be obsolete.

The reengineering process should be similar to the product development process so the developers are familiar with the process. The difference is that the reengineering process has fewer phases and less demands on the documentation.

Product strategy is concerned with products through all the stages of their life, from their introduction through to their deletion. An important and difficult step is the identification of when a product ceases to fulfil its rationale for existence. Besides performance (poor sales and profits), resource and logistics led decisions in an analysis of the technology S-curve (earlier described in section 3.5.2) might help the removal process. Product deletion is an essential part of keeping product portfolios profitable, removing underperforming products and creating spare capacity for new product development.

This final chapter concludes the results of this thesis. After a summary the research is criticised and finally the future research is outlined.

7.1 Summary

The problem of this research was described in chapter 1. Since there is a shortage of support from existing knowledge and methods to manage an integrative way of work new knowledge and methods are needed. Since there is a need for better input in decision making better strategies are needed. Since congruence between product strategy and manufacturing strategy is assumed there is a need for a model that assures the congruence. This resulted in the objective:

"To design a model that supports the formulation of product strategy and manufacturing strategy in accordance to each other and thereby facilitate and encourage continuous communication and collaboration between product development and manufacturing system development."

In order to guide the research, two research questions were formulated. The first were aiming at finding the content a product strategy should have to support the formulation of a manufacturing strategy and thereby the manufacturing development function. The second research question was aiming at finding the content a manufacturing strategy should have to support the formulation of product strategy and thereby the product development function (illustrated in Figure 3). Chapter 2 presents the research program this research project is a part of, the method approach and a working procedure for this research project.

The frame of reference begins in chapter 3 with exploring the concept strategy, in special manufacturing strategy and product strategy. Chapter 4 contributed to a better understanding of development processes and how they can be used to guide and support an integrated way of working. Further, chapter 5 gave the insights that Design for X methods and tools are necessary but not sufficient to fulfil the objective of this research. It also contributed to the understanding of the importance of providing the appropriate method or tool in the right phase, as the development process should do.

In chapter 6 a model has been suggested, with the intention to meet the objective of this research. The model is not in any consideration complete or finished at this stage.

7.2 Critical review

The chosen research area is very wide. It has been hard to delimit a research area that is influenced from many separate disciplines of research and also covers such a large part of a company. This illustrates the need for carefully chosen focus for the doctoral part of this work.

Are the research questions answered?

After having explored the world of strategy, both product and manufacturing strategy in literature the answer to the research questions would be that:

- All possible information in the manufacturing strategy could be necessary for the formulation of the product strategy and the product development function.
- All possible information in the product strategy could be necessary for the formulation of the manufacturing strategy and the manufacturing development function.

This means that the research questions aren't really *answered*. However, the first part of this doctoral part has given:

- The vision that was illustrated in Figure 3 is relevant, i.e. corresponding to an industrial need and possible to fulfil.
- The vision has been given a more concrete form and has been detailed essentially, see Figure 22.
- Substantial ground for the direction of this doctoral work, see section 7.3.

The suggested model has not been verified nor validated, which can be criticised from a scientific perspective. The model needs refinement and to be developed further to be useful in practice. Hence, further development, scientific verification and validation play a vital role in the doctoral part of this work.

The literature study covers three areas that are important in this research. However, there may be research results that have been left out, theories and models that are not included but should have been. It is believed that in the forthcoming doctoral studies there is a need to increase the strategy chapter in the frame of reference.

7.3 Future research

In this licentiate part of the research studies, knowledge within (and outside) the research area has been built up, experience from the industry has been captured and a model has been suggested.

At least three main parts of future research can be seen for the doctoral part of the work:

- Some references used in this work are getting old, for instance the classification of DFX by Tichem formulated 1997. It has to be carefully studied what new possibilities that come out of the development of IT aids during the last decade. This will be done in collaboration with for instance the ModArt project at KTH Production Engineering.
- The suggested model must be tested and verified. It needs to become more concrete in order to be of real use in industry.
- The model is presented without a method of how to use it. The plan is to formulate a method to zigzag between the four part of the manufacturing strategy and the product strategy respectively, see Figure 22 (see next page). This method of zigzagging between the two strategies has to be verified in a number of industrial companies, preferably with different manufacturing market situations.

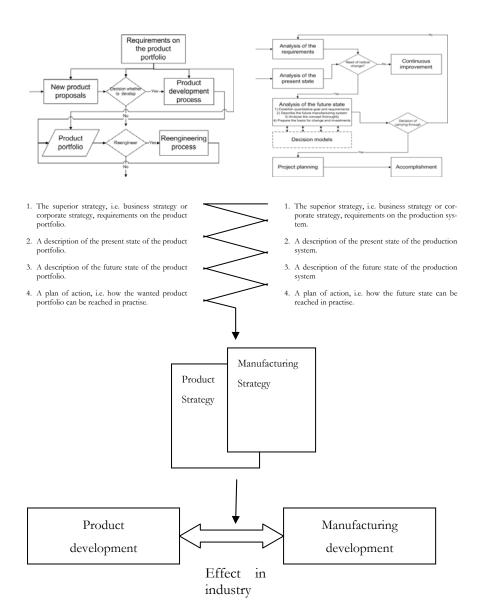


Figure 22 Zig-Zaging between product strategy and manufacturing strategy

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