Customization Through Standardization

- a study on Atlas Copco Tools & Assembly Systems' market offer of fixtured tools to the motor vehicle industry

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Master's thesis written at the
Department of Management & Economics
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LiTH-EKI-EX-2004:49-SE

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Department of Management & Economics
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LiTH-EKI-EX-2004:49-SE

Avdelning, Institution
Division, Department

Ekonomiska institutionen
Department of Management and Economics

Datum
Date

2004-04-26

Språk
Language
Svenska/Swedish
X Engelska/English

Rapporttyp
Report category
Licentiatavhandling
X Examensarbete
C-uppsats
D-uppsats
Övrig rapport

ISBN

ISRN LiTH-EKI-EX-2004:49--SE

Serietitel och serienummer
Title of series, numbering

ISSN

URL för elektronisk version

Titel
Customization Through Standardization
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Sammanfattning
Abstract

Atlas Copco Tools & Assembly Systems (ACTA) is world leader in industrial tools and assembly systems for safety-critical joints. One of the products the company sells is fixtured nutrunners, mainly to the motor vehicle industry. The margins on these highly customized products have been decreasing – much depending on changes in the purchasing behavior of the automotive industry.
Traditionally, the marketing of the fixtured nutrunners has been concentrated to the parts of the product instead of the final product. Today, there is a belief within the organization that many of the sold customized products could be replaced by more standardized applications. There is also a wish to turn the focus of the market offer from the parts towards the final application. These beliefs and wishes resulted in this thesis, with the purpose to propose a new market offer to increase profitability and give more customer benefits.
To reach this purpose we started out with theoretical studies of several different areas. Among those was mass customization, a strategy that combines the benefits of mass production with those of customization. We also performed a prestudy at the headquarters of ACTA in Sickla and visited major customers in Sweden. Using our collected knowledge from the theoretical studies and the prestudy, we conducted an in-depth case study by interviewing customers and people working at ACTA, both in Sweden and in the USA, in order to analyze today's situation. In the analysis, we found several problems with today's offer. For instance, we found that similar products are solved with unique solutions, which has lead to poor cost control and has made it difficult for ACTA to assure the quality of the ordered products. A further problem is the poor sales support and the lack of traceability of sold systems, which reduces sales and leads to unnecessary special solutions. A problem linked to that is the difficulties in getting accurate and sufficient information from the customer, which leads to extra errors and a lot of extra work.
To solve these problems, we recommend ACTA to implement a mass customization strategy. Of course, not all of ACTA's products can be mass customized, but to a large extent it should be possible. To implement a mass customization strategy, we argue that ACTA should take three measures, namely design standard products, modularize the products, and implement a computerized configuration tool. We also suggest that the implementation of the new market offer should be done stepwise. With the proposed new market offer, we believe that ACTA can increase profitability in the area of fixtured nutrunners without losing the flexibility of the products.

Nyckelord
Keyword
Mass customization, modularization, standardization, configurator, motor vehicle industry, industrial tools

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Acknowledgements

This thesis is the final part of our studies at the M.Sc. program of Industrial Engineering and Management International at Linköping Institute of Technology. We were lucky to find a very interesting task at a very interesting place – a strategic task with wide implications for our assigner, Atlas Copco Tools & Assembly Systems. In the process of research and writing we have received irreplaceable help from a number of people, who we would like to acknowledge here.

We would first like to thank our supervisor, KarlJohan Börjeson, and closest colleagues at Atlas Copco Tools & Assembly Systems, Morgan Algarp, Jonas Andersson, and Bo Hellmark, who have been very helpful, supportive, and great sources of knowledge about all parts of the company's business.

We would also like to give special thanks for great help and insightful comments to all those whom we have interviewed inside and outside of the headquarters in Sweden and at the application center in Detroit, USA. We would like to address a special thanks to our hosts in Detroit, Tom Marcum and Dwayne Dupuis, for their great hospitality and good times during our visit.

The written thesis would not look the same without the great help we have received from our opponents, Cecilia Anghus and Sofia Olsson, and our supervisor Staffan Gullander. They have patiently helped us structure our thoughts and enhance the reports readability. Our examiner Anna Öhrwall-Rönnbäck has also been of good help.

Stockholm, April 2004

Martin Cramér Anders Matsson

Table of Content

1 Introduction

This chapter gives the reader a brief background about why the thesis has been written. The purpose, objectives and delimitations are also presented. Finally, the structure of the thesis is presented.

1.1 Background

The title of this thesis is "Customization through Standardization". At first, it might seem paradoxical to mix two, seemingly contradictory words in one sentence. However, we suggest that it is possible to reach highly customized products with the use of standardized building blocks. Throughout the first eighty years of the 20^{th} century, management theory has been concentrated on how to make mass production work well and swiftly but during the last twenty years, a change has been noticed (Lampel & Mintzberg, 1996). Now, the hottest topic is how to make *mass customization* work and what the consequences of such a strategy would be. This may be a new area in research, but strategies that mix mass production and customization have, de facto, been used throughout the century. However, it is only in the last ten to fifteen years that they have been examined and categorized by researchers.

1.2 Problem Background

Atlas Copco Tools & Assembly Systems (ACTA) is a company within the division of Industrial Technique of the Atlas Copco Group. The company is one of the world leaders in industrial tools and assembly systems for safety-critical joints. One of the products they sell is fixtured nutrunners – mainly to the motor vehicle industry. Traditionally, they have been highly customized and the marketing has been concentrated to the parts of the product instead of the final product. This has made it hard for the headquarters to observe and control the business, but also for the salesmen, since they have not had a product to show the customer. The high level of customer adaptation has also lead to low earnings when price awareness among customers has been increasing.

Today, there is a belief within the organization that many of the customized products sold could be served by more standardized applications if only the benefits would be visible to the customer. There is also a wish to turn the focus of the market offer from the parts towards the final application. They hope to achieve this by identifying standard applications that would satisfy a large portion of the market and the applications would be predesigned to reduce lead-times and costs. However, they do not want to lose the possibility to customize the products to the customers’ needs.

1.3 Purpose

The purpose of this thesis is to propose a new market offer that will increase profitability and give more customer benefits. We define the market offer as the total product range that ACTA presents to its customers.

1.4 Objective

The purpose is here broken down in four objectives:

- Evaluate the customer satisfaction with today’s market offer
- Evaluate the internal processes in terms of efficiency and flexibility
- Construct a new market offer that increases customer benefits and profitability
- Propose a way to implement the new market offer and judge its feasibility

1.5 Delimitations

We will only look at existing products. The reason for this is that defining and designing a possible future product would be beyond the scope of this work. This does not mean that the results presented in this report will not be applicable to new product development, but we will not further investigate it. Furthermore, we will only look at the motor vehicle industry (MVI), because it is the biggest customer for fixtured applications and the MVI is the driving force in the manufacturing industry of today.

ACTA is present at a number of markets and although the motor vehicle industry is consolidating and merging on a global level, differences in both behavior and needs still are important. Therefore, the scope of this thesis is limited to the North American and to an extent the European markets.

Moreover, we need to go through the salesmen because they work very closely to the customers and it would not be possible to approach a customer without their permission.

1.6 Structure of the thesis

Introduction

This chapter gives the reader a brief background about why the thesis has been written. The purpose, objectives and delimitations of the thesis are also presented. Finally, the structure of the thesis is presented.

The company, its business and its environment

This chapter describes the history of Atlas Copco Tools & Assembly Systems and the environment of the, in terms of customers and competitors. The products of Atlas Copco Tools & Assembly Systems are presented together with a brief introduction to the art of tightening.

Frame of reference

The frame of reference is the theoretical backbone of the thesis. In this chapter, we will present theories that have helped us in understanding the situation of Atlas Copco Tools & Assembly Systems is facing and how to improve it. The chapter contains presentations on how to evaluate customer needs, an introduction to industrial buying, an introduction to lean manufacturing, a presentation of mass customization and an introduction to modularized product construction. We end the chapter by giving a review of tools for aiding efficient customization.

Model

This chapter presents the working model that has been used when writing the thesis. The chapter also contains the specified research questions that will be answered later in the study. With help from the frame of reference, the specified research questions have been chosen to get important answers in order to fulfill the purpose.

Methodology

While the frame of reference is about the scientific content of the thesis, the methodology is about the scientific approach to writing the thesis. This chapter contains a discussion on how a study is to be conducted by referring to theory as well as a presentation of our approach to scientific work.

Empirical findings and analysis

In this chapter we present and analyze our findings from the interviews and studies. The two elements of findings and analysis are for each topic presented next to each other in order to facilitate for the reader.

Conclusions and recommendations

In this, the last chapter of the thesis, we present our conclusions from the conducted study that corresponds to the purpose. We also provide Atlas Copco Tools & Assembly Systems with recommendations on how to implement our proposal.

Glossary

In the glossary we have explained the abbreviations used in this thesis along with words and expressions that may be hard to understand.

2 The company, its business and its environment

This chapter describes the history of Atlas Copco Tools & Assembly Systems and the environment of the company, in terms of customers and competitors. The products of Atlas Copco Tools & Assembly Systems are presented together with a brief introduction to the art of tightening.

2.1 Atlas Copco

2.1.1 History

AB Atlas was founded in 1873 with the aim to "…produce or purchase for resale all types of equipment used in the building and subsequent running of a railroad network" (The Atlas Copco Way, 1998). The company expanded quickly and the Swedish Railways decided to buy all their railroad carriages from Atlas. However, by 1876, the growth rate of the Swedish Railways decreased and Atlas was faced by a decrease in sales. The company tried to compensate for the loss by selling alternative steel constructions, such as bridges and skeleton frames for church towers, but by 1891, the race was lost. The company was liquidated, though immediately restructured to what was called the New Atlas with the help of the Wallenberg family.

The new company began manufacturing pneumatic tools for use in its own factories, but the reputation of the tools effectiveness and accuracy was spread and they soon became a part of Atlas sales. By time the company also began selling diesel engines, which led to another name change in 1917, to Atlas Diesel. From this time, the company has had production in Sickla, just outside of Stockholm, and it is also in Sickla that the headquarters are situated.

In the late forties it became clear that the company lacked sufficient resources to produce diesel engines to further develop the pneumatic equipment and the diesel business was sold. From this time the company decided to center its business on compressed air machines and equipment. In 1956, the company went through a final name change when it became Atlas Copco (from **Co**mpagnie **P**neumatique **Co**mmercial, a Belgian subsidiary).

In the late sixties, after having had good growth thanks to its successful products, the company was too complex and was therefore divided into three business areas: Construction and Mining Technique, Airpower and Tools.

2.1.2 Atlas Copco of today

Today, Atlas Copco employs about 26 000 people, manufactures products in 17 countries and has a sales and service organization reaching people in 150 countries. The revenues of 2003 totaled MSEK 44 619 out of which 98 % occurred outside of Sweden. Atlas Copco companies develop, manufacture and market pneumatic and electric tools, compressed air equipment and generators, construction and mining equipment and assembly systems, and offer related services and equipment rental.

The Atlas Copco group is today divided into four business areas; Compressor Technique, Rental Service, Industrial Technique and Construction and Mining Technique (Figure 2-1). The business area Industrial Technique develops, manufactures, and markets industrial and professional pneumatic and electric power tools and assembly systems. Main customer groups are the automotive, engineering, construction and residential building industry. The business area is global business leader in pneumatic and electric industrial tools with revenues of MSEK 10 528 in 2003.

Atlas Copco Tools & Assembly Systems consider itself the premium brand of the Industrial Technique division and markets itself as a company of high quality. Other brands include Chicago Pneumatic, Milwaukee, AEG and George Renault. Although being part of the same group, they see themselves as competitors and act as totally different companies.

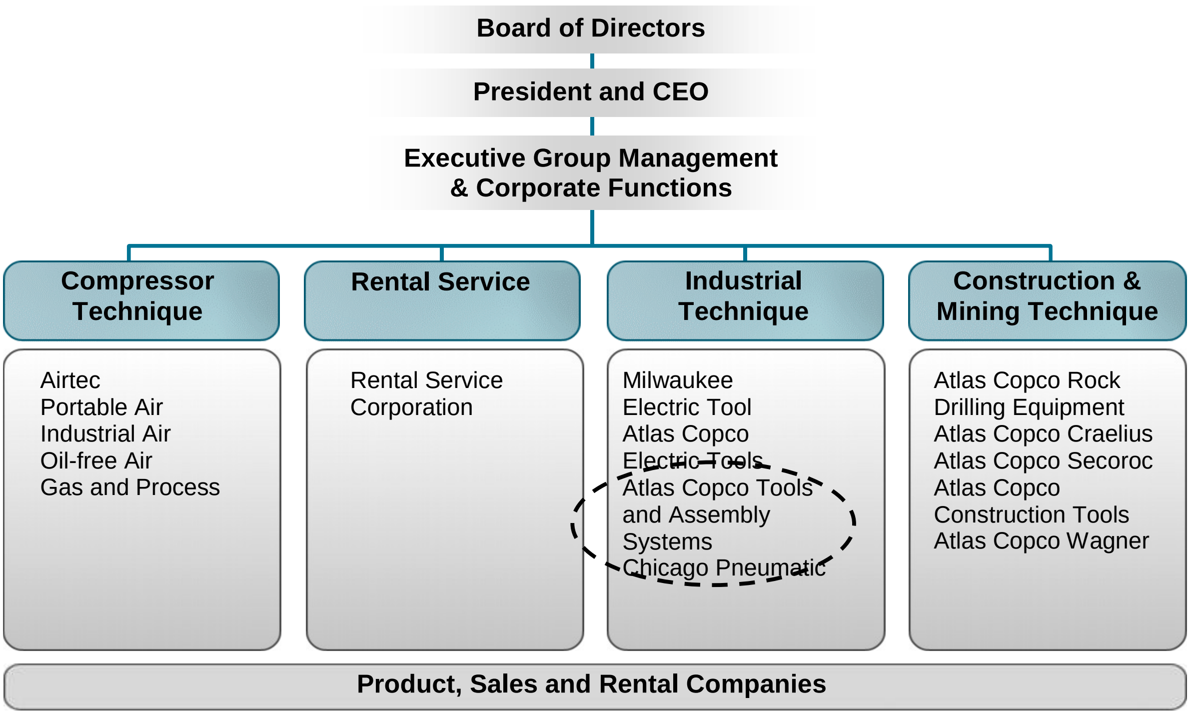

Figure 2-1. Organization chart of Atlas Copco.

2.2 Atlas Copco Tools & Assembly Systems AB

In 2001, the two companies of Atlas Copco Assembly Systems and Atlas Copco Tools were merged forming the company Atlas Copco Tools & Assembly Systems (ACTA) after nearly two decades as different companies (Figure 2-2). The companies had once been split up because of different business ideas – customer adaptation for Assembly Systems and mass production for Tools, but due to change in demand and the products becoming more similar, their respective business ideas grew together. Although the two companies had both been selling their products using the Atlas Copco brand name, the two had different salesmen, cultures and ways of doing business.

Since the merger, the two companies' functions have gradually been fusioned. The marketing and sales functions of the two companies have been working closely for some time. The functions further upstream in the two companies' value chains have on the other hand only recently started to merge. The production of Assembly Systems was previously carried out in Sickla, but was during the winter of 2003-2004 moved to Tierp, where Tools are manufacturing their products. Now all production of ACTA's standard core components is carried out at the Tierp-plant and then shipped to the Power Tools Distribution Centre (PTD) in Hoeselt, Belgium. The PTD serves five divisions of two of Atlas Copco's business areas and promises all customers, internal and external delivery of any product in stock within 24-48 hours.

ACTA has global representation through their Customer Centers (CC), which are located around the world. These handle customer contacts, take care of sales, and also employ project managers to help sales personnel to construct customer-adapted products. Orders with a low level of complication, such as ordinary handheld tools, can be handled by the customer centers alone.

More complicated orders involve one of the companies' three Application Centers (APC) located in Germany, the US and Brazil. The customer centers employ personnel to assemble machinery, often with components coming from both local subcontractors and from the parent company of ACTA.

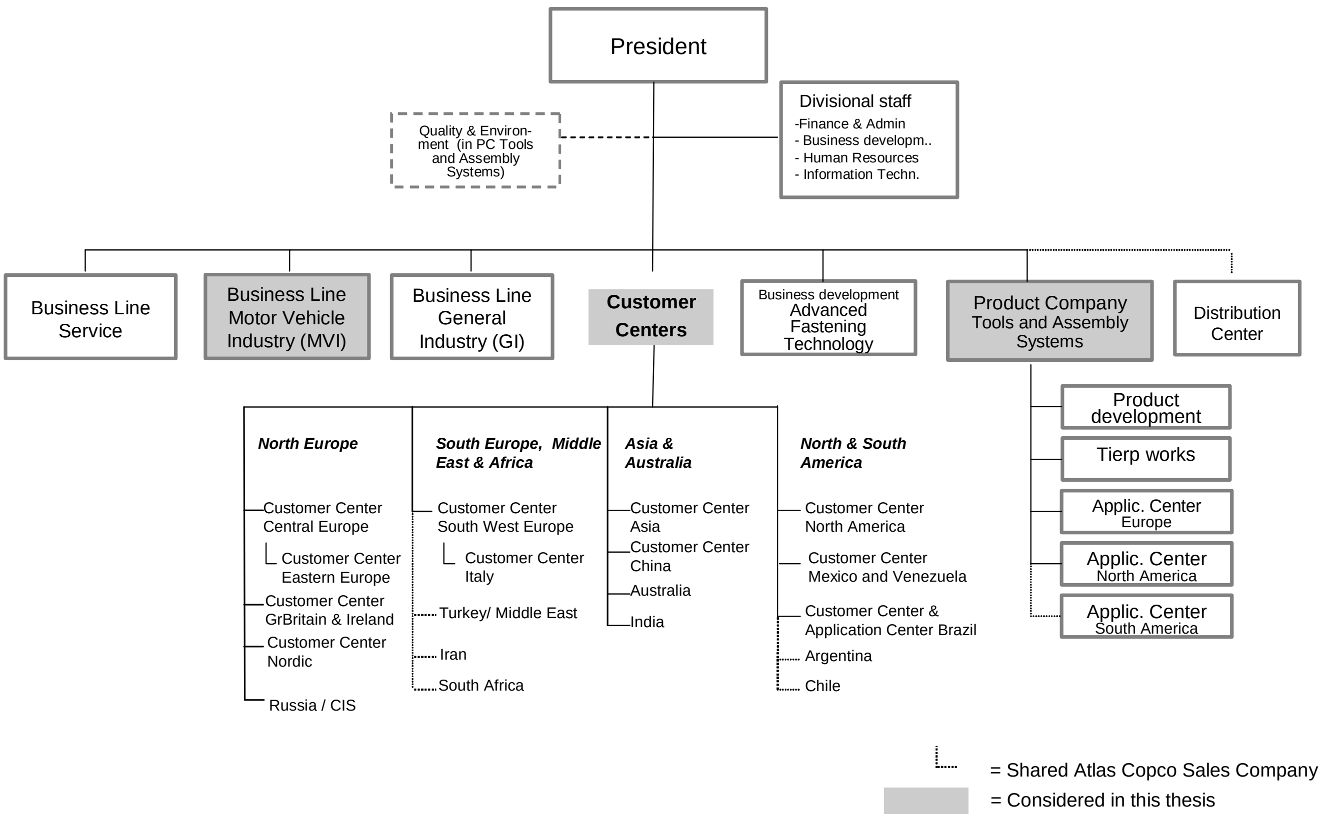

Figure 2-2. Organization chart of Atlas Copco Tools & Assembly Systems.

2.3 Customers

The marketing organization of ACTA is divided into two business lines, General Industry (GI) and Motor Vehicle Industry (MVI). GI is responsible for customers from all types of industries outside the MVI and the customers include aerospace, off-road, white goods and original equipment manufacturers. In the fixtured business, MVI is the dominant with more than 90 % of the sales.

The MVI has been changing a lot during the last years. There have been many mergers and former competitors are now working together. What used to be many independent, national companies are now large international conglomerates that own each other and cooperate in a non-transparent way. ACTA has been affected positively from this, since many manufacturers want to use the same supplier in different plants over the world.

Sales to the MVI are divided in two parts – one that has direct contact with the final customers, i.e. the automakers and one that works through machine tool builders. Machine tool builders are companies that an auto manufacturer contracts to build a new line. Sometimes the auto manufacturer has opinions on what kind of tools shall be used, but in other cases it is totally up to the machine tool builder to decide. Sales to the machine tool builders account for roughly 50 % of the sales to the MVI, but that figure fluctuates a little depending on how many new lines the automakers build that year.

The biggest markets for ACTA are North America and Europe, with each roughly 40 % of the total sales. This might change in the near future, as China and the Far East is a fast growing segment.

2.4 Competitors

The market of tightening equipment is very diversified. This is especially true when it comes to fixtured products. This is due to different local standards among the customers, which is much more important among the fixtured products than the handheld ones (the customer specifications can be on hundreds of pages for a simple fixtured product). The specifications can regard anything from reaching some quality demand to have a special color. A consequence of these different specifications is that local competitors have an advantage, since they are used to working with these specifications and do it much more efficiently.

This diversification means that ACTA has different competitors on each market and in each segment (electric handheld tools, pneumatic tools, fixtured tools etc.), which means that every market needs to be looked at separately. In the fixtured business in Sweden, ACTA competes against a local competitor called Scanrotor that uses nutrunners from Georges Renault (a company within industrial technique, but is in all aspects considered as a competitor). In Germany and German transplants, Bosch is very big and in the US, Stanley, Cooper and Ingersoll-Rand (mainly GI) are big competitors. What distinguishes ACTA from its competitors is the global presence and the broad product spectrum.

2.5 The development of tightening applications

The development of new products in the tightening industry is considered driven by the automotive industry. The reason behind this can be found in the fact that the number of screws and bolts in a car has been decreasing to today’s number of 1 200-1 400 (Druckluftkommentare, 2004), which means that the importance of each tightening has increased. Obviously, there are some tightenings that are more important than other ones. These tightenings include safety features such as brakes, air bags, and seat belts – so-called safety critical applications. Roughly 15 % of the tightenings can be sorted into this group. The rest of the tightenings are still important, but they do not pose a threat to the driver or passenger if they would break and they are usually referred to as quality critical tightenings.

The failure of a safety critical joint would not only be devastating for the driver, but could also impose a threat for the manufacturer in terms of badwill and liability, not to mention the cost to recall cars and control the tightening. This has led the auto industry to push the suppliers to increase the development of quality systems for tightening applications.

Here it is also appropriate to address the difference in the company culture of the European and North American companies in comparison to their counterparts in the Far East. The companies in Europe and North America are trying to get manufacturing plants where the worker cannot do anything wrong, whereas the companies in the Far East trust their employees to a further extent. It should also be noted that the reduction of screws has gone further in the European and North American companies than in the Far East ones. These two facts mean that the interest for guaranteed foolproof tightening applications is lower in the Far East.

2.6 Basic tightening technique

The electrical tools sold by ACTA to the motor vehicle industry are meant to join members with screws and bolts. Important to know is that it is not the bolt, but the clamping force, the force pushing the members together, that is decisive for the quality of the joint. Another thing to remember is that an over-tightened joint, i.e. when a bolt is tightened too hard, is just as unwanted as an under-tightened one, since this might lead to the bolt breaking or changing shape due to the extra force applied.

2.6.1 How to measure the clamping force

Unfortunately, there is no easy way to directly measure the clamping force between two parts, but there is a direct relationship between the clamping force and the torque by which the joint has been tightened.

The preferred method to measure the torque when power tools are used is to measure the dynamic torque, which can be done without the influence of resting friction and the relaxation of the joint. The measuring is done either directly by a built-in or a separate in-line torque transducer or indirectly by current measurement (Figure 2-3). In-line transducers are typically used to calibrate tools, whereas built-in transducers are preferred in assembly line production.

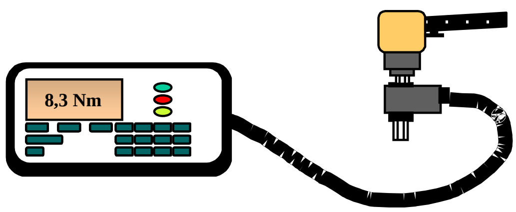

Figure 2-3. A handheld tool with an inline transducer. Measures the torque of the tightening.

Another way to measure the clamp force, which is usually combined with the measurement of the torque, is to measure the tightening angle with an angle encoder. The angle encoder starts to measure the tightening angle, i.e. the rotation of the bolt when a certain predetermined torque value has been reached and controls that the final angle corresponds to the torque. This combination of two methods means that a better quality can be achieved.

2.6.2 How to achieve accuracy in tightening

The actual fastening of a bolt is often done in steps where the bolt is fastened, loosened and then fastened again in several steps, all to avoid effects such as relaxation in the case of joining soft materials. In many cases several bolts keep a joint together which means the joint runs the risk of not being evenly fastened. This has to do with small differences in the material used such as uneven surfaces or dirt on the bolt. In order to get an even clamp distribution in these cases the bolts need to be tightened in synchronization, using the same principle as when fastening a tire to a car. Bolts are then fastened in steps up to different torque levels until they all run down simultaneously. In certain applications, carmakers use as many as 17 steps of fastening, loosening and fastening again in order to reach an even clamp force.

It is not only important to be able to do a good tightening, but also to be able to prove it, long times after. This since a poorly fastened bolt can make the car manufacturer responsible in liability claims. Therefore, advanced tightening products such as the ones of ACTA provide the user with a possibility to store information about previous tightenings.

2.7 Products

ACTA sells products for tightening applications to be used in the manufacturing industry, both handheld and fixtured applications with air (pneumatic) as well as electricity as power source. The electrical nutrunners are connected to sophisticated control systems, which allow the user to specify how the bolt should be tightened (torque, angle, speed etc.) as well as work as a quality control checking that the bolt has been tightened as specified. They also allow traceability of each bolt, which is important in liability claims for instance.

2.7.1 Handheld tools

In the beginning of the 1990's, former Atlas Copco Tools developed a patented electrical engine, called Tensor, which has a high power to weight ratio. This engine is used in ACTA's handheld electrical tools, and the tools are therefore called Tensor tools. Traditionally, pneumatic tools have been the ones used in heavier tightening, since they are much lighter, but with help from this engine, it has been possible to make do without pneumatic tools and make a factory "all-electric". However, handheld pneumatic tools still exist for the heaviest handheld tightening applications, where the electric ones are too heavy. Furthermore, the extra capabilities of electric tools are not always needed, which leaves a big market for air tools. Although there are a few exceptions, the handheld tools are mainly standardized. However, they exist in several families (or product lines), depending on the accuracy of the tool and to what torque level it should be used (Figure 2-4).

Figure 2-4. Examples of electrical handheld Tensor-tools. The top one mounted in a fixture, the middle one with an angle-head and the bottom one straight.

ACTA profiles itself as the company that leads the development in its field. Therefore new products have been released frequently, resulting in that the major part of handheld tools models sold are only a few years old. Such a high level of R&D and short product life cycles is one of the reasons that Atlas Copco tools are among the most expensive in the market.

2.7.2 Fixtured applications

If several nutrunners are used for the same application, so-called multiples, they need to be attached to a fixture. Another reason for attaching the spindles to a fixture is if the applied torque is high. The fixture could be anything from a simple arm that works as a counterweight to complicated installed applications with no physical interaction with the controller of the machine.

In this product segment, the products usually are highly customized to fit the need of each customer. Typically, the fixtured applications are assembled at one of ACTA's application centers where the customization and design of the application is done and thereafter shipped to the customer. This means that there is no worldwide standard design of the applications.

The fixtured applications are usually complicated and the products are not presented to the customer as a working application but as different parts, which can be built to a system. This has many implications, such as long delivery times and difficulties for the customer to understand the offer, but above all, it means poor cost control since a lot of local content and unique engineering is involved (Figure 2-5).

A fixtured application can be made using several of ACTA's nutrunners. More demanding applications with higher demands for speed, durability and number of nuts

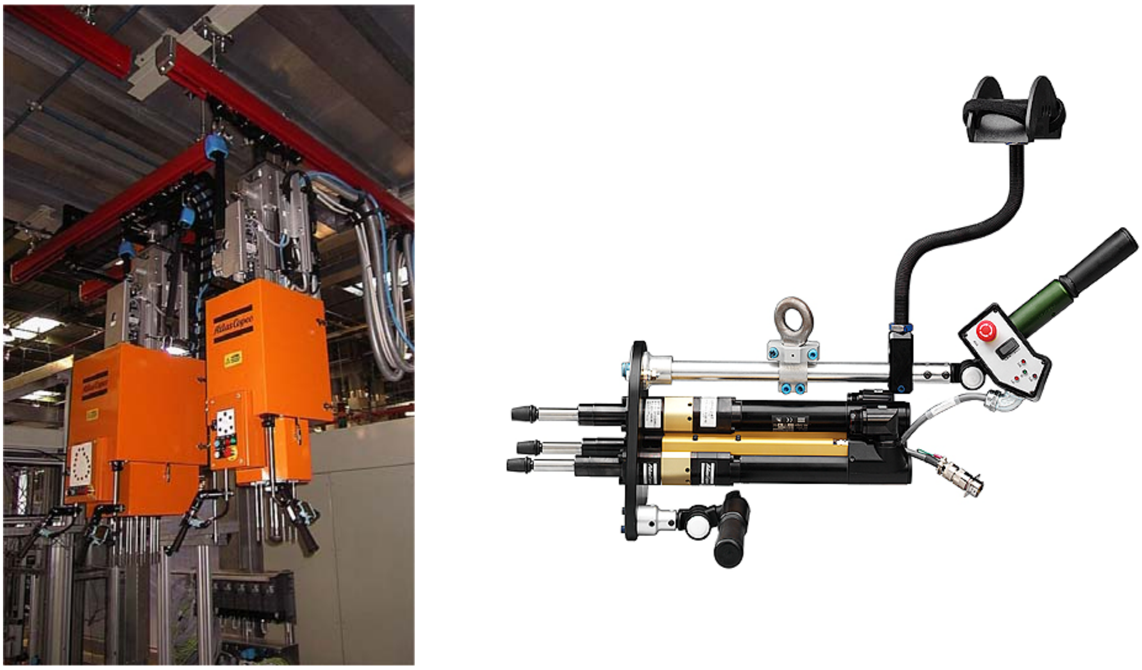

Figure 2-5. Examples of fixtured tools. To the left a typical installed application and to the right the new Express concept.

to be run at once normally use the QMX-nutrunners. They are designed to be able to run for a very long time with high reliability and without the need for much maintenance. These tools come from former Assembly Systems and can only be mounted, i.e. not be used in handheld applications. Less demanding applications normally only need nutrunners from the Tensor range, from former Tools, mounted in a fixture. These nutrunners are designed with ergonomics as one of the most important design parameters, and are not optimized for fixtured applications. ACTA is now trying to sell the nutrunners that best suits the customers, but previously the two companies have actually been competitors in quite a few cases.

2.7.3 Express

In the beginning of this decade Atlas Copco noticed a change in demand for its fixtured tools. Customers became more price sensitive, and after September 11 and the recession, the demand decreased. During this period what was to become Atlas Copco Tools & Assembly Systems was also formed. This change brought along a wish to make the market offer of the two companies more homogeneous to make it easier for the customers and salesmen to grasp it.

In response to this change in the market, a new product called Express was launched in 2003. Express is a standardized system with the possibility to choose from a few different predetermined configurations and the components are always kept in stock (Figure 2-5). It is possible to add a few more customized features to the Express system (hand scanners etc.), but this is kept to a minimum. This is a totally new concept for the fixtured products and it is now possible for the salesmen to show a working application to the customers. Together with the concept, a quotation software was developed to let the salesmen construct a quote without the need of the quoting department. Furthermore, time from order to delivery is only four to six weeks (planned to decrease to three weeks during this year), compared to nine to fifteen weeks for the traditional products is also a big change. However, Express does not cover the needs of more than a part of the market and the delivered systems are still often being engineered according to specific customer needs. Nevertheless, the Express system gives many of the advantages of mass production, although still being a partly customized product

Another similarity between Express and standard products, apart from that they can be demonstrated before the sale, is that Express orders do not need a project manager. The reason is that an Express system is preconfigured and will only allow minor modifications.

2.7.4 Control systems

Every electric tool is connected to a Tightening Controller (TC) and each tool family has their own TC. The most advanced controller for the handheld tools is called PowerFocus 3000, which exist in three different versions with different capabilities – gold, silver and bronze (e.g. the bronze has no networking capability). The versions all have the same architecture, but a hardware lock decides if it should be gold, silver or bronze. This has the advantage that it is easy to upgrade the TC to a different version if the customer would need to in the future. The PowerFocus 3000 is one of the TC's from former Tools, but each handheld tool has a dedicated one.

The TC that is used together with the QMX nutrunners is called PowerMACS (**M**onitoring **A**nd **C**ontrol **S**ystem). It exists in two versions, gold and silver. In order to change between the versions, the TC must be sent to an application center (which is harder and take longer time than changing between different versions of PowerFocus). The former Assembly Systems developed this system and it is a lot more advanced in terms of networking and tightening strategies than the ones for handheld tools. It is however perceived as complicated by people who are not used to working with it.

The two systems cannot be interplaced and have no common parts. Furthermore, they can only be used to one type of spindles (Tensor for PowerFocus and QMX for PowerMACS). This is due to the history of ACTA as two different, competing companies.

2.8 Projects

All businesses within ACTA involving special solutions such as fixtures, shelves, computers or customer adaptation are called projects. These are handled by project managers who are situated at the application centers in those markets where it is located in the same country as the customer centers. In all other countries they work with the local project team at the CC. The duty of the project manager is to coordinate the work of the different personnel involved in the production, these can be engineers, electricians, programmers or assembly personnel.

A big difference between standard products and projects is that since projects are designed locally and for a one-time purpose they involve a high degree of local content. The project managers and their co-workers try to use the same parts from the same subcontractors every time, but no standard ACTA-solutions exist, except from parts being shipped via the PTD.

3 Frame of reference

The frame of reference is the theoretical backbone of the thesis. There are two types of theories presented. The first type is theories on how to understand the business of Atlas Copco Tools & Assembly Systems, namely theories on how to evaluate customer needs and industrial buying behavior. The second type is theories that will help us to understand the internal processes of ACTA and to form a more suitable market offer for the fixtured products. Those are theories on lean manufacturing, mass customization, modularized product design, and we end the chapter by giving a review of tools for aiding efficient customization.

3.1 Justification of chosen theories

As described above, there are mainly two types of theories presented in this chapter. It can however be hard to understand why we have chosen these theories and not other theories, as well as what we expect to achieve by presenting them. This first part of the frame of reference, which translates to the first two chapters, is there in order to understand and evaluate the business of ACTA. In the first chapter, we describe theories that can be applied to understand the customers' needs. We have chosen theories that concern how different criteria of a product relate to customer demands. The second chapter includes theories on industrial buying behavior. We present both general theories on industrial buying, but also industry specific studies, i.e. studies on how industrial buying is done in the motor vehicle industry.

The second part of the frame of reference concerns theories that translate the external demands of the environment into internal processes that answer to these demands. We chose the theories of mass customization because the products of ACTA are highly customized, but the company competes against small, local workshops and ACTA cannot use the same strategy as these small companies. A good way to combine customization with the size of a large, multinational company is mass customization. The following theories on product architecture, modularization and supporting tools for efficient customization are means to aid ACTA in implementing an effective mass customization strategy.

It should also be noted that the theories presented in this chapter are not only for the benefit of this thesis, but can also be used by ACTA personnel as a collection of theories on mass customization and modularization.

3.2 The nature of customer demands

“Everything is worth what its purchaser will pay for it” (Pubilius Syrus, 100 B.C.). This might be true, but since everyone strives to keep his or her costs down that price can hardly be identified. The best way to assess what the customer is willing to pay and, more important, for what, is to conduct some sort of demand evaluation.

When developing a product the customer objective needs to be kept in mind. Matzler et al. (1996) write: “An increase in the customer loyalty rate by 5 percent can increase the profit of a business by 100 percent due to the fact that satisfied customers purchase the products more often and in greater quantities…and are less price-sensitive…” But what satisfies a customer? Matzler et al. (1996) continue by describing Kano’s model of customer satisfaction (Figure 3-1).

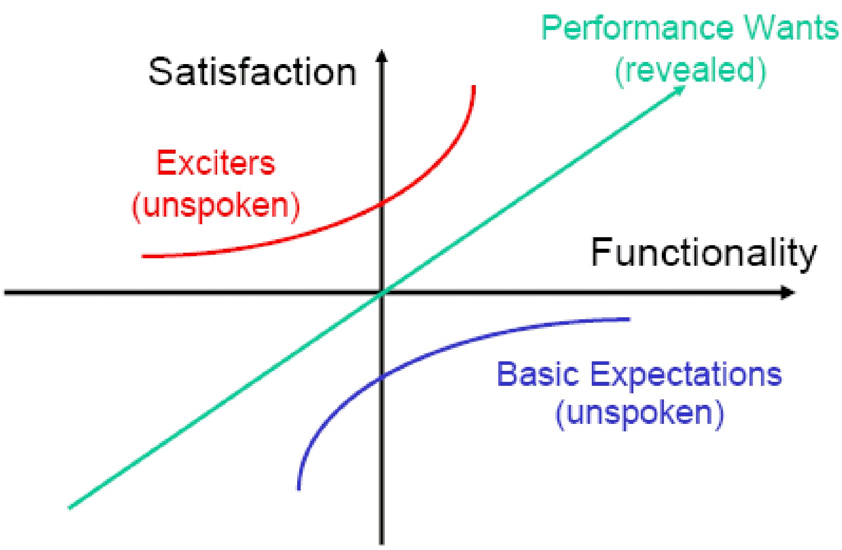

Figure 3-1. Kano’s model of customer satisfaction

The basic expectations, or must be requirements, are the basic criteria of a product. The failure of fulfilling one of these will lead to extreme dissatisfaction as they are taken for granted, but the fulfilling of them can never make the customer satisfied; only not dissatisfied. They are unspoken because they are implied, self-evident and obvious and are hence necessary if the product is even to be considered.

The fulfillment of performance wants, or one-dimensional requirements, proportionally gives customer satisfaction. These are explicitly demanded by the customers and are usually measurable and technical.

The third group, exciters or attractive requirement, has the greatest influence on customer satisfaction. They are neither explicit nor expected and are typically customer tailored or features that cause delight.

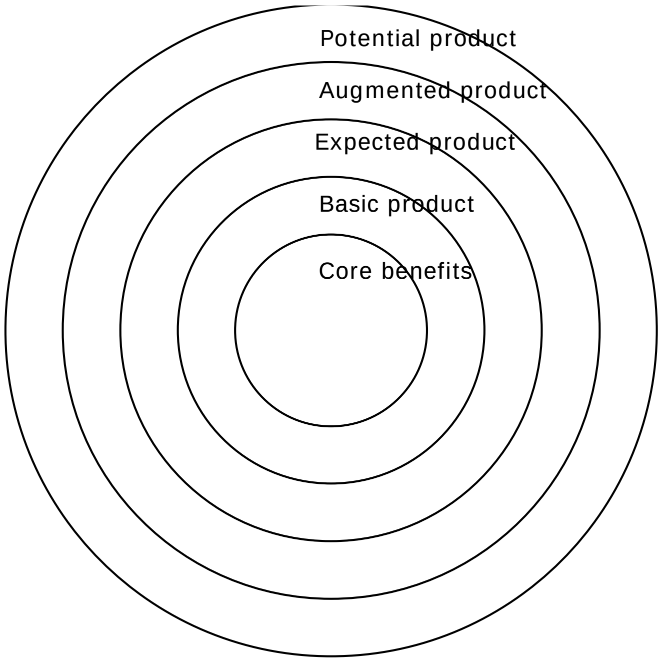

Figure 3-2. Kotler’s model of categorizing customer demands.

Kotler (2000) has a similar model of categorizing customer demands from core benefits, the reason of being for the product, via the basic product to potential product in five levels (Figure 3-2). The model constitutes a customer value hierarchy, with each level normally not only adding to customer satisfaction but also to internal costs.

3.3 The nature of industrial buying

3.3.1 Characteristics

Industrial buying is carried out on markets with some important differences from the consumer markets. Kotler (2000) has summarized the following differences:

Business markets are characterized by a low number of large buyers, a fact that has made close relationships common. The building of relations may also have been aided by the fact that the business buyers often are geographically concentrated. Since the demand for business goods is derived from the demand for consumer goods it is crucial for the business marketer to know the final consumers. In particular since the *acceleration effect* can make a small change in consumer demand lead to a huge change in business demand. The demand for many business goods is further inelastic; a reasonable price change in business goods is unlikely to affect demand. This of course assumes that all suppliers of a good changes their prices simultaneously, e.g. raw materials. Trained professionals carry out industrial buying and the need for technical information is therefore high. There are normally more people influencing business buying decisions, often grouped in some kind of buying committee. More people involved also mean more sales calls and often a more time-consuming buying process. Business buyers often buy directly from manufacturers, especially when buying technically complex products. Reciprocity, buying from a firm that in its turn is a customer of the buying firm, is common in business buying. The last characteristic of business buying is that leasing is common, in order to gain advantages such as newer products and financial benefits.

3.3.2 Buying situations

There are three types of buying situations that can occur in business buying; *new task*, *modified rebuy* and *straight rebuy*. The new task buying situation consists of several stages; awareness, interest, evaluation, trial and adoption. (Kotler 2000)

The *new task* buying situation, when the organization decides to buy a completely new product from a totally new supplier, is characterized by a high degree of uncertainty and risk since the product specifications need to be defined. Extensive problem solving and many involved functions characterize the situation. It is frequently occurring when acquiring capital goods. The *modified rebuy* normally involves less problem solving but the biggest difference is that it involves a lot less risk. This occurs when a new product is bought from a known supplier or a known product from a new supplier. *Straight rebuys* mostly concerns consumable items and are therefore not of particular interest for this thesis. (van Weele, 2002)

3.3.3 Buyers

All of those involved in the buying process are according to Kotler (2000) grouped in a virtual buying center, the decision-making unit of a buying organization. All its members play one or several of seven different generic roles in the center (Table 3-1). For a salesman it is fundamental to know who has the power and when he has it. This, since different people can possess decision-making power depending on what is bought and in what situation, e.g. a spare part bought in a preventive purpose or for acute repairing.

Table 3-1. Roles in the buying center according to Kotler (2000)

Generic roles in the buying center

- Initiators - those who recognize that a purchase can solve a problem.
- Users - those who will use the product.
- Influencers - those who provide information and criteria to evaluate the alternatives.
- Deciders - those who decide on requirements or suppliers.
- Approvers - those who authorize the proposed actions of deciders or buyers.
- Buyers - those who have the formal authority to select suppliers and arrange terms. Their main role is that as a negotiator.
- Gatekeepers - persons trough whom a seller has to go to reach the persons playing the other roles.

Everyone involved in the buying center, and the buyers in particular, are affected by a number of factors that can be grouped on the following levels: Environmental, organizational, interpersonal and individual level (Figure 3-3). (Kotler, 2000)

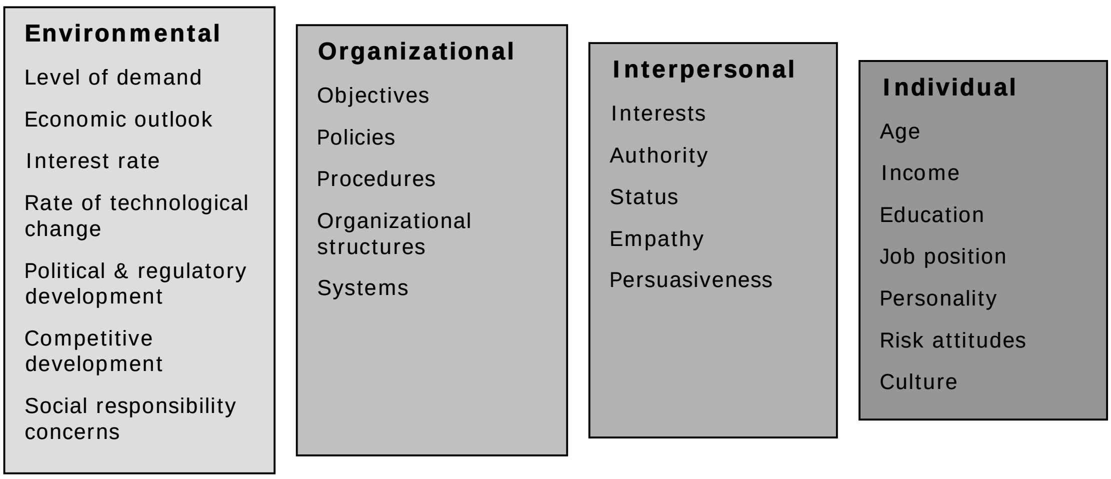

Figure 3-3. Factors affecting the buyer on different levels (Kotler, 2000).

3.3.4 Supplier selection criteria

Dickson (Krig & Stenström, 2001) conducted a query among 272 North American purchasers in order to find out what factors were important in a purchase. His study resulted in 23 selection criteria (Table 3-2).

Table 3-2. The buyer selection criteria according to Dickson

Rank	Factor	Mean rating
1	Quality	3,51
2	Delivery	3,42
3	Performance history	3,00
4	Warranties & claim policies	2,85
5	Production facilities & capacity	2,78
6	Price	2,76
7	Technical capability	2,55
8	Financial position	2,51
9	Procedural compliance	2,49
10	Communication system	2,43

With help from Dickson’s findings, Krig & Stenström (2001) ranked the top selection criteria for the two Swedish heavy truck manufacturers, Scania and Volvo. This study was made with a somewhat different approach than the one of Dickson, because of a different scope and with a desire to better reflect the present preferences. The study did show some criteria that were perceived as equally important by the two companies (Table 3-3). It must however be pointed out that the focus of the study was on repetitive buying. This is probably the reason why communication systems or Electronic Data Interchange (EDI) were perceived as extremely important.

Table 3-3. Top selction criteria for Scania & Volvo (Krig & Stenström, 2001)

Scania's evaluation	Selection criteria	Volvo's evaluation
Extreme importance	Environmental friendliness	Average importance
Extreme importance	Safety	Average importance
Extreme importance	Quality	Extreme importance
Extreme importance	Delivery	Extreme importance
Extreme importance	Communication system	Extreme importance
Considerable importance	Price	Extreme importance (top priority)
Considerable importance	Spare parts	Considerable importance
Considerable importance	Geographical location	Considerable importance
Average importance	Warranties & claim policies	Considerable importance
Average importance	Financial position	Average importance
N/A	Performance history	Considerable importance

Stalk et al (1996) state that the customers often choose between two options that have made different trade-offs, but they are often forced to choose between two options that have made the same compromises. The authors go as far as saying that the most important of these compromises are forced on the customers by companies that have lost touch with their customers' needs and that "finding and breaking those compromises can unleash new demand and create breakaway growth".

3.3.5 Purchasing engineering

Reducing time to market is an important issue in all industries, not at least in the automotive industry with its fast changes and intensifying international competition (Japanese ministry of economy trade and industry, 2003). van Weele (2002) says that among engineers and developers, the willingness to consider changes in materials and products will be limited once a suitable option is found. The reason is that an alternative choice will have to be tested and approved again, leading to a lot of extra work and risk. These costs rise over time as the product is being developed (Figure

3-4). These extra costs mean that the purchaser is locked in to the one solution chosen by the designers leading to difficulties in dealing with the supplier.

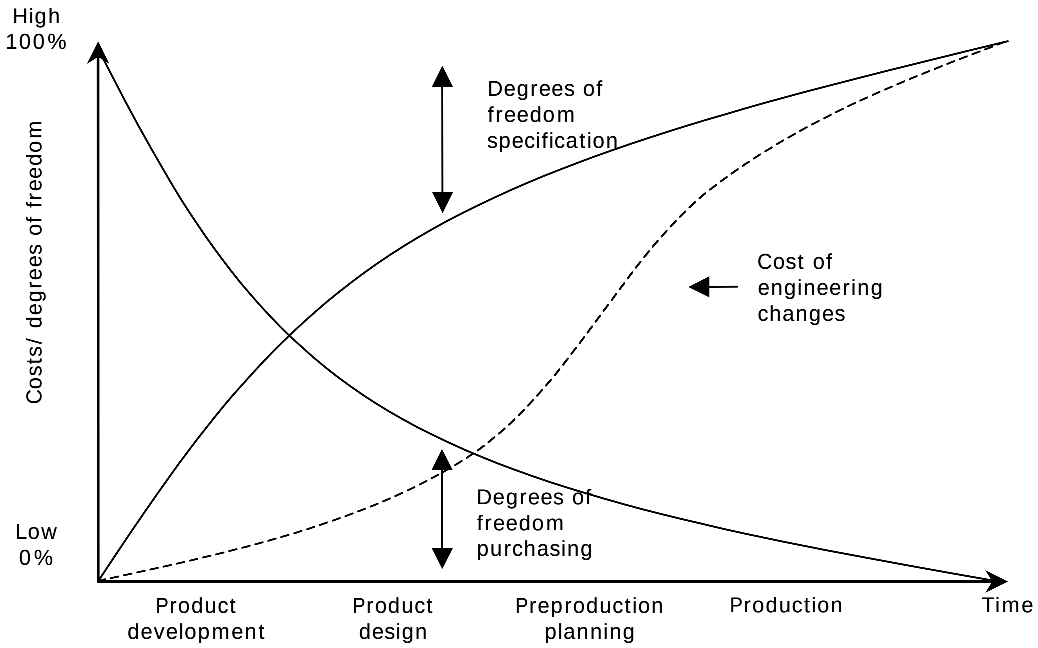

Figure 3-4. The degree of freedom of purchasing in the engingeering process. (Adopted from van Weele, 2002)

According to a survey conducted by Azzone & Masella (1991) time to market has a direct relationship to the possibility of creating greater value. The authors state that time can create value in two ways; directly through a higher market share and a premium price, and indirectly through widespread internal improvement of the company's efficiency and productivity. The indirect effects are positive side effects from a strive to reduce times within a company. The direct effects on the other hand come from something referred to as a "time elasticity of demand". This elasticity means that the demand and the potential profit are sensible to changes in lead times. Hence, the customers are willing to choose the product, and pay more for it than they would otherwise, if they can get what they ask for in a very short time.

3.3.6 Quality control

According to van Weele (2002) the emphasis in quality control has shifted from correction to prevention as a part of total quality management. This means the purchasing departments objective is to "…maintain and/or improve the quality of goods and services to be purchased." i.e. to select "...the supplier who can guarantee a sufficient level of quality" now and in the future. The study made by Krig & Stenström

(2001) affirms that Swedish heavy truck manufacturers puts top importance on quality, which complies with van Weele (2002), who says that the automotive industry is in the lead of the evolution of purchasing practice.

It is not so much quality, as the lack of it that costs money. Therefore, the concept of quality improvement can actually be used to initiate quality improvement initiatives (van Weele, 2002). Large corporations spend big sums on assuring their quality and with today's consciousness of quality issues in the motor vehicle industry, it is evident that suppliers with assured quality have a benefit.

van Weele presents *the total quality costs model* (Figure 3-5), which shows that increased quality of parts only reduces costs up to a certain degree. Then it starts costing money for the company. This degree is of course dependent on what the part is supposed to be used for. A relevant example is that automotive manufacturers are willing to spend a lot more on the fastening of a safety critical joint than a non-safety critical joint.

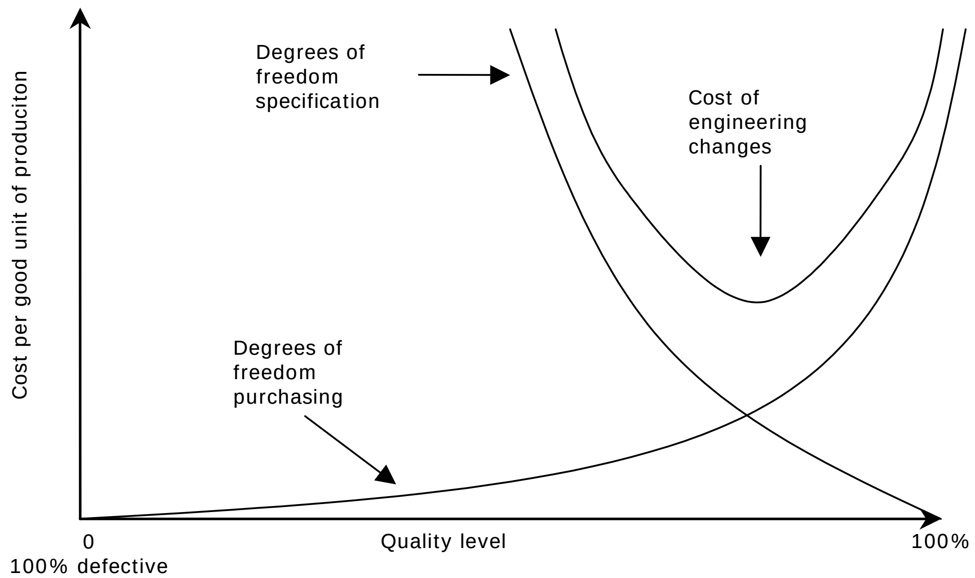

Figure 3-5. Juran's model of Optimum Quality Costs. Adopted from van Weele (2002).

3.4 Lean production

In 1990, James Womack, Daniel Jones and Daniel Roos launched a book, *The Machine That Changed the World*, in which they presented a new production principle that had been developed by Toyota. They labeled this new principle *lean production*, because it does more and more with less and less (Womack & Jones, 1996). Lean production can be seen as a contrast to mass production. One important word in the world of lean production is *muda*, which is a Japanese word that means waste. In lean production it specifically means “any human activity which absorbs resources but creates no value: mistakes which require rectification, production of items no one wants so that inventories and remaindered goods pile up, processing steps which aren’t actually needed, movement of employees and transport of goods from one place to another without any purpose, groups of people in a downstream activity standing around waiting because an upstream activity has not delivered on time, and goods and services which don’t meet the needs of the customer.” (Womack & Jones, 1996).

3.4.1 The five principles of lean production

By implementing lean thinking, the amount of *muda* can be reduced. Womack & Jones (1996) summarized lean thinking in five principles. The first principle is to *specify value*. The producer creates value, but only the final customer can define value. Companies tend to have a problem defining value, and often concentrate on making their processes as efficient as possible, although it might not be what the customer wants. One example is the aviation industry, which persists letting the customers travel to huge hubs to change planes, instead of letting the customers travel directly in small airplanes.

The second principle is to *identify the value stream*. The value stream is all the actions needed to bring a product through the three critical management tasks: the *problem-solving task*, the *information management task* and finally the *physical transformation task*. Analyzing the value stream will almost always show that three types of actions occur along the value stream. The first type is those actions that definitely create value, such as welding the tubes of a bicycle frame together. The second type is those actions that are found to create no value, but cannot be avoided with the current technologies, such as inspecting the welds to ensure quality (this is called type one *muda* in the terminology of Womack & Jones). The third type is those actions that create no value and can be easily avoidable (type two *muda*). If actions that can be defined as type two *muda* are identified, they should be eliminated as soon as possible.

The third principle of lean thinking is *flow*. Once the first two steps have been done and wasteful actions been eliminated, it is time to make the remaining value-creating steps *flow*. This usually involves a lot of changes in production, including the change from thinking of batches to thinking of flow. Henry Ford was the first to discover the world of flow when he introduced continuous flow in the production of the model T. However, he only found the special case with high volume products that used the same parts and tools, and were produced for many years. Taiichi Ohno, the executive at Toyota, who was the first to implement the techniques of lean thinking after World War II, addressed the general case with small-lot production of dozens or hundreds of copies and not millions. The companies that undergo the change from thinking in batches and queues to thinking in continuous flows undergo something that is called *kaikaku*, which is roughly translated to radical improvement. This is in contrast with *kaizen*, Japanese for continuous incremental improvement. *Kaikaku* usually implies effects such as doubling productivity and huge reduction in errors.

The fourth principle is *pull*. With reduced time through the value stream, the company can let the customers decide what they want and produce it on demand, instead of pushing through products that the customers have not asked for. This makes the demands of the customers more stable, since they know they can get what they want, when they want it.

The fifth, and final principle of lean thinking is *perfection*. When the first four steps have been carried out successfully, an interesting thing happens. The four initial principles start to interact in a virtuous circle. When the value flows faster, hidden *muda* in the value stream will be exposed, pulling harder will expose obstacles in the flow, and product teams working closely to the customer will be able to specify value more accurately. This is the *kaizen* part of the change, as opposed to the first, radical *kaikaku* bonus of implementing lean production.

Womack & Jones (1996) stress that implementing lean production is counterintuitive, but the benefits from implementing it are enormous. They also emphasize that the capital investments required are very modest and in some cases even negative, because bulky equipment and facilities can be freed and sold.

3.5 Mass customization

3.5.1 What is mass customization?

Mass customization is a way to mix the concepts of economy of scale with that of economy of scope. This makes it possible to produce at the low cost of mass production but still being able to produce individually customized products (Hart, 1995). It is also important to acknowledge the difference between product variety and mass customization. With product variety, you can satisfy more customers, but in contrast to mass customization, the customer has no possibility to influence the product properties and specifications. (Duray et al, 2000). This may seem as a subtle difference, but it shows a big difference in the way a company looks upon customer involvement in the product development process. A system of large product variety can be described as a *push system*, whereas a mass customization system mainly is a *pull system*, if the terminology of lean production is used.

3.5.2 Different types of mass customizers

There exist several different models on how to classify mass customizers. McCutcheon et al. (1994) use a three-dimensional model to determine a company's need for mass customization. The dimensions are *responsiveness*, *customization* and *differentiation stage* (Figure 3-6). The authors argue that when the demand for customization is low, a company can employ a *make-to-stock* (MTS) approach, which means that the short lead times will be realized by inventory. However, with a high demand for customization, such a strategy is very costly and inefficient and the authors present three different approaches to employ in that case – a *make-to-order* (MTO), an *assemble-to-order* (ATO) and a *build-to-forecast* (BTF) approach. The MTO approach is good when the customer is willing to wait for the product, which also means that the stage of product differentiation is of lesser importance. If delivery time is an issue, either an ATO- or a BTF approach can be employed. The former when the differentiation stage is late in the production process and the latter when the differentiation takes place early in the process.

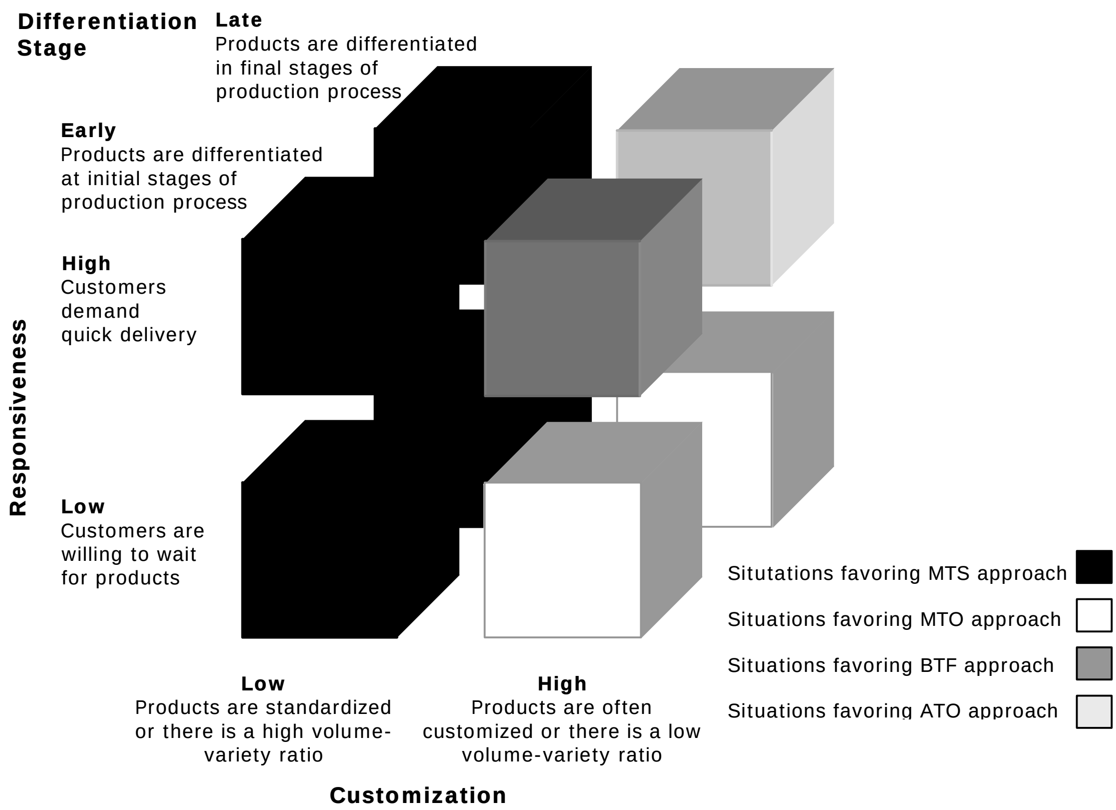

Figure 3-6. Classification of mass customizers according to McCutcheon et al. (1994)

Lampel & Mintzberg (1996) take on a different approach when defining mass customization. Their idea is that customization is an outside-in process that starts close to the customer with the customization of distribution. It continues upstream in the value chain to assembly, fabrication and finally design. With this they define five different strategies and thereby reach a continuum of customization strategies (Figure 3-7).

- Pure standardization: All of the processes are standardized and no distinction is made between different customers. Example: Ford model T

- Segmented standardization: The distribution is customized, letting the customer decide between different choices of the product. From the company's point of view, this means aggregating the customers in different market segments, thereby being able to give the customer a wider choice without loosing much on the standardized production. Example: Today's variety of cereal brands or the variety of automobile models that followed the model T.

- Customized standardization: When applying this strategy, both the distribution and the assembly is customized. The customers would specify their own products from standardized modules. Hence, the fabrication would still be standardized, but not the assembly. Example: Hamburger chains that offer the customer to specify their preferences for ketchup, mustard, tomatoes and so on.

- Tailored standardization: The company presents a standard model to the customer and adapts it to the customer's needs and requests. Example: Birthday cake with your name on it.

- Pure customization: In this strategy, customization is being used throughout the value chain and thereby giving the customer the most amount of freedom. Example: Large-scale production machinery or the Olympic Games.

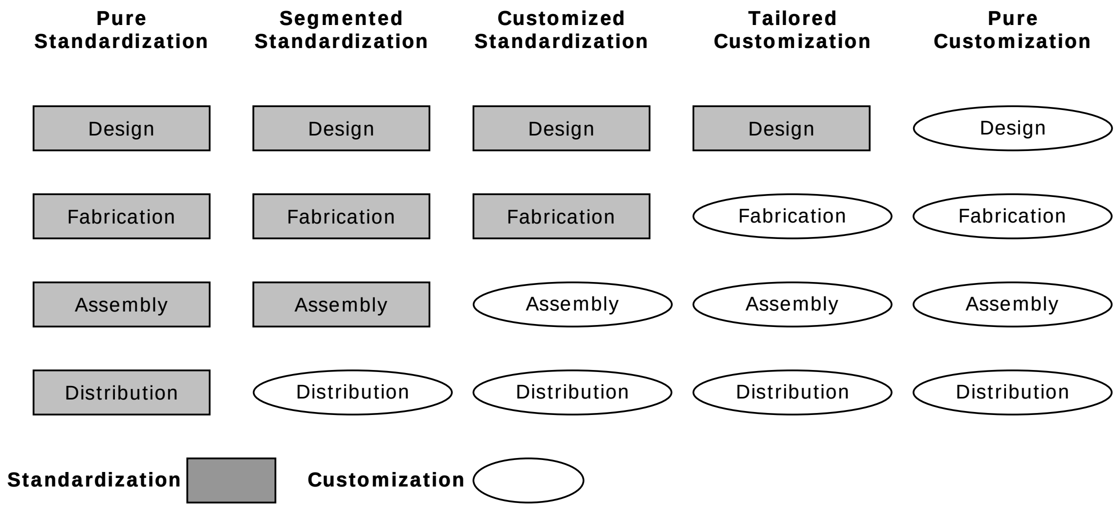

Figure 3-7. Different strategies according to Lampel & Mintzberg

Duray et al. (2000) developed the classification one step further. They argued that to be a competitive mass customizer you have to implement a modular product design. From this hypothesis, they developed a model consisting of two dimensions. One is point of customer involvement (complying with the model of Lampel & Mintzberg) and the other the type of modularity. With this, they were able to aggregate the mass customizers into four different, mutually exclusive archetypes (Figure 3-8). They also argue that with this model, it is possible to find companies that do not follow a mass customization strategy, although it may seem they do.

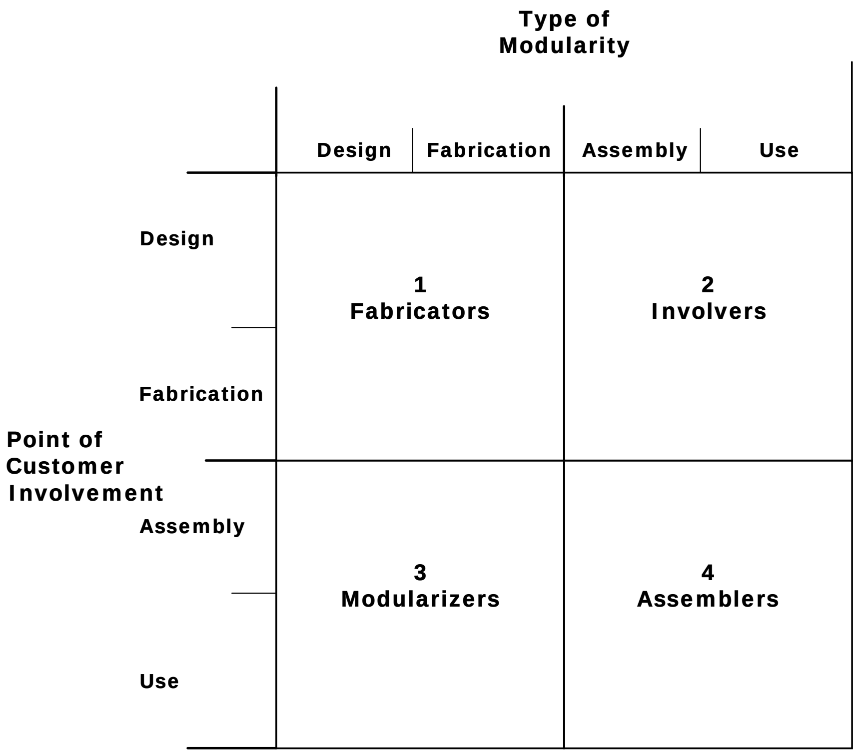

Figure 3-8. Classification of mass customizers according to Duray et al.

- Fabricators: In this group of companies, the customers are involved early in the process and it is possible for the customer to get specially designed modules. In addition, components can be custom made to fit the customers' need.

- Involvers: Also in this group, the customers are involved early. The difference to fabricators is that no new modules are being produced to specify particular needs. Instead, the customization is reached through a unique combination of standard modules.

- Modularizers: Companies in this group also use modules, but not primarily to achieve customization. The point of customer involvement is late and they can thereby use standardized modules to achieve component commonality between different products and a better economy of scale.

- Assemblers: This group matches a production system of a mass producer quite well. They produce the products out of standard modules and thereby reach a wide range of variety. However, by allowing the customer to specify the products from the modules they qualify as mass customizers (and not just mass producers with product variety).

3.6 Product Architecture

3.6.1 Different types of product architecture

Ulrich (1995) defines product architecture as:

- The arrangement of *functional elements.*
- The mapping from *functional elements* to *physical components.*
- The specification of the *interfaces* among interacting physical components.

The *functional elements* of a product are defined as what a product should do, such as “generate electricity”. The *physical components* are the parts that implement a product’s functions and they are often aggregated into physical building blocks, called *chunks* (Ulrich & Eppinger, 1995). Finally, all interacting components need to be connected by some sort of *interface*. These interfaces could be geometrical, as with the gears in a car, or may be non-contact as in the infrared remote control to the TV. Interfaces can be standardized (as the protocols for data transmission over the Internet), but do not need to be. By looking at the mapping of the functional elements to the physical components it is possible to classify different types of product architecture. Depending on how this mapping is done, two extremes can be distinguished – modular architecture and integral architecture (Ulrich, 1995). Modular architecture has the following two properties (Ulrich & Eppinger, 1995):

- Chunks implement one or a few functional elements in their entirety
- The interactions between the chunks are well defined and are generally fundamental to the primary functions of the products

An integral architecture, on the other hand, has one or more of the following properties:

- Functional elements of the product are implemented using more than one chunk
- A single chunk implements many functional elements
- The interactions between chunks are ill defined and may be incidental to the primary function of the products

Most products do not fit in any of these categories, but have some modular and some integral characteristics. Moreover, there is no way to say that one of the architectures is superior to the other – it all depends on the product and the way it is being produced. For example, they both offer the possibility of high variety, with the difference that with an integral architecture the production process needs to be flexible to be able to reach the variety, but with a modular architecture the design of the modules defines the scope of variety. However, if the product is complex and have large tooling costs or the components need to be made in large lot sizes due to high setup costs, there is little or no way to economically reach product variety with an integral design. (Ulrich, 1995)

3.6.2 Standardization

Component standardization is the use of the same components in multiple products. According to Ulrich (1995), "standardization can only arise when a component implements commonly useful functions and the interface to the component is identical across more than one different product." A modular architecture facilitates the use, or rather is a precondition to the use of standardized components, because the chunks only implement one or a few functional elements and the interfaces are clearly defined. In an integral architecture, components in one product would only be useful in another product with the exact same combination of functional elements. The use of standardized components affects such different areas as cost, product performance and product development.

In general, with the use of standardized components, they become cheaper (bigger quantities allow greater economies of scale etc.), but in some cases, they become more expensive. This happens when the effort to standardize leads to the use of components with excess capabilities being used. However, this standardization can be economically justified by the reduced complexity in inventory management, purchasing, quality control etc. The product performance can also be positively affected by the use of standardized components, since the component supplier is able to accumulate more experience about the component. Furthermore, standardized components can reduce the complexity in product development, which can reduce product development time. (Ulrich, 1995)

3.7 Modularization

Erixon (1998) defines modularization as "decomposition of a product into building blocks (modules) with specified interfaces, driven by company-specific reasons". In this chapter the concept of modularization and the implications of modular product design will be explained further. The reason for elaborating on modularization is, as stated in chapter 3.5.2 by Duray et al. (2000), that a modular architecture is a requirement to be a successful mass customizer. Moreover, Ulrich (1995), states that a modular architecture is a prerequisite for a high product variety when the products are complex.

3.7.1 Reasons to modularize

Modularizing a product is a costly process and consequently there have to be important reasons with positive effects of having modular product architecture. Östgren (1994) identified twelve generic reasons for a technical solution to be part of a module based on case studies in Swedish industry, which he called *module drivers*:

Product development and design

- Carry-over – the module will be used in a future product generation.
- Technology push – the module is likely to go through a major shift or improvement of technology during the product family lifecycle. This is often externally decided change, which are difficult to plan.
- Planned design changes – the module is scheduled to go trough some changes according to an internally decided plan.

Variance

- Different specification – the module varies in terms of function and performance between the product variants.
- Styling – the module varies in terms of color and shape between the product variants of the product family.

Production

- Common unit – the module will be used across the whole product family.
- Process/organization – the module suits a special process or has suitable work content for a group.

Quality

- Separate testing – the module should be tested separately.

Purchasing

- Strategic supplier – the module may be outsourced.

After sales

- Service / Maintenance – the module needs to be easily serviced and maintained during the life of the product.

- Upgrading – the module may be replaced for another part with different function or performance.

- Recycling – the module needs special attention when the product has served its life.

Additional module drivers

Gullander et al. (1999) suggest three additional module drivers. They argue that the module drivers of Östgren only consider technical aspects of the product. The additional module drivers suggested by Gullander et al. are:

- Local content demands – the buyer might have demands that some parts of the product must be produced locally. The reasons for this vary and can be everything from an interest in technology transfer from seller to buyer, to demands to be able to use a special local weapon system.

- Partnership demands – when two parties decide to develop a product together, the development and production can be facilitated with a modular product structure.

- Protection of core competence – to protect a company's core competencies, they can be concentrated in "fortress" modules to minimize the risk of loosing them. Another way to reach this goal is to design split-modules that are highly dependent on each other.

There may also exist several company-specific reasons for modularization such as strategy, financial limitations, legal restrictions, etc. (Erixon, 1998), which are not included in these generic module drivers.

3.7.2 Implications of a modular design

There are a number of identified effects and implications of introducing modular product architecture. However, it is important to address that the effects of modularization do not emerge *thanks to* modularization, but that they can be achieved by *using* modularization (Erixon et al., 1996). It is therefore of utmost important that the top management understands this issue and are clear as of what they want to achieve by modularizing the product.

Strategic implications of modularization

The modularization of a product does not only have implications on the product itself, but also will affect the company's processes and structure in a number of different ways. A company must always be able to answer to quick changes in the market and in changing technology, but to compete in a modular world, the company also has to keep the interfaces between the modules intact. One way to address this problem is to have a modular organization structure with independent developers. To make sure the teams develop modules that can be integrated in one final design, a strong leadership is required. (Baldwin & Clark, 1997)

Quantifiable effects of modularization

Erixon et al. (1994) examined some of the effects of modularization at a few different companies and found several interesting facts (Table 3-4).

Table 3-4. Cost reduction thanks to modularization in %. (+) indicates improvement but not possible to quantify or a measured improvement the company did not want to publish. Adopted from Erixon (1998).

	Electrolux kitchen	FMG	Geotronics	Isaberg	Scania	Volvo	Sepson	Electrolux major appl.	Median	Range
Lead time in assembly	61	33	73	+	50		58	10	54	10-73
Total inventory	+	57	65	+	+		+	+	61	57-65
Assembly time	+	48		+	20	60	37	10	37	10-60
Direct material	+			6	0	-3	+	10	6	-3-10
Logistics	+	+		+	+	-75	+	30	-22	-75-30
Quality	+	+	37	+	75		+	+	56	37-75
Product develop. time	30	+	+			+		60	45	30-60

Lead time reduction

If a product is modularized, it is possible to have a parallel instead of a sequential assembly, which reduces the lead time in the assembly.

Total inventory

Total inventory consists of two parts – work in progress (WIP) and inventory of finished goods. In the studied companies, the lead time reduction has lead to a decrease of WIP as well as a decrease in the inventory of finished goods. The latter has further been reduced thanks to a well-designed modularity, which has lead to fewer components with larger volumes. This has made it possible to reduce the safety stock.

Assembly time

Not only the lead time, but also the total assembly time can be reduced through modularization. This can be reached with a well-designed interface between the modules, together with a reduction of the total number of components in each module.

Direct material

By modularization it is possible to reduce the number of components. This can lead to larger volumes of the purchased components, which indirectly could mean a reduction in procurement costs.

Logistics

A common result of modularization is a decrease in the number of different articles. Nilsson (1990) conducted a study together with several large Swedish industrial companies (former Atlas Copco Tools was one of them) and found that the average cost of introducing a new part number is *at least* 46 000 SEK and the cost for maintaining it ranges from 6 000 SEK per year and up.

Quality

If it is possible to test the function of each module before final assembly, it will reduce the number of defects as well as reduce the time to correct them.

Product development time

If the interfaces between the modules are decided upon early in the development, the modules can be developed at the same time, thereby reducing the product development time.

Nonquantifiable effects of modularization

Apart from the effects presented in the last chapter, Erixon et al. (1994) have identified effects of modularization that are not as easy to quantify. Although not as easy to verify, they could be the decisive ones in the choice whether to modularize a product or not.

Possibility to automatize

One of the effects of a modular product is the possibility to have common submodules, which will be produced in larger quantities than the final product variants. This can make it economically justifiable to invest in systems for automatic assembly.

Easier design of a customized product

For companies with a high degree of customized products, the quotation process can be facilitated. It will be possible to construct a customer specific product from standardized building blocks, which in turn have an internal price that easily can be added up to a price of the product.

3.7.3 When not to modularize?

Although there are many positive effects when a company modularizes its products, there exist certain cases when a company should consider not to modularize its products. Erixon et al. (1994) identify three different cases when modular design could be inferior to integrated design. The first case is when the products are truly specialized and the functional resemblance between the products is very low, which means that the extra development costs for a modularized product could exceed the gains from modularization. The second case is when the product should have a technical optimization such as a specific power/weight ratio, because modularization could increase the weight of the products. The third case is when the product is a simple, high volume product without the need of much development within the next few years.

3.7.4 How to modularize a product

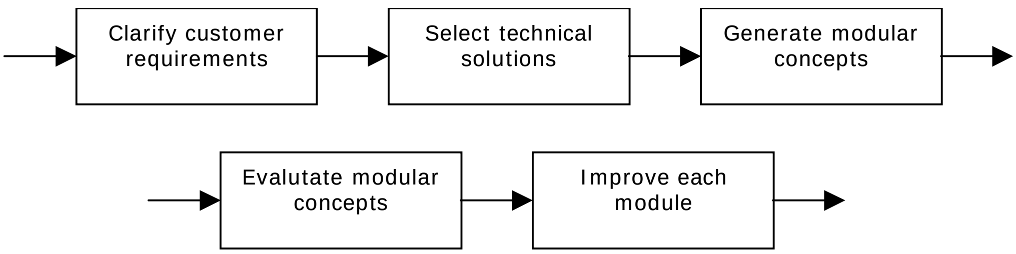

Figure 3-9. Modular Function Deployment, MFD. The first and last arrow symbolize that product development is an iterative and never-ending process

Developing modular products is much more difficult than developing the same products without having to regard the complexity of modularity. However, during the last ten years, there have been many advances, which have facilitated the design of modular products. One of these is the advances in computer technology, which have made it possible to process and store the vast amount of data needed to develop and control a modular design process (Baldwin & Clark, 1997). Another advance is the development of structured rules on how to design a modular product. Erixon (1998) has developed a method called Modular Function Deployment (MFD), which tries to structure and systemize the development process for modular products. The method tries to translate and transform customer needs into actual design parameters and to optimize them with regard to modularity. The method includes five steps (Figure 3-9). The causality of the process is only a model – in reality, all product development is an iterative process and the steps must not be made in the order presented below. A more thorough presentation of the MFD process can be found in appendix A.

3.8 Supporting tools for efficient customization

Important capabilities for companies that produce and deliver highly customized products are effective and efficient design, quotation and negotiation stages. To achieve this, the information flow has to be fast and accurate. Moreover, the coordination between project management and production is important in order to be able to deliver *what* the customer want, *when* the customer wants it (Kritchanchai & MacCarthy, 1999).

If a company wants to pursue a mass customization strategy, it is important that the whole value stream is efficient and responds quickly to the needs of the customer. The implementation of modular product architecture is just a stepping-stone to be an efficient mass customizer. According to Pine et al. (1993), there are four key attributes to make mass customization work:

1. *Instantaneous*. The product the customer wants has to be defined rapidly and translated into design criteria. Then the design criteria are quickly translated into a set of processes, which are integrated to form a product or service.

2. *Costless*. Once the system has been set up, it must add as little as possible to the cost of making the product.

3. *Seamless*. If there are seams in the organization, there will be seams in the product, such as programs or software that do not work well together.

4. *Frictionless*. The need to create instant teams for every customer leaves no time for any friction between the team members.

Where Pine et al. (1993) take on a more holistic view of the company, Sivard (2000) looks more on the actual process of quoting and producing a product. According to Sivard (2000), an efficient order process is the key to achieve efficient customization and the order process issues include:

- Flexible manufacturing and sales-delivery process – to achieve a process in which variety is easy to realize.
- Efficient configuration of a variant – to support the specification of a particular variant, from customer need to manufacturing specification.
- Flexible architecture, processes and information management – to adapt to fast changes in markets and technologies.

Sivard (2000) further states that from an information management point of view, the order process can be summarized in:

1. Sales configuration – identifying the customer's wishes and specifying a product based on these.
2. Product configuration – generating a manufacturing documentation based on the product specification.
3. Resource and process planning – planning the total materials and resource flow in the manufacturing process based on batches of several orders.

The order process could be made manually, but to make the order process costless, a computerized configuration system must be implemented. Configuration is a way to generate a product based on sets of requirements and component alternatives. It can informally be summarized with two key features (Sabin & Weigel, 1999):

- The product to be configured is assembled from a fixed set of well-defined components types.
- Components interact with each other in a predefined way.

With different requirements or building blocks, different products will be generated (Sivard, 2000). Building a configuration system generally includes two phases – the description of the domain knowledge and the specification of the desired product

(Sabin & Weigel, 1999). The domain knowledge describes the objects of the application and the relations among them, where the product specification describes the requirements that need to be fulfilled by the product. The solution has to produce the list of selected components, and the structure and topology of the product. These are exactly the same documents that are produced traditionally by a designer. Most of the complexity of configuration lies in defining the domain knowledge.

3.8.1 Supporting tool at Sandvik Coromant

Sandvik Coromant, a Swedish manufacturer of cutting tools for the metalworking industry, has implemented configuration software. They call the system *Tailor Made* and it is used to produce special tools based on dimensions specified by the customers. With the software, the salesmen can configure the tools according to the customer's wishes and usually within just a few minutes the quotation is made together with the unique drawing of the tool as well as process data. If the customer decides to order the product, the process data is sent to the plant and the tool will be produced (Figure 3-10). The process starts by the salesman entering the customer's specifications through a user interface and these specifications are processed in the CAPP (Computer Aided Process Planning), the “brain” of the system. The CAPP produces information to the customers in terms of price, possible delivery date and a proposal drawing. It also creates drawings and NC programs for the production as well as plan when the product should be produced, i.e. process planning.

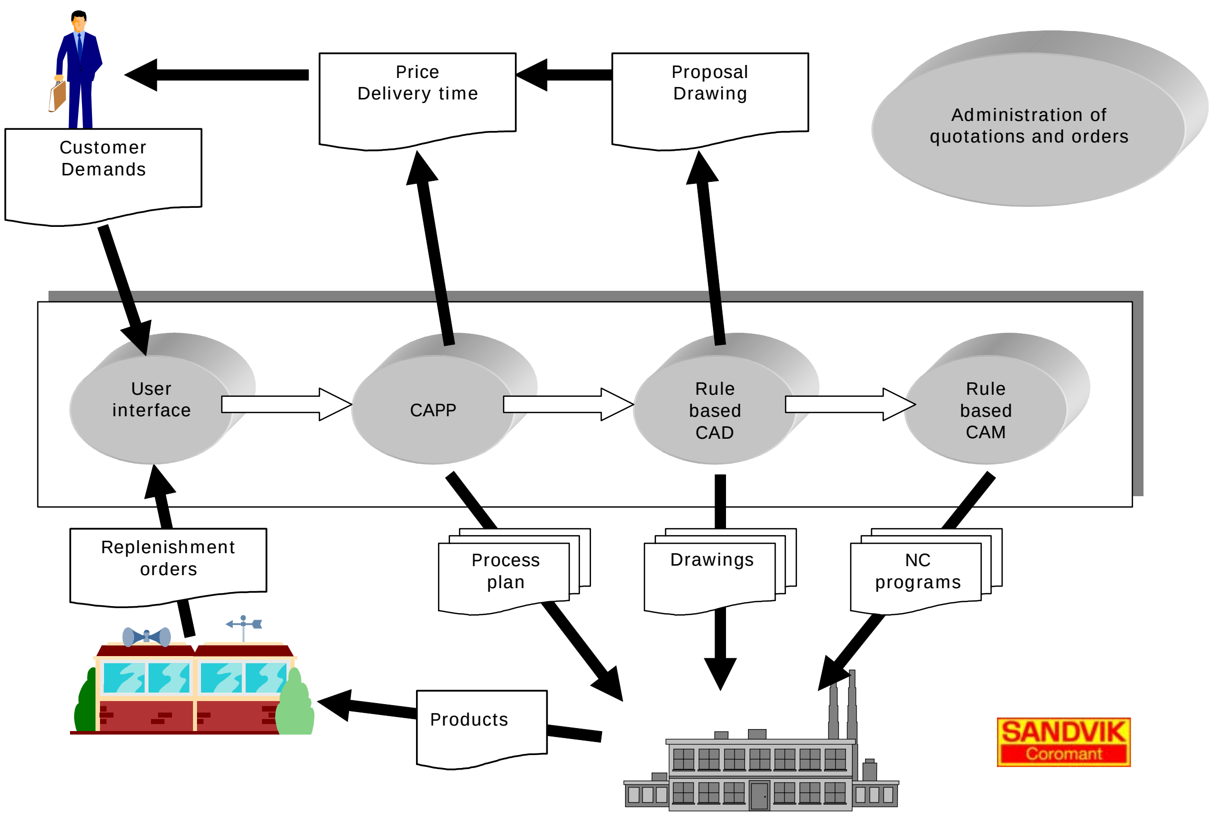

Figure 3-10. The *Tailor Made* system of Sandvik Coromant.

With the Tailor Made system, Sandvik Coromant has been able to centralize the production of specialized tools, which used to be produced locally. They estimate that 80 % of all the special tools go through the Tailor Made system today. Another benefit they have achieved by this system is the reductions of manual work in the quoting process. This is especially important, because the hit rate of the quotes is not 100 %, meaning that there are several quotes that just cost money for each quotation that becomes an order. The drawback with Tailor Made is the initial cost to design a tool. Behind the Tailor Made system lies rule-based design, which is a way to represent many possible alternatives within a product family in a compact way. It is a lot more costly to design a tool according to rule-based design than to design it in a traditional manner. This means that for each product family, a cost analysis must be made to find out if it is worth the effort to design the family with rule-based design.

The Tailor Made system fulfills the key attributes of Pine et al. (1993). It is instantaneous (the customer gets a quote within a few minutes), costless (once the product family is designed, there are no extra costs involved), and seamless (it is a worldwide system and the products can be produced at any of their factories). The last attribute, frictionless, is not really applicable to Sandvik Coromant, because there is no need to form teams to produce the products. The implementation of configuration systems is in analogy with the principles of lean production (chapter 3.4), which emphasizes the elimination of all actions that do not produce value.

3.9 Synthesis of theories presented

This chapter contains many different theories and it can be hard to understand how they interact. Therefore, we have tried to clarify their interrelations in the figure below (Figure 3-11). Industrial buying, the circle in the middle of the figure, is the situation in which Atlas Copco Tools & Assembly Systems and the customers interact on the market. Both parties are affected by the market and affect the way it is shaped.

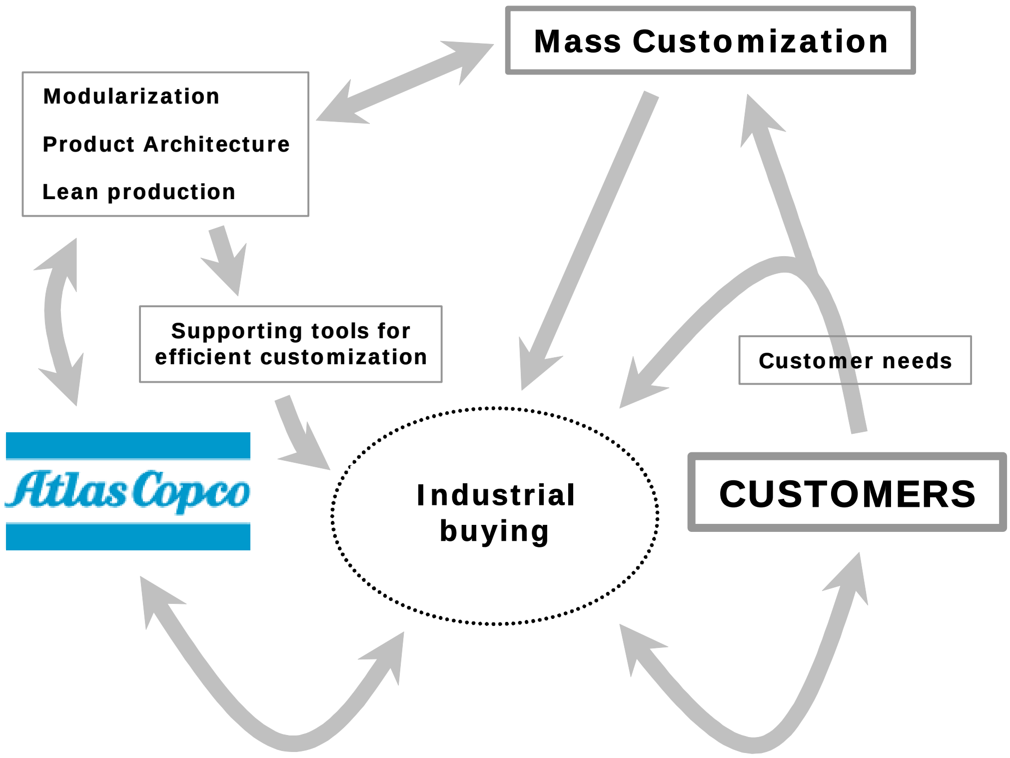

Figure 3-11. Relationship between theories presented in the frame of reference. The arrows indicate how different theories influence each other.

The main strategy presented in the frame of reference is mass customization, which, as described earlier, is a good way to combine the benefits of customization with those of mass production. To form a mass customization strategy, there are two major inputs – the customer needs and the internal processes of the company. Mass customization does, in turn, also influence both the internal processes of the company and the market where it is acting. Finally, the theories on supporting tools for efficient customization present a way to use the benefits of a more standardized and modular architecture in the sales and production processes.

4 Model

This chapter presents the working model that has been used when writing the thesis. The chapter also contains the specified research questions that will be answered later in the study. With help from the frame of reference, the specified research questions have been chosen to get important answers in order to fulfill the purpose.

4.1 Model

Lekvall & Wahlbin (2001) suggest a U-shaped model to define the steps in a study. This model is based on the generic steps in a marketing survey, but thanks to their scientific approach it is useful in most types of research.

The model clearly shows the relations between the different steps of a study and illustrates the order of the steps. It also illustrates the level of abstraction in the work process, as both the problem and the solution are on a more holistic level than the data gathered in the field study.

The first task the researcher faces according to Lekvall & Wahlbin (2001) is a *problem analysis*. This work consists of delimiting and precising the *problem*, identifying the goals with the decision, and making a diagnosis of the problem. If it would result in sufficient material for making a decision that would solve the problem, the study would stop there. If not, the researcher would need to specify the information needed and define the *purpose* for a study enabling the decision.

The next task is to *specify the task* since the purpose of the study often is very condensed. This work is normally done trough a pre-study – a study that forms the frame of reference and results in the *specified task of investigation*.

To assure high standards of the investigation it is important to consider the *approach, method* and *technique* used and to *plan the field-study* and the following *analysis*. This phase results in a *plan of investigation*.

When the *field study* and *data collection* phase is finished the researcher has a *collection of raw data*. The primary analysis of this data should correspond to the more detailed specified task of investigation and thus be prepared for *further analysis* and *interpretation*.

At this stage the *conclusions* can be drawn and these should naturally correspond to the purpose defined in the beginning of the study. When the conclusions are drawn, enough material to make a decision should be at hand, which leaves the last task to *make recommendations* on how the original problem should be solved.

4.1.1 Our model

In this thesis the market perspective is central and therefore, we decided to make use of the model of Lekvall & Wahlbin (2001), with minor modifications (Figure 4-1). Together with our supervisor at ACTA we formulated the problem this thesis is supposed to answer and discussed the problem leading up to the purpose.

Our frame of reference is mostly built up around literature on subjects we found relevant and interviews with people with experiences on the topic. In this phase we had good help from our supervisor from university and from discussions with people within ACTA. Gathering raw data will be done according to the methodology chapter and will be carried out by interviewing ACTA personnel and customers in Sweden and in the USA. Our analysis and conclusions will result in a proposal for a market offer of fixtured products for ACTA and a plan of action of how to construct that offer. It will also include estimations and an evaluation of the proposal and its feasibility.

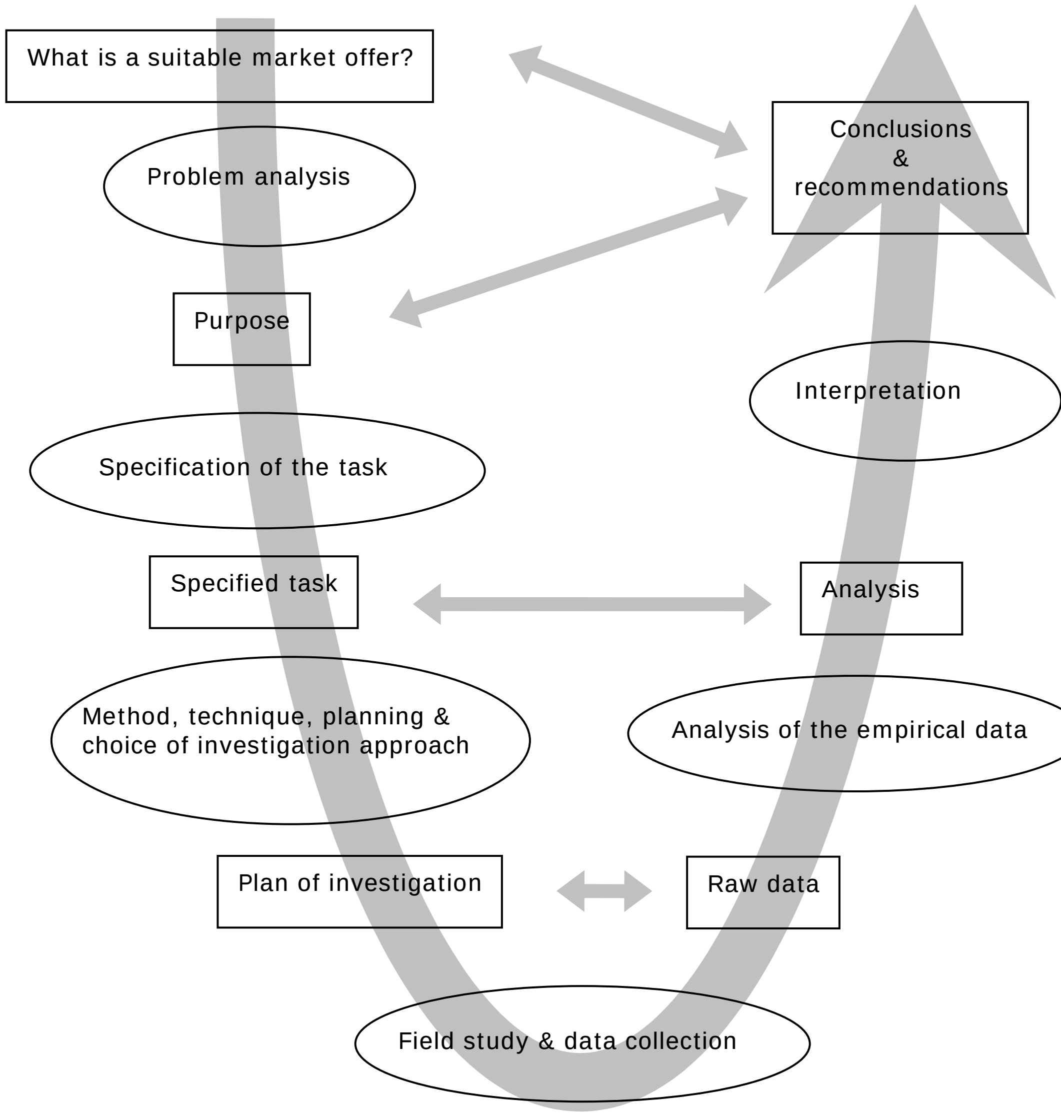

Figure 4-1. Our work process. Modified from Lekvall & Wahlbin (2001). Each square on the left side of the "U" corresponds to a square on the right side of the "U".

4.2 Specification of the task

4.2.1 Specified research questions

The research questions below have been developed in order to gather needed information. With that information, together with our frame of reference, we believe that we will have enough information to be able to fulfill the objectives and the purpose of this thesis.

1. What does ACTA offer the customers today?
2. How do the customers perceive the market offer of ACTA?
3. What are the customers' demands and wishes and are they being satisfied?
4. What internal processes affect the market offer and how do they affect it?
5. How flexible are the processes of ACTA & how prepared is the organization for a change?
6. What internal demands does ACTA have on the market offer?

Questions one trough three concerns the offer and how the customers perceive it. In order to evaluate today's market offer, we need to find out what ACTA actually is selling. As there does not seem to exist any record with information of prior sales, we need to collect it ourselves. We also need to know if the market offer satisfies the customers' demand and if it is presented to and perceived by the customers in the way that ACTA wishes to. Furthermore, the products are presented as being customized special products and we intend to find out to what extent that is true.

According to the literature on modularization, internal commitment to the task and processes that are suited for modular production are highly important for the success of a modularized concept. Therefore, if modularization is to be carried out, questions four trough six need to be answered. According to the personnel, the offer of ACTA is already partly modularized. We need to know to what extent that is true and if so, if the internal processes make use of that advantage. We also need to know if ACTA is ready to introduce a new market offer or if processes need to be changed. The factors that could hinder a new offer can be anything from a bottleneck in production to a certain degree of customization.

5 Methodology

While the frame of reference is about the scientific content of the thesis, the methodology is about the scientific approach to writing the thesis. This chapter contains a discussion on how a study is to be conducted by referring to theory as well as a presentation of our approach to scientific work.

5.1 Orientation of a study

Before conducting a study, it is of great importance to define its orientation, scope and how it is supposed to help in the process of gaining knowledge.

Lekvall & Wahlbin (2001) define four different orientations of a study:

- **Explorative** studies are used to gather basic knowledge. They are commonly used in order to better understand a field of knowledge to be able to continue research with further studies. An explorative study can be a proper study with all normal components, part of defining the task in another study or a combination of the two, as often is the case in bigger academic studies.

- **Descriptive** studies are meant to describe actual conditions. This kind of study has a low level of analysis since it basically just involves the collection and structuring of data. It can however be very complex if the data is abstract.

- **Explaining** studies clarify causal connections and thereby how certain factors affect identified conditions. When conducting a study of this type, a small number of known variables is often of primary interest. Therefore, this approach calls for careful and demanding preparations in order to reach the best results possible.

- **Predicting** studies are meant to predict the outcome of a certain set of conditions. This kind of study does not call for knowledge of all causal connections, but that knowledge would help to validate the results

As can be seen these four types demand an increasing level of prior knowledge. First after obtaining a basic knowledge, it is possible to construct a descriptive model and so on.

A study can be divided into **repetitive** and **one-time** studies. Repetitive studies are of particular interest when a pattern needs to be identified over time, e.g. measurement of performance before and after a marketing effort. A one-time survey on the other hand is more interesting when something needs to be clarified or identified.

5.1.1 Our orientation

The purpose of this thesis calls for a *predicting* study. We will try to identify a new market offer that will increase the profitability and give more customer benefits. This means that we have to predict how a new market offer will be perceived by the customers and how the internal processes would be affected by the change. As explained above, a predicting study is the most demanding one in terms of prior knowledge, which means that we in fact will conduct all of the four different orientations of a study. To be able to propose a new market offer, we need to understand what is being sold today and how the internal processes affects today's offer.

The whole study will be a *one-time* study, because we are not trying to identify any patterns in the market. Instead, we try to identify the market as it is today and propose a new market offer that will be more beneficial to the customers'- as well as the internal needs of today.

5.2 Approach

5.2.1 Methodological approaches

Arbnor & Bjerke (1994) have identified three different methodologies to approach a business economical problem:

- The researcher who uses the **analytical** approach assumes that the reality is objective and hence he can obtain the absolute truth. This approach further assumes that the whole is the sum of the parts.

- By using the **system** approach, the researcher however assumes that relationships between the parts affect the whole through synergy. This means that it is of great importance to keep the whole of the system in mind as it consists of the characteristics of the parts and the combination of the parts. Results obtained from one system cannot automatically be generalized because of the systems' uniqueness. This is the most common approach among Scandinavian business economists.

- A researcher who has adopted the **actors** approach cannot explain knowledge since the approach defines reality as a social construction. The approach hence only offers an understanding of knowledge.

5.2.2 Approaches to investigation

There are according to Lekvall & Wahlbin (2001) two major dimensions in which to define a study. The first concerns if a few cases are to be studied in depth or if many cases are to be studied on the surface. The second concerns if the data and methods of analysis will be of a qualitative or quantitative nature.

Type of study

An in-depth study of only a few cases is called a **case** study. This is often used when the aim is to understand the reasoning of the interviewees. It is difficult to generalize the results from a study with this approach since they give a broad and complex explanation of the cases studied; the form even gives the investigator the possibility to discover new and unexpected facts. For these reasons it is often used in explorative studies. Either typical or extreme respondents can be chosen for a case study, depending on what the researcher wants to find out.

A study of a large number of respondents is often made as a **cross sectional** study. In this kind of study, it is necessary that all data needed for evaluation has been collected from all respondents. If changes are made during the time of the study or if data is missing from some respondents, a judgment will have to be made if the results still are viable for the whole segment. A cross sectional approach is often used in descriptive studies since it gives the researcher the ability to generalize over a larger group than the one of the respondents. It can also be used in explaining studies if one set of variables in the collected material is compared to another set. Cross sectional studies can further be split up into survey studies, comparing different individuals/groups, and experimental studies, comparing different solutions.

A third type of study can also be identified, a **time series** study. This type examines the research objects over time. Typically, the studied variables and research-objects are limited in quantity.

Data and its interpretation

Data expressed with **quantitative** methods is typically numbers and objective information. Data that is expressed **qualitatively** on the other hand is more likely to be subjective as its interpretation can differ a lot between individuals. It can take the form of words or images.

Expressing data is however only a start. Its interpretation can further be made both quantitatively and qualitatively, depending on if the researcher wants to present the results as hard facts or qualified interpretations.

5.2.3 Our approach

Since this thesis demands an understanding of different actors' views; technicians', buyers' and developers', and the sum of their acting, synergies are highly interesting. We have therefore chosen the *system approach*.

To understand all the things explained in the last paragraph and how they interact, a large-scale *case study* will be conducted and the data will be expressed and interpreted *qualitatively*. A case study of that magnitude will benefit from advantages such as the freedom given by the case approach at the same time as it offers some possibilities to draw conclusions about a larger population. The system approach also states the need for the researcher to be present in the studied system to gather data and gain understanding. Therefore, we need to be open to synergies in the form of other combinations and solutions, and maybe even adapt some data in the analysis – something that calls for a flexible approach.

5.3 Gathering data

According to Lekvall & Wahlbin (2001), data sources are divided into primary and secondary, where secondary data is previous work in written form. Secondary data is an important source of information and a researcher with a high level of integrity can get good results from this kind of data. However, in many cases it is necessary to gather primary data. Lekvall & Wahlbin (2001) have defined **observation** and **communication** as the main methods to gather primary data for marketing purposes.

- **Observation** is a reliable method but it has obvious limits since it only can be used to study behaviors and current events. Past and future events as well as the knowledge, views and values cannot be gathered using this method.

- **Communication** can be made trough a questionnaire, by telephone or as a personal interview. The way of posing questions and responding to them is often the same in all of these different forms, but they do imply important differences in cost, speed, control and possibility to adapt to the situation.

The differences in cost, speed, control, and possibility to adapt often mean that the way of gathering data depends on what kind of study is to be conducted. A case study is best conducted through a combination of observation and communication, with personal interviews as the most significant input, whereas a cross sectional study of scope is better conducted trough written questionnaires. All different ways of gathering data can be conducted in more or less structured ways making them more or less suitable for comparative studies.

There are several methods for making a sample of respondents to a study. **Probabilistic** methods render a sample from which statistically viable results can be reached. **Non-probabilistic** methods on the contrary, e.g. convenience samples, can be more interesting for the study despite the fact that generalization cannot be made with help from the sample. (Lekvall & Wahlbin, 2001)

When conducting a study in a business-to-business environment where relationships are much more common it can however be more interesting to concentrate the study to customers to whom ties and relations are stronger. (Ottosson, 1993)

5.3.1 Our way of gathering data

We will primarily use *communication* as our way to gather data and it will be through personal interviews. The way these interviews will be conducted is explained in chapter 5.4. We will use a *non-probabilistic* method to render our sample. The reason for this is that it would be impossible for us to consider more than a few different customers, because of the time frame. However, internally, we will try to talk to people from several different areas to see the problems from different perspectives and hopefully get a more unbiased view of the situation. In total, we plan to interview roughly thirty people, both people within and outside of ACTA.

Due to our low knowledge, the large variety of the final products at ACTA, and the lack of a database with historical data, we will need to talk to salesmen to identify what they actually are selling. Furthermore, we will need to talk to people internally at ACTA – in Sweden as well as at the application centers – in order to fully understand the internal processes behind an ordered fixtured product. We will also need to talk to salesmen and customers to find out if the customers' needs are fulfilled.

5.4 Interview technique

When conducting any type of scientific research that involves interviews, it is important to have a firm methodology before starting the interviews. Kvale (1997) defines seven stages of an interview study (Table 5-1). The linearity in the interview process does not imply a linear process in the qualitative study, but is merely there to give a structure to a chaotic process.

Table 5-1. The seven stages of an interview study. Adopted from Kvale (1997).

1. **Discussion of the theme of the study.** Describe the purpose of the study and the background of the topic to be studied.
2. **Planning.** Plan all the seven stages of the study.
3. **Interview.** Conduct the interviews with the use of an interview guide.
4. **Print-out.** Prepare the material for analysis, which usually includes a written transcript of the interviews.
5. **Analysis.** Decide what type of analysis method to use, depending on the purpose and topic of the study as well as the interview material.
6. **Verification.** Determine the validity, reliability as well as the generalization of the result of the interviews.
7. **Reporting.** Report the result of the survey and the used methods in accordance to scientific criteria.

5.4.1 The interview guide

The interview guide or questionnaire is a tool for the interviewer when conducting the interviews. Depending on the type of study, it can be differently detailed. In an **unstructured** interview, the questionnaire merely consists of a checklist to guide the interviewer and lets the interviewer modify the interview after the circumstances. This is a preferred method when little is known of the subject such as an explorative study. The opposite is a **structured** interview, where the interviewer is forced to follow the questionnaire, which consists of highly detailed questions. This method is preferred when conducting many interviews that need to be compared (Hague, 1992). Finally, there is a mix of the two, called **semi-structured** interviews. In this type of interviews, the interview guide briefly describes the topics of the interview and suggestions of questions to be asked. It allows the interviewer to ask follow-up questions, but not as freely as in an unstructured interview (Kvale, 1997). Semi-structured interviews are used widely in business-to-business interviewing where it is necessary to maintain some flexibility to allow for the wide differences that exist between respondent firms (Hague, 1992).

Each question during an interview should be judged both **thematically** and **dynamically**. In the thematic dimension, it is examined how the question relates to the topic being studied. In the dynamic dimension, it is not the topic that is important, but in what way the question creates a positive atmosphere between the interviewer and the interviewee. This means that a good thematic question does not need to be a good dynamic one and vice versa (Kvale, 1997).

5.4.2 The quality of the interview

Because the interview is the raw material to the analysis, the quality of the total survey will be affected greatly if the quality of the original interviews is low. There are however some criteria according to which it is possible to judge the quality of an interview (Table 5-2).

Table 5-2. Interview quality criteria. Adopted from Kvale (1997)

- The extent of spontaneous, specific and relevant answers from the interviewee.
- The shorter interview questions and the longer answers, the better.
- To what degree the interviewer clarifies and follows up the answers.
- The ideal interview is mainly interpreted during the interview.
- The interviewer tries to verify his/her interpretations of the interviewee's answers during the interview.
- The interview is “self-communicating” – it is a story in itself and does not need a lot of extra explanations.

5.4.3 Methods for interview analysis

Kvale (1997) has identified five different methods to analyze interviews:

1. **Concentration.** The interview is divided into natural segments, which are concentrated to one or two sentences extracting the most important information in regard to the topic of the study.

2. **Categorization.** A number of categories are used to code each interview to find out what the interviewee thinks about the topic of the category (agreeing/not agreeing to a proposition etc.). This enables a quantitative analysis of a qualitative material.

3. **Structuring through storytelling.** The interviewer can use the stories told during the interview to get a deeper understanding of the interviewee or the interviewer can also use the storytelling to create a story out of what has been said during the interview. The advantages of this method are that a story naturally has a logical order of time and a social dimension, which facilitates the analysis of underlying social structures.

4. **Interpretation.** This method tries to interpret the underlying meaning of something said or done during the interview. It can be compared to the work of a literature critic.

5. **Ad hoc.** This is probably the most common method of interview analysis. The analysis is done, as the name states, ad hoc. No standard method is used, but the researcher can use several methods and thereby find underlying relationships that would not be possible to find by using one of the standard methods.

5.4.4 Our choice of interview technique

We believe that the best way to conduct the interviews will be in a *semi-structured* way, since it will allow us to be more flexible in our approach in comparison to structured interviews but still will mean that the results can be compared. One problem with the interviews is that the people we will interview will have very different backgrounds, ranging from customers to product developers. This means that the interviews will need to be different depending on the people we will interview, because the information they can provide varies. Yet, it is possible to identify a few different groups of interviewees:

- Salesmen
- Customers
- People responsible for projects and internal processes at the APC in Detroit
- Product developers in Stockholm
- Marketing personnel in Stockholm

This means that the questions for the interviewees could be quite similar in each of these groups, but in between the groups, there would be more differences. In appendix B, our interview guide is presented.

When it comes to analyzing the data, we will use an *ad hoc*-method. The method we have chosen is a combination of *concentration* and *categorizing*. The reason for this is that the data will be highly diversified due to the several areas of interest as well as the different background of the interviewees.

5.5 Criticism of the methodology

5.5.1 Choice of methodology

We have chosen to conduct several personal in-depth interviews with people both within and outside of Atlas Copco Tools & Assembly Systems. We believe that the personal contact has eliminated much of the possible misunderstandings from written questionnaires or telephone interviews, but the possibility still exists that misunderstandings may have occurred, both when interviews were conducted in Swedish and English. However, recording the interviews when possible should reduce the risk for misunderstandings, since we have been able to go trough them again. We have also been able to get back to the interviewees when in doubt.

The people we have interviewed have mainly been within the ACTA organization, which could mean that they have given us an understanding of the situation lacking nuances. We do believe that it could be a problem. However, we do not think that the interviewees have kept much information or opinions from us, because we have worked within ACTA and have had the credibility of independent students. The large number of people we have talked to should also help us to eliminate personal opinions.

As for the choice of people interviewed, the study might lose in credibility since most of them work within ACTA. Against this can be said that each salesman work with a large number of people within the customers' organization that have different roles at different stages of the decision making process. Therefore, their knowledge is representing the sum of the customers' opinions.

5.5.2 Validity

Validity has to do with whether the method chosen for the research actually measures what is meant to be measured. Lekvall & Wahlbin (2001) defines predictive validity as whether the results of a study reflect the actual conditions or not. We have gathered most of our information through interviews, which we think is the method best suited for the purpose of the study. Therefore, in our case there is a risk that we might have missed relevant people to interview, ignored important questions or misinterpreted the interviewees. Validity can be augmented by letting the interviewees read and comment what has been summarized about their opinions. We have been confirming our results with our supervisor and his colleagues, who have a thorough understanding of the company and should be able to identify major mistakes.

We believe that the study is predictively valid and therefore presenting a true image of the reality of ACTA.

5.5.3 Reliability

Reliability is a measure of the methods ability to resist the influence of random events. If the same research were to be conducted several times, the results should be the same if the reliability was high (Lekvall & Wahlbin, 2001). We have chosen many of our interviewees by recommendation and judgment, something that affects the reliability in a negative way. Asking the same questions to several interviewees should however reduce that risk.

5.5.4 Possibility of generalization

This study has been conducted on behalf of Atlas Copco Tools & Assembly Systems. It should however be useful for many companies selling highly customized products. The literature on modularization and the cases presented today emphasize companies with highly standardized products, but there is a lack of examples of companies wanting to use modularity to become more effective without loosing in customer adaptability.

6 Empirical findings and analysis

In this chapter we present and analyze our findings from the interviews and studies The chapter starts with a description of who has been interviewed, what has been studied, and the reasons for choosing our approach. After that follows the empirical findings and our analyses on the topics of the study. The two elements of findings and analysis are presented next to each other on every topic in order to facilitate for the reader. Following each major area we summarize the most important parts of the analyses.

The first subject of analysis presented is the market offer. The reader will here be introduced to different opinions on the offer. The second subject is about the customers' relation to ACTA and about their needs. The third subject discusses the internal processes of the company and the analysis is ended with a discussion on the manufacturing strategies of ACTA.

6.1 The data gathering process

6.1.1 Sources

The empirical findings presented in this chapter were gathered during many interviews and studies of printed and stored material at ACTA. However, our first discussions with ACTA personnel, conducted at the headquarters in Sickla, helped us understand the situation and specify the problem and identify what information was needed for the further studies.

The data collected from the databases of ACTA was not what we had hoped for. Instead of finding a searchable and complete documentation of what had been sold, we only found poorly structured documentation of some of the products sold. From this source, the essential information gathered was examples and photographs of working products that have actually been delivered. In order to gather more substantial information about the final products, we had to turn to people who are working with them. These people were primarily the project managers and engineers interviewed at the headquarters in Sickla and in Detroit.

The first phase of interviews was conducted in Sweden. In this, we aimed at understanding the Swedish marketing and sales of ACTA and to assess the possibility to introduce a new market offer. This phase included thorough discussions with salesmen and people involved in the buying centers at plants of the Volvo group and

Volvo cars in Sweden. We had the opportunity to follow two salesmen for two days each, something that gave us good insight into their opinions and thoughts. Because we have been writing the thesis based in Sickla we also had the possibility to speak several times to the project managers, project engineers and marketing people working in Sickla. All the interviews conducted in Sickla lasted between one and two hours.

The interviews in Detroit were more concentrated and structured. Because of the limited time we had there, we conducted two interviews per day. They were held with salesmen and people with different positions at the application center and lasted between one and two hours. We were also given the opportunity to follow salesmen for one and a half days and visit some of the customers' plants while in Detroit. At the plants, we could see working applications and interview customers. In total, the visit to Detroit resulted in 14 interviews with ACTA personnel and four visits to automotive plants.

After we returned from Detroit, we conducted more interviews with ACTA personnel in Sickla in order to learn more and verify the results from our previous studies. In total 14 people were interviewed at the ACTA headquarters.

6.1.2 Finding sources

Because we were working at the headquarters, we had the benefit of working close to people that had contact with the entire organization in their daily work. Thereby, they could help us to find the people we needed to speak to within the organization. Except from the customers, the people interviewed outside of ACTA were found with help from the literature.

In order to benefit from the networks of the people employed within ACTA, we have asked the interviewees if they think that there is somebody who they think we should talk to. This could mean that we only spoke to people with similar views and opinions, but we have noticed that most often they have given us names of people who have different opinions than they do.

In order to get in contact with customer employees to interview we asked the salesmen for help. This solution was chosen because of the complex structure of the buying centers and the difficulty to get in contact with someone that had knowledge about the purchasing of tools. Asking the salesmen for help was a good way to get in contact with knowledgeable people because of the close relationships between customers and salesmen. Another reason for choosing this approach was that the salesmen are very protective about their customers and want to supervise all contact with the customers (which of course is understandable).

One possible way of understanding ACTA, its business and the environment would be to follow the parties of a specific deal. In this work, we have chosen not to take this approach because of time, cost, and accuracy. Given the limited scope of time it would be hard if not impossible to find a representative deal and follow it from the specification of the customer's needs all the way to delivery. Because such an approach would call for several visits to the customer – a customer that probably would be located abroad – it would be too expensive. The limited accuracy of the approach lies in the fact that it is very hard if not impossible to determine what a typical deal actually is.

6.1.3 Errors during the interviews

There is always a risk of misinterpretations of what has been said. However, one of the benefits of a case study approach is that it presents the possibility to ask follow-up questions during the interview to reduce these misinterpretations. We have also taped the interviews (when possible) to be able to return to the interviews. In some cases, we have contacted the interviewees after the interview to clarify if something has been unclear.

The possibility that the respondents answer what they think the interviewer wants to hear is another source of error. This problem has probably been more acute during our interviews in Detroit, because of the power dependency between Stockholm and Detroit. Furthermore, the customers may not have wanted to say everything they thought about ACTA in front of the salesmen.

A further source of error is that the interviewees may have tried to make the answer to a question as favorable as possible to their situation, which shows that it is difficult to interview people about past events. There is no real solution to this problem, but to interview several people and try to double-check the information given.

Trusting the salesmen in choosing people to interview might mean that we have not met the right customers and furthermore, that we might not have met the correct people at the plants. We have tried to decrease the impact of this problem by asking not only the customers, but everybody who we have interviewed about how ACTA and its products are perceived from an external perspective.

Finally, there is the possibility that we have asked the wrong questions. To reduce this error, we tried to gain as much knowledge as possible before conducting the interviews. This knowledge was gained in two steps. Prestudies about the company and the products helped us to understand ACTA's business, and literature studies helped us in understanding what questions were of an important nature to evaluate the company.

6.2 Market offer

In this chapter, we present what we have learnt about the market offer of ACTA through our study. There are different perceptions on what the market offer of ACTA is. In this thesis the market offer is defined as the total product range that ACTA presents to its customers. However, some people within the organization, especially people working at the headquarters, believe that the offer is what is being shipped from Sweden, i.e. the components presented in the product catalogues. The catalogues present spindles, cables and tightening controllers but not things such as fixtures. Not everybody recognizes the things being added to the products at the application centers, so called local content, as work of ACTA.

The market offer is difficult to identify. Our interviewees believe that most applications have very little differences in functionality. However, they all agree that the applications sold differ to a much higher extent than should be needed. Poor traceability makes it even harder to know what has been sold. Some documentation is made on sold products but this is not done continuously and is done neither in all countries nor on a standardized form. A salesman of the US sales force said: "an order won has a thousand fathers while an order lost is an orphan". This illustrates that a lack of routines and discipline prevent traceability and statistics of what has been sold and of the changes that have been made to products.

> *"An order won has a thousand fathers while an order lost is an orphan"*

Common applications that ACTA products are used for include assembly of con rod, main bearing cap, flywheel, clutch, cam cover, cylinder head, piston jets, wheel, U-bolts, brake caliper, indexer, hub nut, axle assembly, and gear box cover.

The market offer of ACTA is a complete one. The company supply the customers with all different types of tools and applications for nutrunning; air and electrical tools, hand tools and fixtured tools and standard as well as specially developed tools and control units. This combined with the various features of the tightening controllers and control equipment means Atlas Copco can supply the tooling needed to almost all fastening applications in the industry. It needs to be pointed out here that the standard tools and control units mentioned above are components of fixtures, not entire fixtured applications.

Some products are sold as standard applications on a local level. Most people interviewed also believe that there could be more of these standard applications and even company standards instead of local standards, if only common solutions were presented. A successful introduction of such solutions would however need extensive persuasion of all parties involved in everything from production to sales.

Although the fixtured products are standardized to a certain extent, many of the components do not have a standard. Cables can be taken as an example. Different cables need to be used depending on the combination of tightening controllers and tools used. This has to do with that the signals are analogue, that the wear of the cables differ with the applications, and that more flexible cables are needed for certain applications. Because durable cables are many times as expensive as less durable ones, it cannot be motivated to use a better one than necessary.

In 2000, the Express concept came around because the market was getting tougher and Atlas Copco had to find new ways to sell fixtured tools. It was the first time they sold fixtured tools as a product. Although there are differences in the opinions on what Express stands for, the visionaries within ACTA agree on the concept as being a landmark for their fixtured products. Its advantages are that it can be sold by salesmen with less experience from fixtured tooling and of course, which was part of its original purpose, that it is a product that more easily could be targeted to the General Industry (everything but the motor vehicle industry). The GI and tier one automotive suppliers often do not have as strict specifications as the MVI, so it makes more sense to sell them a standard package.

> *“Express is an evolution into how to make standard configurations for fixtured tooling”*

Analysis

We agree that the Atlas Copco offer of fixtured tools is a complete offer. It contains a wide range of fastening tools for the assembly industry and the company’s global presence matches the global customers of the motor vehicle and other industries well. The offer is however in many senses sprawled and would benefit from being more focused in terms of standard products, preferably on an international level.

6.2.2 Customer perceptions of ACTA & its offer

Benefits

ACTA's main customer benefit is according to both internal and external sources its products. The general opinion is that Atlas Copco products are best at quality, reliability, and communication with external systems. It is also believed that they have the best ergonomic qualities on their handheld tools. The ease of maintenance of ACTA products is supposedly at the same level as Stanley, but better than the other nutrunner manufacturers on the American market. The performance and durability are other important factors for electrical nutrunners of the type ACTA make. Atlas Copco are said to have products with a good reputation in both of those fields.

The quality of the products concerns the short-term quality issues, i.e. if the components hold for their purpose and if the assembly has been well made. The performance refers to such matters as power to weight ratio and the torque range the tool can be used for. Reliability of a product has to do with how well the products do what they are supposed to do, i.e. the precision of the tightening and the exactness of the measurements. The durability refers to the technical life length of the products i.e. how long time it will take before they have to be replaced on the seller's expense.

The flexibility of a tool is an important factor for a car manufacturer. One reason for this is short product life spans in the motor vehicle industry and frequent changes in the layout of a production line. Familiarity with the product is also important to the customers. This means that they do not always choose the most apt option. We have for example been told that Ford has chosen the PowerFocus tightening controller, developed for the Tensor product line, over the special one developed for another product line of handheld tools.

A good relation to the salesman is highly important for the customers. This is especially true for the members of the customers buying center who have much contact with the salesman and the tools, but bad experiences from a supplier will affect everyone involved in the purchase.

Analysis

The fact that Ford decided to choose another tightening controller than the one specially developed for the DL tools proves that ACTA benefits from familiarity between the products. As the Ford example shows, this familiarity could be better within the handheld tools product line. The familiarity between the product lines of handheld and fixtured tools is according to what we have seen and heard close to non-existent. This lack of familiarity also lowers the flexibility of use for the customers.

Delivery times

Delivery times are not seen as a problem for customers today. Atlas Copco fixtured tools have about the same delivery times as the competitors and on handheld tools, the delivery times are shorter than the competitors' delivery times. We have been told that ACTA might have lost some orders of fixtured products due to longer delivery times, but in those cases it was supposedly because the competitor assembled all forces in order to get it done on time. However, some of the salesmen said that they had sold Tensor products where a QMX nutrunner would have been more suited, just because of shorter delivery times.

An interesting aspect is that ACTA always count some slack in delivery times in order to meet the promised delivery date. Delivery times are particularly important when the tools are supposed to be placed on an assembly line and the installation needs to be scheduled to a time when production is stopped. Many of our interviewees have confirmed that historical experience of the supplier is of great importance when choosing a tool-supplier.

Analysis

In Krig & Stenströms (2001) study, delivery time is given extreme importance by both truck makers. This probably has more to do with materials for production than tools. Judging by the slack counted into the delivery times by ACTA, a promised delivery time of machinery is probably something that needs to be fulfilled in order to be considered for future orders. This emphasis on having a good track record corresponds with the importance of keeping good relations in industrial buying.

We conclude that the delivery time is not easy to fit into the Kano model (Figure 3-1). Depending on the type of purchase the motivation to pay a premium price for faster delivery varies. However, the continuous strive towards shorter lead times in the automotive industry means shorter delivery times can be a competitive edge, as stated by Azzone & Massela (1991).

Two companies

Because ACTA has been split up into two companies and fixtured tools have been sold as competing products by the two companies of Assembly Systems and Tools, customers still perceive ACTA as two companies. The current situation in the USA with salesmen mostly representing what used to be Tools is a reason behind this situation. This situation is not perceived as positive by anyone we have interviewed.

There is a belief within the organization that the Express concept is a way to unify the company. It means that Tools salesmen have an easier time to sell fixtured tools.

Because Express is more of a standard product and more comparable to the offer of the handheld tools, it also means that with its help, the customers can easier understand what is included in the ACTA offer.

Analysis

The fact that customers perceive the company as two separate units means there is a risk that ACTA can lose complete orders. This could to a certain extent be prevented by a sales force that in a better way would promote the entire offer, but if the customers do not perceive ACTA as one unit, ACTA will most probably not be asked when complete orders are being bought.

6.2.3 Internal perception of the offer

ACTA personnel are proud representatives of their company. They feel Atlas Copco provides the best products and is the top player, because it is the only company that can offer such a wide product range of assembly tools.

The internal views of the market offer are homogenous. The only major difference lies in the definitions of what actually is the product – the more customer contact the better the understanding is of what actually is being sold. This does however not mean that the understanding of the offer is better. For instance, many salesmen have a hard time selling and understanding the PowerMACS products and when they should be used. They obviously have not understood them since other salesmen both sell and believe these products are necessary and good parts of the ACTA offer.

Product range

Today many wish to use the PowerFocus system for both the Tensor and the QMX nutrunners. The main reasons presented for this are that the PowerMACS is too complicated and contains many unnecessary features. A salesman said 90 % of the PowerMACS customers only need the PowerFocus functionality. However, everyone agree on the need for the complexity of PowerMACS for certain applications. The two families of tightening controllers and nutrunners sold by Atlas Copco are a heritage from the time when ACTA was two separate companies. They were developed to please different needs. PowerMACS and QMX were developed to tackle many different tightening strategies, provide superior durability and dependability, whereas PowerFocus and Tensor were developed to be flexible and easy to use and configure.

It can be concluded that with only one company, having two families of tightening controllers is not perceived as very necessary – one family with more flexibility is wanted. Even today, the PowerFocus as well as the PowerMACS equipment are sold in different versions. Bronze PowerFocus exists and silver and gold of both TC's, depending on the features wanted. It should be noted that today it is not possible to combine a Tensor nutrunner with a PowerMACS tightening controller or a QMX nutrunner with a PowerFocus.

Overall, there seems to be a great conviction of the benefits of providing the customers with a full range of tools and control systems. A senior salesman pointed out that Ingersoll-Rand limited their control system range, and as a result could not stay competitive as supplier to power train plants. The reason he gave was that the fastenings that needed the control system they cut from their product line are so crucial to power train applications that their possible customers never would have been able to rely solely on Ingersoll-Rand as a fastening-tool supplier.

Possibility to standardize

The people we interviewed said that products look different depending on the customer and where in the world the product will be used. The most important thing was the customer. We were introduced to concepts such as "Ford brown", a color used to paint the cabinets delivered to Ford. Most people did not believe that it would be possible to standardize applications sold to the MVI, because the car companies are very specific in what they want to buy. However, many of our interviewees told us that the buying behavior of the big car manufacturers is changing in terms of people as well as ideas.

Several of the persons who have been interviewed for this thesis express a concern that the Express concept is cannibalizing the sales of engineered products to old MVI customers.

> *"With quick delivery, low cost and knowing that the quality is there, there should not be any problem arguing with the customer"*

One of the people we interviewed said that there should not be any problem selling a standard solution once the advantages are obvious for the customers. However, to be able to show the advantages, there has to be a standard design developed, and as of today, that does not exist. Another salesman was convinced that there should not be any problem arguing with a customer once quality is proven, lead times are short and costs down. There is an example from Ford, where ACTA has made a standard design for wheel multiples with the result that Ford buy all of their wheel multiples from ACTA.

Analysis

We believe that the concern that Express is cannibalizing on other sales has to do with the lower gross-price of the Express products and a belief that this reflects the profits made by ACTA on the two.

We agree with the belief of many of our interviewees that with the change within the automotive industry, the problem with an exaggerated demand for unique solutions will diminish. The perception that a standard solution, and with that shortened delivery times, will be beneficial for sales corresponds with the findings of Azzone & Massela (1991), who stated that with shortened delivery times, customers incentives to buy is increased and their price sensitivity decreased. That it is beneficial to have an example product ready at an early stage, standardized and with documentation, also corresponds with van Weele (2002).

6.2.4 Price

In the cases when ACTA's products are similar to those of the competitors in what the customers look for, ACTA's price level is often higher than the one of the competitors. The most frequent response given by salesmen when asking them why ACTA lose orders was the high prices.

Increasing power to purchasing might be a disadvantage for a premium price company. An American salesman actually mentions the more powerful purchasing functions at GM and Chrysler as a reason to why Atlas Copco is weaker there than at Ford, where the purchasing function is less powerful. The salesmen say they can tackle the price issue by involvement at an early stage of the buying process. Total cost of ownership is also something they try to put the emphasis on. Since ACTA puts pride in promoting their products as means to cut costs they do not want to compete on price.

The price policies are not the same for ACTA and all of its competitors. This can be clarified with the example of when Ford in the USA asked ACTA and Stanley to show how much all spare parts for similar machines would cost. Constructing a "spare part copy" of the Stanley machine would cost the customer 2.5 times the new price whereas ACTA only charged 1.8-1.9 times the price for all spare parts. This study did not consider the price relations between ACTA and Stanley.

Analysis

With the increased importance of purchasing the high price level of ACTA might of course be a problem, especially in the case of specialized fixtured products, which are very difficult to compare for a layman such as a purchaser. The opinion that price is *the primary reason to why ACTA lose orders should further be taken with a certain reservation since it might be a way for salesmen of hiding their mistakes.*

The product's price was attributed great importance by truck makers in the study of Krig & Stenström (2001); Volvo considered it the most important factor. Most of the Atlas Copco salesmen share the view that price is the most important factor for purchasers within the automotive manufacturing companies. This could be a disadvantage for a premium price company such as Atlas Copco, in particular since the price structure might make ACTA products seem more expensive than they actually are. However, because the purchaser is not the only one making the decision, total cost of ownership and cost reductions being a benefit of using the products constitute strong sales arguments. Price is an inverted performance want in the Kano model (Figure 3-1), but to provide tools that assures a negative total cost of ownership would be an exciter.

6.2.5 Summary – Market offer

- The market offer is complete but sprawled and would benefit from homogeneity
- The products hold high quality, reliability and possibility to communicate with external systems
- There is a low level of familiarity and flexibility between and within product lines
- Meeting a promised delivery time is crucial and lowering delivery times could give competitive edge
- ACTA is perceived as two companies by the customers and thereby risk losing orders
- The demand for unique solutions is diminishing
- Price is becoming increasingly important for the customers

6.3 Customers

6.3.1 Customer relations

Changes in purchasing

Everyone interviewed for this thesis agree on that a change of ideas is in progress at the American automotive companies. With the retirement of older middle level managers, old relations between salesmen and customers, buddy-buddy systems, are broken up or losing importance. This development is aided by the increased importance of the purchasing departments. These are shifts perceived both by junior and senior salesmen at ACTA and they agree that it is changing the way in which selling to the MVI is done. An example of the change in purchasing is that a big customer at a Ford plant said he chose Atlas Copco products because of corporate level procurement contracts. As most major automotive manufacturers, Ford does not want to become dependent on a sole supplier and has therefore decided what supplier the factories should use. Having one supplier at each factory makes handling of spare parts easier, and making sure not all factories buy the same brand of tools assures competitive suppliers.

Atlas Copco salesmen feel that the change in the motor vehicle industry brings along a focus on total cost of ownership. However, this change does not come from the automotive companies, but from their suppliers as a mean to tackle the automotive companies increased focus on price.

Analysis

The breaking up of old relations means the customers are more likely to look for new suppliers than they were before when buying new tools. The more powerful purchasing functions affect ACTA because it means more focus will be put on easily tangible parameters such as price.

Striving to cut costs in purchasing means lower importance is given to direct product qualities. These will instead have to be presented as factors that lower total cost of ownership by the salesmen. However, the perception by ACTA employees that this development is not coming from the automotive companies, but is being driven by their suppliers, is contradictory to that of van Weele (2002).

New sales and rebuys

Most of the customer contact time for ACTA personnel is spent in dealing with end-users and engineers working at the production lines. For the salesmen, around 20 % of their sales time consists of dealing with purchasers. This work includes both relationship-building activities and service-related issues. The benefits of having good relations and reputation among production technicians can be seen in an example from a Volvo-plant. On our visit there, ACTA was asked to provide the plant with an adapter and front-ends for tools that had been bought by a competitor. The competitor had taken the order on price, but poor quality led to a disappointed customer.

Automotive companies have to plan ahead when installing complicated machinery since it has implications on the whole production flow. Therefore, the products ACTA sell in order to establish themselves are often simpler tools. However, a large part of the sales of tools is being done as modified rebuys by companies that have already bought other tools from the same supplier. Because a fixtured tool has a longer life length than a handheld and is more difficult to replace, this has the effect that once a fixtured tool is installed on an assembly line Atlas Copco normally gets many subsequent orders for handheld tools.

Analysis

Volvo attributed performance history considerable importance according to Krig & Stenström (2001) and it is obviously an important sales argument for ACTA as well. To experience the benefits of a tool in person is of course invaluable, but we strongly believe having standard products can be almost as good in many cases. If, for example, a factory has not bought new tools for some time and needs new models, they could evaluate those tools by being referred to others that are using the tools in question. A standard offer can also be used to assure the customer of an identical product the next time in case of a rebuy.

6.3.2 Customer needs

What is perceived as the main benefits of tools of ACTA's type also represent actual customer needs. The main benefits of the QMX-series are durability, reliability, speed, a high performance to weight ratio, and traceability. Control and monitoring were the actual reasons that first gave fixtured electrical tools its success whereas the possibility to avoid oil and noise from air-tools was the reason to why Atlas Copco started working on finding alternatives.

Increased need for quality

A need for high quality in motor vehicle production is confirmed by all personnel within ACTA as well as by customers. The importance of quality in production is of course reflected on a need for tools with high quality, reliability and performance. This is being noticed by ACTA, but their market has not grown as much as the need for quality, since the need for high quality has also lead to the development of alternative ways of increasing fastening quality. The use of better materials with more even surfaces assures better fastenings with the same tools.

The high importance placed on quality means manufacturers will have to prove and assure their production, all in order to minimize the impact of human errors and hazard. This of course has high priority for ACTA, both in certifying their own production and in facilitating the customers' work with help from ACTA products. Be it by storing information about previous fastenings, providing tools that indicate when to tighten and when to change front piece of the tool or by controlling that the tools and the operators do what they are supposed to do.

The need for high quality tools is related to the pace of production. All our interviewees agree on a higher pace of production in the USA than in Europe. This difference in pace has to do with higher productivity and another view upon how to use resources. American tools as well as workers are subjects to higher stress than their European counterparts are.

Analysis

The agreement on a need for high quality corresponds with the literature and practice. A practical example of the implications of poor quality can be taken from Volvo Cars that in early February withdrew 105 000 cars due to a safety risk with already sold cars (Dagens Nyheter, 2004). This particular problem actually had to do with bad fastenings of nuts. However, the problem got out of proportions since poor traceability did not allow Volvo to identify the exact cars that did not meet quality requirements. Such problems are frequent and imply huge costs for the manufacturers.

Both Scania and Volvo ranked quality as extremely important in the study of Krig & Stenström (2001) and our study confirms that it is a central factor when buying power tools as stated above. Depending on the type of the factory, its importance varies. In American factories with high pace and optimized assembly lines, increased quality would be an exciter in the Kano model (Figure 3-1) whereas in the European factories with a lower pace it would be a performance want. This means that quality is something to strive for, but not something, that on a global level, could motivate a price out of proportion.

Identifying problems and defining specifications

With restructuring and changes in production, the knowledge within the motor vehicle industry companies has changed. Specialists on tightening have previously been common on the production-floors but due to downsizing, the use of less demanding materials, and better tools this knowledge is now much less spread. One of our interviewees suggested that such a loss means the understanding is poorer and the need for simple and easy to use tools will increase in the future. He made a comparison with the software companies that have been striving to make the products increasingly easy to use and thus making the customers understand and demand that products should not be complicated to use without a good reason. The loss has however been tackled with more extensive process definitions to assure quality.

Analysis

Attempts to assure quality have been made. However, many tightening problems remain unique and there are in most cases different aspects to be considered every time new machinery is bought. Therefore, we see that the change in the industry has made the need for competent salesmen at least as high as earlier. In many cases the companies need more help than previously, not only with specifying the product to be purchased but also to specify the problems or needs that need to be solved.

Assure high uptime

Apart from assuring quality in production, customers need to assure a high uptime of the production facilities. The reason is that the economic consequences of letting the production stand still are huge. This has been pointed out as one of the most important issues of customers, salesmen and service personnel.

The implications of a stop of production can be illustrated with an example from the Volvo cars final assembly plant at Torslanda, Sweden. Their production is one car per minute, with a listed price of several hundred thousand SEK per car. All production is being made to order, which means that a stop of production of half an hour gives a revenue loss of 30 times the price per car. However, they would still need to pay the operating costs.

Analysis

The need of customers to assure high uptime has two implications for a supplier such as Atlas Copco Tools & Assembly Systems: Products need to be good in themselves, i.e. no problems should occur, and this should preferably be assured trough quality assurance. ACTA also need to be able to take care of occurring problems very fast. In order to do that they need to have spare parts available on short-term notice, something that also is necessary in order to replace parts that break due to fair wear and tear.

Spare parts are given considerable importance by both truck manufacturers in the study of Krig & Stenström (2001). This corresponds with our findings that high uptime is a major concern for the customers of Atlas Copco. A well functioning central warehouse, and promises to provide spare parts eight years after the items are removed from the product line, eliminates this problem as far as standard parts are concerned. However, special parts are something that customers order extra, just to be on the safe side. Further standardization could therefore provide a good argument for a low total cost of ownership. This would be a performance want in the Kano model of our frame of reference.

Documentation

Documentation is pointed out as a customer problem with the Express concept. Motor vehicle manufacturers such as the "big three" (Chrysler, GM & Ford) in Detroit all have their own standards on how they want the product documentation printed that are not met by the Express documentation. This has to do with such simple things as how and where on the drawing they want the components names to be printed. It also has to do with that they want different component numbers than ACTA's and the amount of documentation.

Analysis

We do not believe documentation to be a problem other than in a transition phase. With the design and quoting becoming increasingly automated, it should be easy to automatically generate the requested documents according to the customer's specifications. Such automated documentation could also constitute a customer advantage in that it could easily provide the same product with multilingual documentation.

Examination

Many customers like to see their products before delivery and conclusion of the purchase. This often leads to changes on the product – changes that our interviewees believe have more to do with the products aesthetical appearance than with its performance. There is a direct relationship between if the product is demonstrated and the number of order change requests (OCR's). The reason is probably that the manufacturers did not form an image of the product beforehand or did not picture the same image as the salesman or project manager did. Products sold as Express are not demonstrated as often as the other products. This partly has to do with the lack of frequent contact between the project manager and the customer.

Analysis

The packaging and promotion of a product or service is an important part of the marketing (Kotler 2000). Agreeing on a clear definition of what is bought is important in order to come to arrangement about procurements. We therefore believe the fact that the Express system is better specified and productified, and that the customers have seen real pictures of working examples of their products beforehand are reasons to greater acceptance of the provided solution.

Communication systems

Communication systems are in the case of ACTA the liaison between tools, and between workstations and the factory network. This is an area where development is going fast and many different standards exist in terms of communication protocols etc. The impression of software-developers is that the number of different protocols is growing, limiting the ability to use a single standard.

Analysis

The communication systems considered in the study by Krig & Stenström (2001) in question in the heavy truck study are EDI-systems that concern materials supply, which are not of particular importance when making discrete buys of high monetary value items as assembly tools. The communication systems of the products are however important in order to provide communication between the tools and the factory information system, especially with the more advanced tools that provide error signals in the case of faults. These systems are therefore an important part of the ACTA offer and something that has been a natural part of fastening equipment for a long time. The possibilities of affecting the IT-infrastructure is low for a company such as ACTA and the communication system is therefore a basic expectation in the Kotler model (Figure 3-2), or in other words a must in order to be considered as a supplier.

Ergonomics

Ergonomics is important for handheld tools and is continuously an area of improvement. On some applications, the reason for using a fixtured electrical tool is ergonomics, or safety for the assembler.

Analysis

Krig & Stenström (2001) pointed on high importance for environmental friendliness. Since electrical assembly tools are not articles of consumption, environmental friendliness is only interesting in that they do not pollute the factory with noise or oil and provide the workers with good ergonomic qualities.

Having good ergonomic qualities on a fixtured application is a reason that would fit in the basic product of the Kotler model or as a basic expectation in the Kano model (Figure 3-2 and Figure 3-1) and not something that would provide a unique selling point.

6.3.3 Summary – Customers

- Purchasing functions are becoming more powerful which increases emphasis on total cost of ownership and other easily comparable parameters, but most of all on price
- Standard products can assure the customers of what they will get, both in the case of new sales and rebuys
- The need for assured quality, both in used materials and manufactured products, is continuously increasing in the motor vehicle industry
- The customers have a continuously high need of help in defining their problems and in making product specifications
- The need for a high uptime of production means spare parts have to be ingeniously designed and deliverable on a short term notice
- Products that have been shown or demonstrated in advance are more likely to be accepted by the customers without requests for changes

6.4 Internal Processes

The process of ordering and producing a regular fixtured product is quite lengthy and includes several different parts (Figure 6-1). The first part is the problem definition, which is done either by the customer alone, or in cooperation with a salesman. When the problem has been specified, the customer requests a quote (RFQ) for a system. If so, the proposals department creates a quote for the specified system. This process takes between one and four weeks depending on how complicated the system is. It is also dependent on whether the information communicated from the customer to the proposals department is sufficient and accurate. The next step is customer evaluation, where the customer evaluates the quote to find out if the system satisfies the needs. If not, the quote may have to be remade. If the customer decides to order the system, the next step in the process is engineering or product design, which takes around five weeks for a normal system. The final stage of the process is production that takes from four to ten weeks for normal systems. During the last two parts of the process, order change requests (OCR's) frequently occur, which slows down the process even further.

The process is not that lengthy when an Express system is ordered. The quoting is done within 24 hours from an RFQ and the system is delivered within four to six weeks from date of order.

In this chapter, we will discuss the different steps in the ordering process. The parts on scope creeping, order change requests and delivery time are not part of the actual order process, but are closely linked to the internal processes. That is why they appear at the end of this chapter.

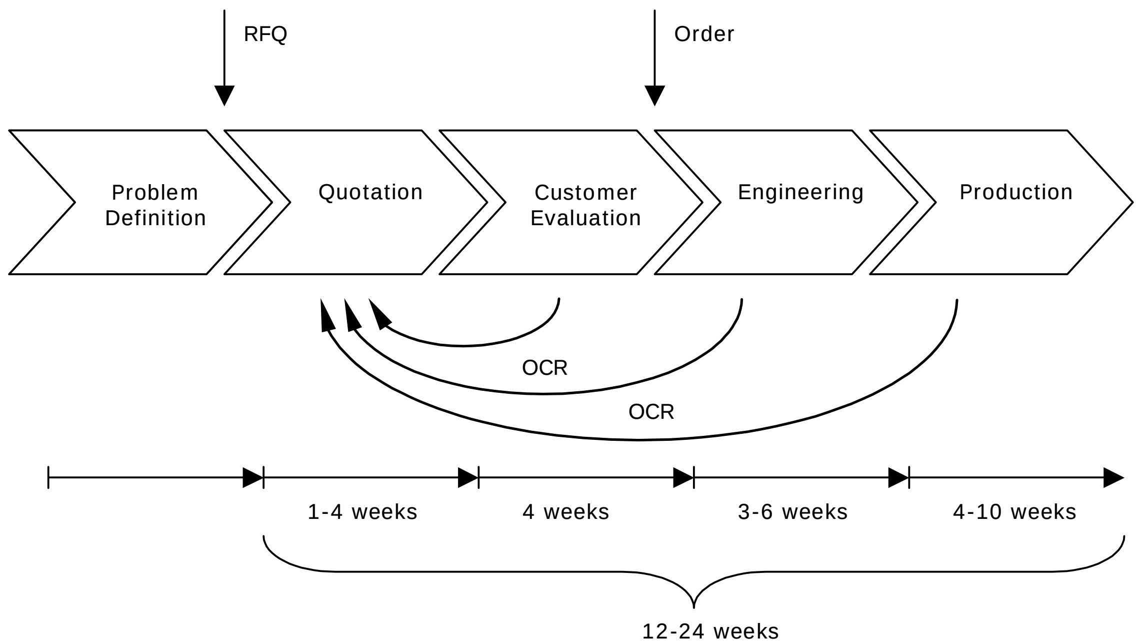

Figure 6-1. The process of ordering a fixtured product

6.4.1 Sales

One thing that we encountered was that the salesmen of Atlas Copco Tools & Assembly Systems have difficulties selling fixtured tooling. In the USA 90 % of the sales of fixtured tools was done by 10 % of the sales force, mostly former Assembly Systems salesmen, who are used to selling fixtured systems. When the two companies merged, one of the advantages for Assembly Systems was to get more salesmen to sell fixtured products, because the sales force of Tools was a lot larger than the one of Assembly Systems. However, this did not happen. Instead, the salesmen from Assembly Systems started to sell handheld tools (which is considered easier), with the result that there are fewer salesmen selling fixtured tooling today. One difference between the US and Europe is that in Europe the salesmen work in teams. The salesmen get help from the APC as soon as fixtured tooling will be quoted, which means that the salesmen get help in selling those products.

There seem to be several reasons behind the fact that the former Tools salesmen do not sell fixtured nutrunners. The people we interviewed said one reason was that the fixtured products are considered complex and the salesmen do not know how to sell them. Fixtured nutrunners are sold as systems, whereas handheld tools are sold more as catalogue products and there are a lot more things to consider when selling fixtured nutrunners than with handheld tools. Furthermore, the products have two totally different control systems, which mean that the salesmen need to learn several parallel systems. Some of the people we interviewed said that it was not harder to sell fixtured tooling, just different, but this view is not shared but everybody within the company. Another view is that the problem is not due to lack of sales training, but lack of practice in selling fixtured tools.

Analysis

It is a big problem that the tools salesmen cannot sell the fixtured products, because it means that a big part of the sales force does not sell any of the fixtured products. The main reason seems to be that the products are very unlike and it takes a lot of effort for salesmen to learn how to sell fixtured tools although they can sell handheld tools. We base this assumption on the fact that salesmen who are used to selling fixtured products (i.e. the ones from former Assembly Systems) have no problem selling them.

A further reason that the sales are low is probably the commission structure. In the US, the salary of the salesmen is mainly based on commission on the volumes of what they have sold. Therefore, they tend to sell the products that are easiest to sell. We believe that a big challenge for ACTA in the future is to make the whole sales force capable of selling all the products.

6.4.2 Quotation

Many of the people we interviewed said getting the correct information from the customers was the hardest part in the whole value chain, and that most mistakes occurred during that first step. When a customer requests a quote, it takes around a week to get it if all information is at hand. One of the people we interviewed said that it used to be as much as two to three weeks to get a quote on a system. Thus, they did not consider one week to be a long time. One reason that it takes this long is that the document the salesmen fill in, on which the quote is based, is considered insufficient.

It is apparently good for quoting a standard system, but as soon as there are special things that need to be considered, the salesmen do not know where to fill them in. This means that the people doing the quotes need to contact the salesmen to find out the extra information that is missing. In the US, this has the effect that one person is working as a gatekeeper, who looks through incoming documents to see if everything is there and contacts the salesman if information is missing. However, one thing to remember is that the salesmen from former Assembly Systems have no problem filling in the forms.

Analysis

The hardest part in the whole value chain seems to be getting the correct information from the customer. This leads to extra time in the quoting process and can lead to order change requests (see chapter 6.4.6). According to Pine et al. (1993), the first two key attributes on how to make mass customization work are that the system is instantaneous and costless. A quoting time of at least one week is neither instantaneous nor costless. In fact, it is very costly and adds costs also to all those quotes that are not won. This could be a vicious circle if the orders are not always won, because the extra costs from quoting one system need to be put on the next system as overhead costs, which in turn will reduce the possibility of winning that order. This reasoning is valid even when a mass customization strategy is not the goal.

6.4.3 Product design and development

The design of the fixtured products can be said to consist of two parts – one that designs the spindles, TC's and cables, and one that design the final application. The former is made in Sweden, whereas the latter is made at the place where the product is built (this is usually one of the two APC's, but as explained in chapter 6.4.4, production is sometimes done in external workshops).

The organization of the development department in Sweden has recently changed. Today it is a matrix organization divided in different development lines, each responsible for one part of the product (Figure 6-2). With this division, it is easier to use synergies between the different products.

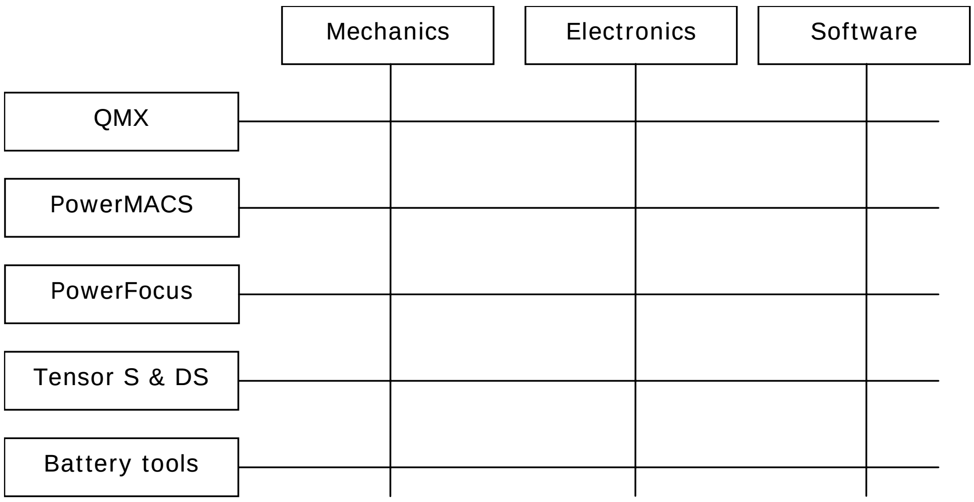

Figure 6-2. The organization of the development department.

Electronics and software

Today, there are no common parts between PowerFocus and PowerMACS. The cause is the sharp dividing line that used to be between former Assembly Systems and Tools. This has led to the development of two different control systems, PowerFocus and PowerMACS. It is considered one of the biggest weaknesses of the products today that they are so different. Not only do the products cost more to develop, they are also harder to sell because the customers and salesmen need to learn more systems.

According to the people we interviewed, one of the biggest challenges right now is to commonalize the two systems. There should not be any bigger problem to use the same parts in the hardware of the TC – it is standard electronic components in both of them, they are just built up differently. The cables today are different because there are more signals coming from a QMX than from a Tensor tool. They are also different because the quality of the cables needs to be higher for the handheld tools, because they are being more heavily used (bent, stepped on etc.). In future generations, the signals will probably be digital, which would make it possible to use the same cable in all different applications. However, there would probably still be a need to have different qualities of the cables due to the big price differences.

A harder thing to standardize is the software of the TC's. Today, they are very different. The software of PowerMACS is concentrated on having many different tightening strategies and communication capabilities, while the software of PowerFocus is more focused on being user friendly. The people we talked to said that it would probably be possible to standardize the software, but it would be more difficult than to standardize the hardware. The reason for that is that the whole software would need to be rebuilt in order for it to work. It would also need some kind of system similar to the hardware locks of PowerFocus, so that not every TC would have the capabilities of the PowerMACS of today (it would not only be unnecessary, it would also make it extremely complicated for the customer, who does not need all the capabilities).

Mechanics

Because of the history of having two separate companies, there are no common parts between the Tensor tools and the QMX nutrunners. Both the handheld tools and the QMX nutrunners have a modular architecture, although the modularity of the QMX spindles is just a result of a natural division in motor, gears etc. They can be said to consist of five main parts: the motor, the gears, the transducer, the front part, and a retractable socket holder. There exist other variants, which include offset gears, angle encoders or an extra transducer etc., but these could just be seen as extra modules.

The modular design of the handheld tools is on the other hand a result of building a modular “tree” with all the different parts and how they can be interconnected. There is no further development of parts of the tree once it has been developed, although that is theoretically feasible. The tree is being used in the design of the different variants that exist of one tool, such as pistol grip and right angle tools.

Another difference between the two families is the amount of special products. The Tensor tools are almost always standard tools, but the QMX nutrunners are special tools in 10 to 30 % of the cases, depending on what you count as special tools. If only those spindles that are highly specialized, which need two to three weeks of design are defined as special spindles, then it is around 10 %. However, if those spindles that are not a part of the standard range but have a standardized design are counted as well, then special spindles accounts for around one third of the spindles.

The mechanical part faces two big challenges, according to the people we interviewed. The first thing is to try to commonalize the products as much as possible, i.e. use the same parts in the QMX nutrunners as in the handheld tools. The standardization of the parts is viewed as something inevitable, although it may make the development of future products harder. The second thing is to try to cut costs, since the mechanics of the spindles is a mature product and will not develop as quickly as the TC in the future. Cutting costs can partly be accomplished by using more common parts for the different products.

There are several difficulties when trying to use the same parts in the two systems. The first thing to remember is that the Tensor tools have been developed with ergonomics as one of the most important factors, while the QMX nutrunners have durability and performance as the most important factors. The QMX spindle is also developed to be able to fit several spindles close to one another but this is not something that has been important in the development of the Tensor products. Although there are several different demands on the two product families, there seems to be a consensus that many parts can be used in both families. The people we interviewed said that one way to get a more durable product for the fixtured products, though using the same parts as the Tensor tools, would be to rate the parts differently. This means that a part that is used in a Tensor tool to withstand 300 Nm will be used in a QMX with a maximum torque value of 150 Nm and so on.

In spite of the fact that many parts can be standardized between the Tensor tools and the QMX nutrunners, some things remain that need to be different. One example is the outer design, which in the case for QMX is triangular to offer a small distance between the spindles, but in the handheld tools, it is round to be able to make the tool as small as possible and easy to hold with the hands. Another thing that is difficult to commonalize is the socket holder. The QMX spindles use a pin to fasten the socket to assure that it stays. The Tensor tools, on the other hand, use a small retractable ball to fasten the socket. This facilitates the fast change of sockets and the fastening is sufficient because an operator is always present when the tool is being used.

Final application

The design of the final application is done either at one of the two application centers or at a workshop in the proximity of a customer center. Today, there does not exist any standard design of the different applications. Instead, they are designed every time a customer wants one and different parts are used depending on where it is designed. According to the people we interviewed, the designers use old drawings to reduce time and effort. In the USA, they have been successful in reducing engineering time from four to three weeks. Nevertheless, they believe that it should be possible to reduce it with another week, if they just used more standard designs. It is interesting to compare the design of a one-spindle application that is built in the traditional way to one that is built according to the Express concept. One person that we interviewed said that the Express would take around two hours to design (just a redesign of an old order), whereas designing the system the traditional way would take 30 hours. The final product would have the same functionality. He also said that design time does not increase linearly with the number of spindles, but is proportionally the largest part of an order with just one spindle.

Several of the people we interviewed believed that it would be possible to standardize applications with up to six spindles with torque values up to 200 Nm. The Express concept is a way to carry out this standardization. Right now, the product developers in Sweden are redesigning the Express concept. The reason for that is that the people in the USA who designed it in the first place are systems builders, not product developers.

Another interesting thing we encountered during our interviews was the vast amount of “best” solutions. There seems to be as many best solutions as there are designers. This is due to the decentralized structure of ACTA but another important factor is the lack of a central database of what has been sold. Today, the traceability of sold applications is possible, but not administrative, which means that if somebody wants to find out what has been sold somewhere, it is possible to get the information, but it would take time. What is more, it would probably be in different format depending on what and where it has been sold. Consequently, it is not possible to look it up in a database somewhere and find the information within minutes.

Analysis

Everybody we talked to saw several benefits of trying to standardize the components of the different tool families. According to Ulrich (1995), standardization can only arise when a component implements commonly useful functions. He also states that a modular architecture is a precondition to the standardization of components. Both of these conditions are fulfilled for ACTA’s products, which indicate that it should be possible to standardize more than today. However, it is important to realize that the people we interviewed were not certain as to what degree the standardization could be driven. The reason for that is that they had not had time to do all the testing needed to investigate it.

Another interesting fact is the modularity of the QMX spindles. Today they are highly modularized, although the modularity is not really being used. This is a typical example of what Erixon et al. (1996) said, that the effects of modularization do not emerge thanks to modularization, but they can be achieved by using modularization.

If we look at the final applications, we can see three problems concerned with the redesigning of similar products:

- *It costs a lot to redesign every product*
- *It takes a lot of time*
- *Similar products look different*

The first problem is obvious – it costs extra to design the same product several times. However, there are also hidden costs linked to local designs. Nilsson (1990) calculated the cost of introducing one article to SEK 46 000. This figure is a little bit out of date, but still shows that having a standardized worldwide design can save a lot of money. In addition, the second problem is clear – having to wait for a new design takes time, which increases the lead time. That the third point is a problem is maybe not that obvious, but it actually has two implications. The first is that the customers of ACTA want to have a proven solution, especially if they buy the same product as they already have bought to another plant, but also for first time purchases. The second implication is that the salesmen cannot tell the customer exactly what the final application will look like, but only that it will look something like this old product. This is also something that can increase the amount of OCR's, because the customer is not sure of what to buy (as described in chapter 6.4.6).

The lack of a database of sold or designed applications counteracts the information flow of good solutions within the organization and is another important factor that hinder the implementation of standard design.

One problem in the standardization effort is the amount of best solutions. In many cases, this is actually true, because there can be several solutions that are just as good, but different. The designers do not want to give up their solutions, since they are accustomed to them. Another problem with the local solutions is that the designers cannot see the whole picture and make the correct cost effective decisions. The Express concept is an example of that and is currently being redesigned, since the original designers in the US were only working on a local, albeit large, market.

The problem of overcoming local solutions is probably the biggest obstacle in deciding on a standardized design and making the designers adhere to it. We do however believe that this problem can be overcome if only the leadership is strong, unbiased to local solutions, and can see what is sold on every market.

6.4.4 Production

Just as the design is made at different places, production is also made at different places. The production of the spindles and the other core components (TC, cables) is done in Sweden, and the production of the final application is made at one of the two application centers or in some cases at an external workshop close to a customer center. All production at the applications centers is made-to-order. Atlas Copco Tools & Assembly Systems produces the spindles, but the production of the TC's and cables is outsourced. The parts of the spindles are bought and are only being assembled. This is in contrast to the handheld tools, where Atlas Copco makes the whole tool. Today, standard spindles are produced to stock, but this is a recent change. Before, the application centers needed to wait for the spindles to be produced before they could get them. This meant a lead time of around eight weeks just to get the spindles.

When a customer orders a product, the engineering department starts to design the application. At the same time, they order the core components from PTD. The reason why they can order these before the application is designed, is that the type of spindle usually is decided at the time of order. When the product is designed, all the other parts are ordered locally. This means that a product in Germany has no common parts with a product produced in the USA. There is work being done on reducing production times. During the last year, the purchasing department in the US has reduced the time it takes to get the parts from the suppliers and today they are able to get all the major parts within two weeks. To reduce time in the shop, they have tried to promote an educational program in the shop to get assemblers that are more skilled to be able to use the work force more efficiently.

There is also some production made locally at the customer centers. The reason for this production is that it is cheaper in many cases. For example, it is cheaper to produce according to local Fiat norms and rules in Italy than at the APC Germany. In Italy, Fiat does not even need to communicate the norms, because the local workshops only produce according to those norms and know them. In contrast, the APC in Germany needs to know norms of all the major car manufacturers in Europe. To illustrate this problem, take a simple task such as making a sign in Italian. It is much more likely to go wrong in Germany where people do not speak Italian than in Italy.

The order and production process is a little bit different when an Express system is ordered, because there is not much need of design. In fact, there should be no design at all, but usually the system needs to be modified in some way. This typically takes a couple of hours. Another difference is that all parts needed are kept in stock. Assembling an Express system is very simple and the workers hardly need to look at the drawings. It takes about a day to assemble it and testing takes another day.

The people we interviewed said that they though it would be possible to produce a system in two to four weeks from the placement of the order. The two weeks referred to Express systems and the four weeks to normal engineered systems. Today the lead time is around nine weeks for a normal system.

Analysis

We think lead times of nine weeks are too long. The Express concept has shown that it is possible to have lead times of four to six weeks on fixtured systems, and this is without optimizing the design or the process. The people we interviewed thought a lead time of two weeks would be possible once this was done. However, in order to reach the goal of reducing the lead times, the systems need to be a lot more standardized and in some way predefined. The modular design of the Express concept is very important, because it proves that it is possible to construct fixtured systems out of predefined modules.

The vast amount of local content means that ACTA has no central control of the parts and the products look different depending on where they are produced. With such a strategy, there is no common appearance of the products. What is more, it is very difficult to assure an overall quality of the products. Furthermore, the fact that a lot of purchasing is done locally could mean that the sourcing is made sub-optimally.

6.4.5 Scope creeping

Scope creeping refers to adding things that are not part of the predefined scope; may it be the scope of one quote or the scope of the Express concept. For Express, this has been a big problem because it has changed the scope of the concept. Compared to traditional systems, it has gone faster to get a quote on an Express system and to get it delivered once ordered. Express systems have also been priced differently and have had a different commission structure than traditional systems. These factors have made the salesmen quote an Express system, although it has not really been an Express system. In addition, several times the customers have not been aware of that they actually have ordered an Express system. The result has been that the customers have wanted to get what they are used to get in terms of documentation and project management, although it is not a part of the Express concept. When this has happened once, the salesmen have thought it was OK to add these extra features to the Express system and the next time the same kind of system is ordered it will be regarded as Express. The result is a change of the scope of Express.

For ordinary quotes, scope creeping has meant that things have been included in a quote that was not there from the beginning. Thus, many orders that were profitable from the beginning have become unprofitable.

Analysis

Scope creeping is mainly a problem for the Express concept, but the problem that extra things are added to orders also occurs for the traditional systems. This shows on *an underlying problem, that the sales force does not really know what they sell and later the customer demands things that they thought was included from the beginning. The salesmen need to be very clear to the customer as of what is included in the price. Otherwise, this can drastically reduce profitability of the fixtured products.*

6.4.6 Order Change Requests

Order change requests (OCR's) are changes of the order that the customer asks for after an order has been placed. The process for an OCR is that the customer calls and asks for a change. After that, the project manager writes a new proposal to the customer to verify that everything is correctly understood. The project manager also fills in an internal OCR form. Before an OCR can be approved, the customer has to respond to the new proposal. This whole process usually takes one to one and a half week and the administrative costs are around $150. It is very hard to know how much to charge for an order change, because it is difficult to assess its impact. For example, a change in the number of nutrunners from ten to eleven means that the TC's will not fit in the designated cabinet, which means that a new cabinet has to be ordered. As that example shows, a change in one component can lead to a whole chain of changes that are not directly linked to the OCR. Usually, the customers do not understand these impacts and are not willing to pay for anything more than the direct costs associated with their changes. Today, customers ask for changes but are not fully charged (if charged at all) for the occurred costs. The result is that systems, which were profitable from the beginning, become unprofitable due to all the changes.

There are many reasons for OCR's. One reason is that the customer makes changes at the plant after the order is placed and need to change the order. Another reason is that neither the customer nor the salesman is sure of what is needed when the order is placed. This is due to that the products are complex and it is hard to cover all the aspects of them. Several people also believe that the high number of OCR's is due to the long delivery times. They mean that if this time were reduced, the customer would not have time to request an order change. In addition, they believe that the customers would understand that a change would cost a lot of money once the product has been delivered and therefore be more reluctant to do changes or at least carry the costs.

Interestingly, roughly 90-95 % of the customers file an OCR on a normal system, but on an Express system, this figure is only 10-20 %. Therefore, it would be interesting to compare the differences between the two systems. The first difference is the quotation process. In a normal system, the quoting takes around a week, but in Express, there is special software developed for the quotation and a system is quoted within 24 hours. To be able to have a quick quotation process, the Express system is constructed from predetermined configurations compared to a regular system that can be designed in many ways. The next difference is that all the parts are kept in stock for an Express system and therefore, the system can be delivered within four to six weeks from order. For a regular system, the delivery time is closer to ten weeks. The final difference is that an Express system is sold with a “try and buy” deal. This lets the customer try the product in production and return it if the system is not suited. However, it has never happened that the customer has returned a delivered system.

Another reason for the difference is that the customer is a lot more involved in the process of producing a normal system than an Express system. In a normal system, the customer and the salesman builds it from scratch, whereas in an Express system, the customer can choose from a number of predetermined configurations. The predetermined configurations of the Express concept work as a framework that the salesmen and customers can work within, when creating the quotes. What is more, the customer visits at the application center before they get the products are another reason to the difference in OCR’s. Only 20-30 % of the Express customers visit the application center, compared to almost everybody for conventional products. Sometimes it can be as many as 20 people coming to see the product and the result is always changes of some kind.

It is hard to decide the main reason for the difference in OCR’s between the Express concept and ordinary products, but comparing the situation with two other companies makes the situation a little bit clearer. Dell states that they hardly have any OCR’s, because a computer is normally shipped within 3.5 days after an order is placed (Hall, 2000). This means that the customer has no time to change an order. Another company, Metso Minerals, was able to cut their OCR’s by 50 % when they introduced a new configuration software for quoting that facilitated the information flow between the customers and the sales force.

Analysis

As stated above, OCR’s are very common and they have many impacts on the production process; they consume time, money, are hard to price, and imply greater risk of error due to reassumed work. Furthermore, they are impediments in the flow of the production and designing processes, which according to the third principle of lean production is something to strive to reduce.

The predetermined configurations and clearer quotes of the Express systems means that both the customers and the salesmen are more aware of what has been ordered and it is harder for the customer to argue that something already was included in the quote, which can make them more reluctant to ask for an OCR. Moreover, the case of

Dell and Metso Minerals, two companies that work in a manner very similar to that of the Express concept, showed that the amount of OCR's could drastically be reduced if the information flow from salesman to production would be facilitated both in time and in scope.

6.4.7 Delivery time

The delivery time of a product is usually around ten weeks from time of order and for the Express system, it is between four and six weeks. The salesmen we talked to did not find the delivery time to be a problem, because most customers were used to it and planned accordingly.

Analysis

We believe the delivery times are quite a big problem. Maybe not as a primary problem, but the effects of long delivery times are extra capital bound in production and more OCR's (as explained in chapter 6.4.6 above). Furthermore, according to the third principle of lean production, it is very important to make the value flow along the value stream and the faster it flows, the more hidden muda will be exposed. According to the people we talked to, a delivery time of two weeks would be possible for standardized products, but a prerequisite of that is that everything flows without any impediments, such as problem at the quotation stage or OCR's.

A change in the delivery time could also mean a break of the compromises of the industry. Compromises are concessions demanded of customer by all or most product providers, which in contrast to trade-offs cannot be overcome. According to Stalk et al. (1996), "the most important compromises are forced on customers simply because companies have lost touch with those customers' needs. Finding and breaking those compromises can unleash new demand and create breakaway growth." ACTA broke a compromise when they developed the Tensor motor. Before, customers had to decide between getting an air tool with less accuracy than an electric tool, or an electric tool that was more accurate, but very heavy. With the Tensor motor, it was possible to combine the accuracy of the electric tools with the low weight of an air tool. We believe that being the first to drastically decrease the delivery times would increase both the market share and the profitability of the fixtured nutrunners (Azzone & Massela, 1991).

6.4.8 Summary – Internal processes

- Few salesmen can sell traditional fixtured products

- The information flow during quoting is often inaccurate. This makes quotation timely and costly and it can make the delivered product different from the desired product
- Scope creeping is an effect of poor information flow and leads to poor cost control
- The organization of ACTA realizes the benefits of a certain standardization of the products
- The fixtured products almost never use standard design, and always contain a high degree of local content. This drives costs, time consumption, makes quality assurance harder, and lowers the familiarity
- The lack of an easily searchable database leads to unnecessary unique solutions
- Order change requests are more common for unique solutions than for standardized solutions. They are a menace because they lead to increased costs that are hard to price
- Long lead times and delivery times are costly for the company and an impediment to potential new business

6.5 ACTA's manufacturing strategy

Analysis

It is interesting to see where ACTA fits in the different classifications of mass customization that were presented in the frame of reference (chapter 3.5). Today, ACTA designs all of the regular fixtured products from scratch each time one is ordered and the customer can decide on everything from color to size of the products. The products do not consist of any modules, because the TC's and the spindles are not modules, but subassemblies, according to the theories of modularization. Furthermore, the customers are willing to wait for the products once they are ordered. According to McCutcheon et al. (1994), such a situation would favor a make-to-order approach. However, there are indications that the customers want the products faster and faster. If that happens, ACTA would need to choose an assemble-to-order approach to reduce lead times. A build-to-forecast approach would not be suitable, since the volumes of the products are too low.

If the classification of Lampel & Mintzberg (1996) were used, ACTA would be considered a pure customizer with customized design, fabrication, assembly and distribution. This clearly shows that the company does not employ any mass customization strategy. This fact becomes even clearer if ACTA is classified according to Duray et al. (2000). ACTA would not be considered a mass customizer, but would resemble a fabricator. The difference is that no modularity is used to achieve customization, i.e. the mass *in mass customization is missing.*

All of these different classifications show that ACTA is a customizer and not a mass customizer. This would not be a problem if ACTA would work in an unchanging world. That is however not the fact. One of the reasons that the Express concept was developed was to overcome the increasing pressure from purchasing. We believe that this is just the beginning of the change and if ACTA wants to stay competitive, changes need to be made in the market offer to answer to the changes that are bound to come. Another reason to implement a mass customization strategy is the benefits of combining the economy of scope with that of the economy of scale.

7 Conclusions and recommendations

In this, the last chapter of the thesis, we present the conclusions from the conducted study that corresponds to our purpose. At the beginning of the chapter, we give some general conclusions drawn from the analysis in the last chapter. Then we proceed by describing how we believe a new market offer should be designed. Chapter 7.3 covers how we think the new market offer should be implemented to be able to draw full benefits from it. In chapter 7.4, we describe the implications on a few different actors of the new market offer. In the final chapter of this thesis, we have a short concluding discussion and recommendations of future research.

7.1 General conclusions

In our interviews with the salesmen and people working at the APC in Detroit, we found that getting accurate and sufficient information from the customers was the most difficult part, which is shown by the fact that most of the mistakes appeared at that stage. This complies with Kritchanchai & MacCarthy (1999), who emphasizes the importance of a well-developed information flow process for companies working in a similar environment as ACTA.

Another observation we made was the problem the salesmen have when selling fixtured systems. Some people meant that this problem was due to lack of training, whereas other people said the reason was lack of practice. Whatever reason, the problem persists. It is important that ACTA in some way solves this problem, either by having dedicated salesmen for fixtured systems or introducing some kind of sales support. Implementing good sales support could also improve the information flow from customer to the APC.

Many of the people we talked to said that the automotive industry would not accept standard solutions, since they are used to getting everything their way. However, the next moment the same people said that the Express concept had cannibalized on sold engineered systems to the automotive industry. We believe one of the most important findings is that the Express concept has been so widely accepted although it is a standard system. It implies that it should be possible to introduce standardized systems that are cut to fit an application at the customer's plant, if only the benefits could be effectively communicated to the customer.

In the analysis, we found several problems that had a negative influence on the profitability of ACTA and we will elaborate on the problems we consider most acute. One is that similar problems are solved with unique solutions, which has lead to poor cost control and has made it difficult for ACTA to assure the quality of the ordered products. A further problem is the poor sales support and the lack of traceability of sold systems, which reduces sales and leads to unnecessary special solutions. A problem linked to that, is the difficulties in getting accurate and sufficient information from the customer. It leads to extra errors and a lot of extra work.

Moreover, it was found that ACTA cannot be considered a mass customizer, but rather a customizer. Today, the customers are willing to wait for the products, because they know no other way. We believe that it is possible to reduce the lead times without loosing the customization of the products and at the same time achieve cost control. The time of the order process presented in the analysis could be reduced to two to six weeks by implementing a different approach to customization (Figure 7-1). Firstly, the quotation process could be done in less than 24 hours by using a computerized configuration tool. In the ideal case, it should just take a few minutes. Secondly, the customer evaluation process should go faster, because the standardized products would be easier to understand and evaluate than a unique one. The engineering step is nonexistent, because the drawings would be made in the computerized configuration tool. Production, finally, would also go faster because of repeatability in production and because the assemblers recognize the parts.

It would also reduce the number of OCR's. The list below summarizes some of the most important problems:

- Getting accurate and sufficient information from customers
- Similar problems solved with unique solutions
- Poor sales support and lack of traceability
- Long lead times

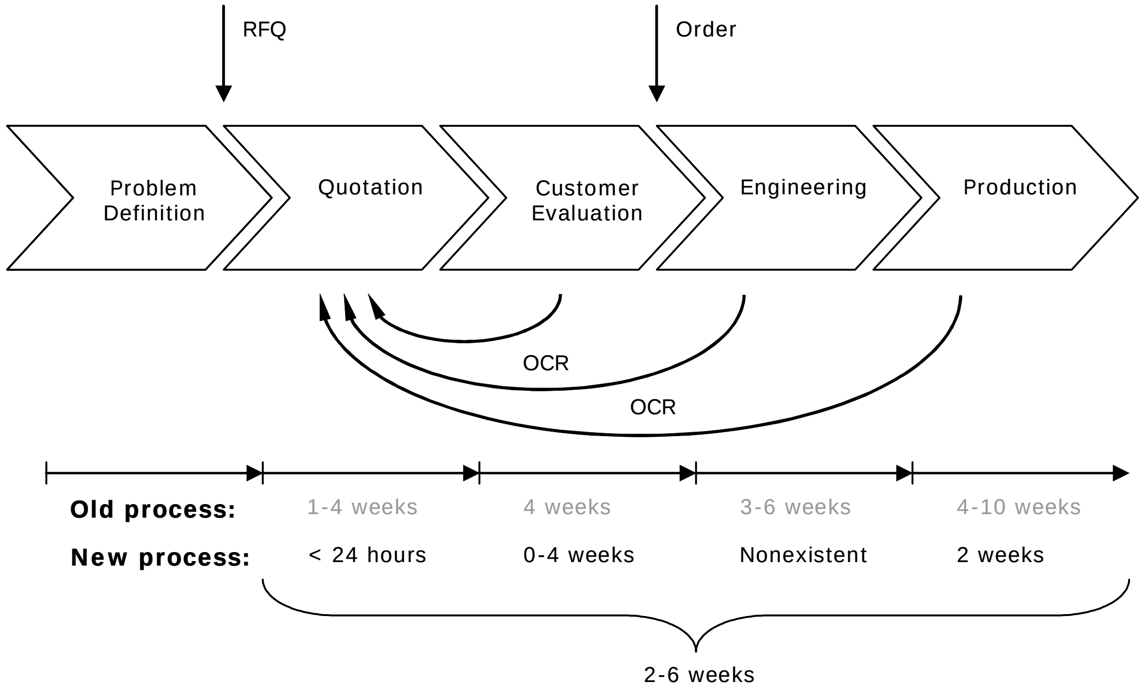

Figure 7-1. The new process of ordering a fixtured product.

7.2 New market offer

We propose that ACTA should implement a mass customization strategy. Of course, not all of ACTA's products can be mass customized, but to a large extent it should be possible. Here it is also appropriate to stress that we do not want to get rid of the engineered solutions. We believe they are a very important part of the market offer and in some cases essential to get an order. To completely let the special products go at an early stage of mass customization could also mean that ACTA were to cut off the branch they are sitting on. Moreover, they can serve as customer-financed R&D for the mass customized products. To implement a mass customization strategy, we argue that ACTA should take three measures:

- Design standard products
- Modularize the products
- Implement a computerized configuration tool

Firstly, standard products have to be identified and designed to meet the customers' demands. For instance, today a wheel multiple never looks the same twice, although it fulfills the same demand every time a customer buys the product. Secondly, the products should consist of standardized modules, which would simplify the flexibility of the products and thirdly, a computerized configuration tool should be implemented.

Each of the measures affects every part of the process in a different way. For instance, standard products would make the problem definition easier because a predefined solution already exists and the customer evaluation would be faster, since the products are less complex. A configuration tool would make the quotation process instantaneous and the standard modules would reduce time in production.

If ACTA would carry out the three measures, it would be possible to construct a market offer consisting of three types of products:

- Standard products
- Modified standard products
- Special products

The standard products would have a predefined structure and it should be possible to promote them as they are, i.e. this is ACTA's wheel multiple or application for clutch assembly. Although the structure is predefined, it should be possible to customize some things to meet the customers' need, such as the distance between the multiples, different torque values, different tightening strategies, different TC models, and different format of documentation. The important thing to remember is that the customization should be regulated to achieve cost and scope control of the sold products.

The second type of products would be modified standard. They would be built up by the library of modules available, but they would not be defined as a standard product. The idea with these products is that the salesman can use the configuration tool to build a customized system together with the customer, by just using the predefined modules. They would be similar to the Express concept.

The third type of products is special products. They would be products that are truly unique and need to be designed from scratch. Nothing hinders the designers to use the standardized modules to build one of these products. In fact, it should be encouraged. To design these products, ACTA will have great use of the expertise gained over the years of systems design.

We believe that it would be possible to change the market offer from consisting of mostly special products to consist of mostly standard- and modified standard products (Figure 7-2). It is hard to estimate as of how much can be changed, since it for example depends on how many standard products that will be introduced, if new market shares will be reached with the new products, and how well the changes will be met within the organization. However, through our interviews, we believe that there is a big potential of change.

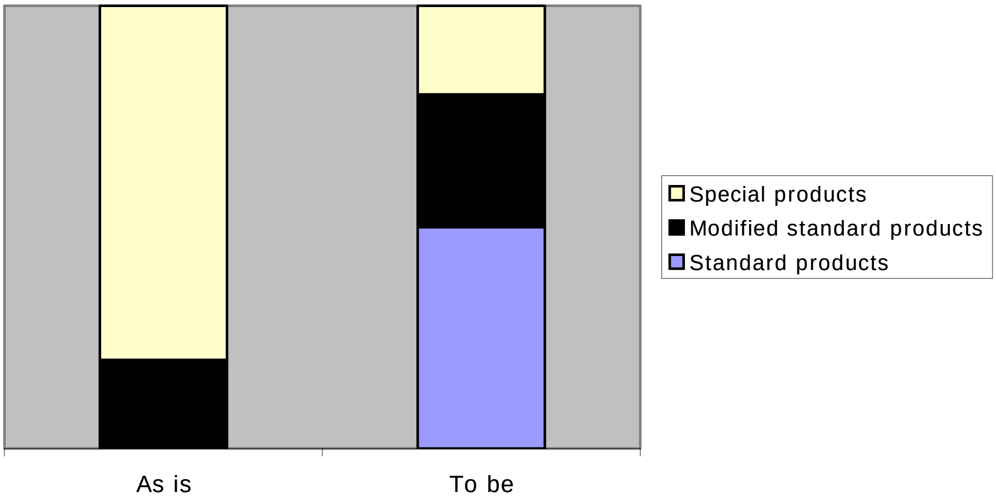

Figure 7-2. The share of special, modified standard, and standard products today and what we believe should be possible to achieve.

When changing the offer we believe that it is important for ACTA to be conscious about the company's current assets, in order not to trade away advantages. These assets can be internal as well as customer benefits. During a modularization process, many customer and internal benefits will be identified since it consists of a customer evaluation and involves members from many functions. The benefits discovered during this phase might be associated with a specific application and thus not recognized in this thesis. However, the benefits identified in the *customer perceptions* chapter of our analysis are among the most important assets to keep.

7.2.1 Standard products

In the analysis, we found that the products are perceived as complex and salesmen from former Tools have difficulties selling fixtured systems. There is also a high degree of local content and there are many order change requests. The scope and cost control of the sold products are poor and the lead times are very long. We propose that ACTA should identify and design standard products to overcome these problems. Below we describe the benefits and disadvantages of introducing standard products and what part of the ordering process they will affect (Figure 7-3).

Internal benefits

If there were a standard design, the products would be more tangible and thus easier to promote. The salesmen could concentrate on the uniqueness of the customer's problem instead of as today, where the salesman has to build a system from scratch each time. Furthermore, the standard products could work as door openers – it is easier to try a product that is predefined and has a proven history. It would also be possible to catch the day-to-day sales. Today, if a customer has a problem that needs to be solved by a fixtured product, it takes several weeks before a suitable solution to the problem has been found. If there were standard products, there might already exist a solution to the customer's problem.

Standard products would also lower the costs of the products. The need of project management would decrease, which would mean less overhead costs. If standard products were quoted, it would mean that the costly quotation and design processes could be decreased. Moreover, because the customer can see the products beforehand and there would be a clearer agreement on what has been sold, the amount of OCR's would decrease. The decrease in OCR's would further be accentuated thanks to the decreased lead times in design and production.

Having standard products would also decrease the high amount of local content of the products. This would mean an increased cost control of sold products and would make the quality assurance easier. The corporate image would also be clearer and customer and salesmen would be able to recognize an Atlas Copco product all over the world. Moreover, the assembly of the products would be faster, because the assemblers would recognize the products and know how to assemble them.

A further benefit that maybe is not as obvious is that the customer's incentive to buy would be increased and the price sensitivity would be reduced because of the shorter lead times. This would allow ACTA to keep the premium price or even raise it. Together with the cost cuts, this would increase the profitability of sold products.

Customer benefits

There are not only internal benefits of introducing standard products. It would also be beneficial for the customers. The most important factor is the reduced risk associated with buying a fixtured system. If each system is produced from scratch, it is impossible to see the product before it is bought. Today, the customers visit other plants to see a similar system in use, but because each system is different, the customer cannot be absolutely sure of what their system will look like. Furthermore, the customers will be able to get assured quality, thanks to the repeatability of the design – ACTA will have the possibility to test and prove each product beforehand. What is more, the products will have a better performance, as ACTA will have more resources to optimize a standard product.

Standard products would also reduce the costs associated with buying a complex system. Today, a company invests at least 30 man-hours to specify an average system. Those hours include things such as specification meeting, concept review, and design review as well as miscellaneous travel costs and preparation meetings. If there already is a product specified, these costs can drastically be reduced.

Difficulties and disadvantages

A natural fear when thinking about standard products is that the customer might persist in that they get a poorer service, and thus expects compromises to be made from ACTA's side, e.g. lower price. However, as stated above, a standard product will mean product improvements in several ways, which should make it unnecessary to lower prices. To prevent that the customer perceives the product as less valuable, the possibilities of altering the product, by for example choosing the TC, could be used to show the customer that it is a unique product with the benefits of a standard.

Standardization cannot be made over the whole product range. Only certain applications are able to standardize, even with a possibility to moderately adapt the scope of the standard product. The task of deciding what should be kept as special solutions and what should be standardized is a very difficult one. Unless this is done with caution, ACTA will end up with standard products that only meet a small part of the market and will still have most of their customers buying special products.

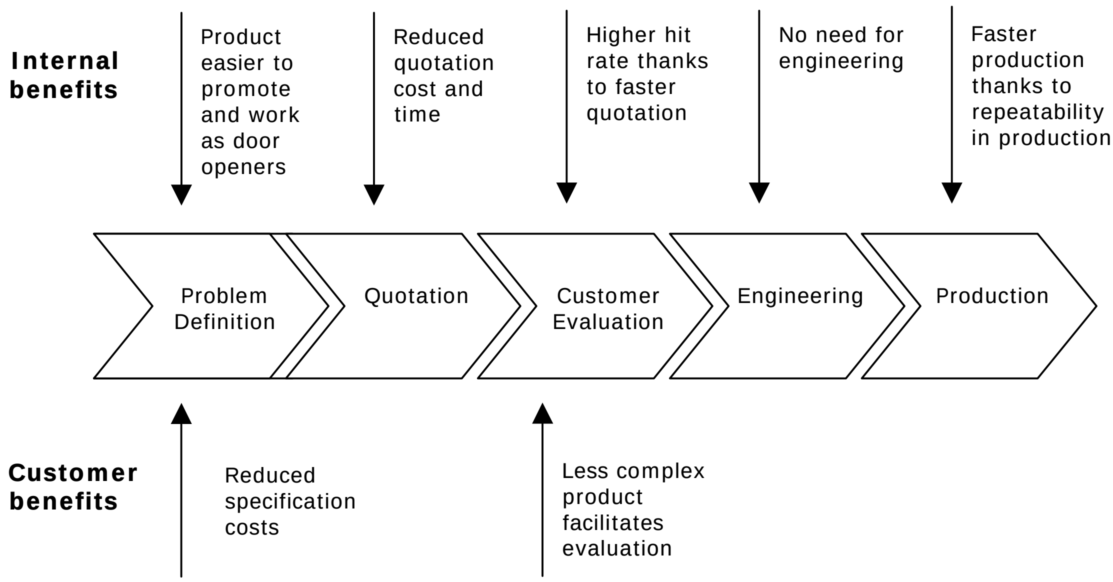

Figure 7-3. Effects of standard products

7.2.2 Standardized modules

In the analysis, we found that there are many different product lines. Moreover, there are no common parts between the products from former Tools and former Assembly Systems and the control systems have different design and have completely different graphical and signal interfaces. This means that ACTA is seen as two different companies and runs the risk of not being the first choice for complete or complementary orders. Furthermore, the parts of similar products are often not interchangeable, since the products are redesigned each time, which leads to different parts being used. To overcome these problems and more, we propose that ACTA should implement standardized modules that build up the fixtured products. The benefits are described below and some of them coincide with the module drivers of Östgren (1994) and Gullander et al. (1999), namely:

- Common unit
- Separate testing
- Different specification
- Local content demands
- Service / Maintenance
- Upgrading

Internal benefits

If Atlas Copco Tools & Assembly Systems were to introduce a modular design, it would be possible to use the same parts in all of the different product lines and the parts would be the same no matter where or when the product has been built. In fact, it would only be one product line but with all the possibilities that the product lines of today offer. Moreover, modularization is standardization on a high level, i.e. product or even product family level. Thus, the standardization propagates down to a lower level, i.e. component level or product level if the modularization was made on product family level. According to Nilsson (1990), reducing the amount of parts means considerable savings and we believe this is possible for ACTA.

A modular design decreases the complexity of the products. One of the results of that are shorter assembly times, which reduces the lead times of the products and decreases the work in progress (WIP). Furthermore, the modules can be tested before final assembly, which increases quality of the final product and decreases the costs associated with correcting errors.

Modularity is a good way to handle variety. If ACTA implements a modular design, the flexibility of the products can be increased. Today, the choice of spindle is dependent on the choice of TC – with a full modular design that would not be the case. It would be possible to combine the durability of the QMX spindles with the less complex interface of PowerFocus when the advanced features of the PowerMACS are not needed. Taking advantage of the flexibility of the products can also be simplified. Today the customer can get a high variety of products, but the salesmen and the designers are not able to handle the vast amount of different solutions. With a modular design, it would be easier to configure and design the correct solution for the customer. Modules could also be used to overcome the differences in regulations between different markets by having local content modules specialized for each market.

Another benefit would be if a customer wishes to upgrade the control system. With a modular design of the software, such upgrading would be very easy. Today, hardware locks are used for the PowerFocus controllers, but for PowerMACS, such a system does not exist. Hence, the customer needs to send the controller to an APC where it is upgraded with the different software. Moreover, standardized modules would make the products look similar and the customers would become familiar to them. We believe this would lead to lock-in effects with customers requesting products to which they are accustomed.

Customer benefits

As with standard design, there are customer benefits of introducing modularity in the products. The service and maintenance would be facilitated for the customers. The more products that use the same modules and components, the lower number of spare parts the customers need to stock. What is more, today the customers buy several extra parts when they buy special solutions because they are aware of the long lead times on those items. If they buy standard products, they would not need to do that, because ACTA would stock the parts.

Another benefit is that the modules could be designed to be easy to interchange. That could facilitate service if the tool breaks down, because the service team would just have to substitute the erroneous module to a new module. Furthermore, finding the error and correct it would go faster for the service team because the same modules would be used in more products. These two effects would reduce the time of production stops, which is extremely important for not least car manufacturers.

Difficulties and disadvantages

The introduction of standardized modules as building blocks is a time-consuming and costly work. Hence, there is a risk that the development of a module could mean unnecessary work in the case where the resulting economy of scale is lower than the development costs.

Some of the components in ACTA's offer might be truly unique or optimized to their purpose according to customer desires. Those components might not be suitable to modularize, and modularization might thus imply greater disadvantages than benefits.

Moreover, when designing a system to replace several existing systems with different capabilities and options, there is always a risk that the final system would need to be compromised in some way to cover the whole spectrum. This could lead to future products that are not as good as the ones of today, but overall they would be more cost effective. Ulrich (1995) addresses another case, where a standardized component actually would be more costly. This could be the result if ACTA tries to standardize all of the different cables to one. Although these may seem as problems that just arise when several products are combined to one, it actually arises every time something is developed – one always needs to make a cost benefit analysis. However, it is more acute when trying to make several products into one.

Striving for products with a specific power to weight ratio is a reason not to modularize according to Erixon et al. (1994). This could be taken as a reason not to modularize by ACTA, given that it is a driving force behind the development of handheld tools. However, it is not as important for fixtured tools. We also believe that using modules similar to the handheld tools of today, could give ACTA the benefit of modularizing over a broad spectrum of products with continuously good power to weight ratio.

Political- and regulatory development are of great importance when developing and selling products used in safety critical applications. Therefore, possible new laws are a potential hazard when developing a modularized product line.

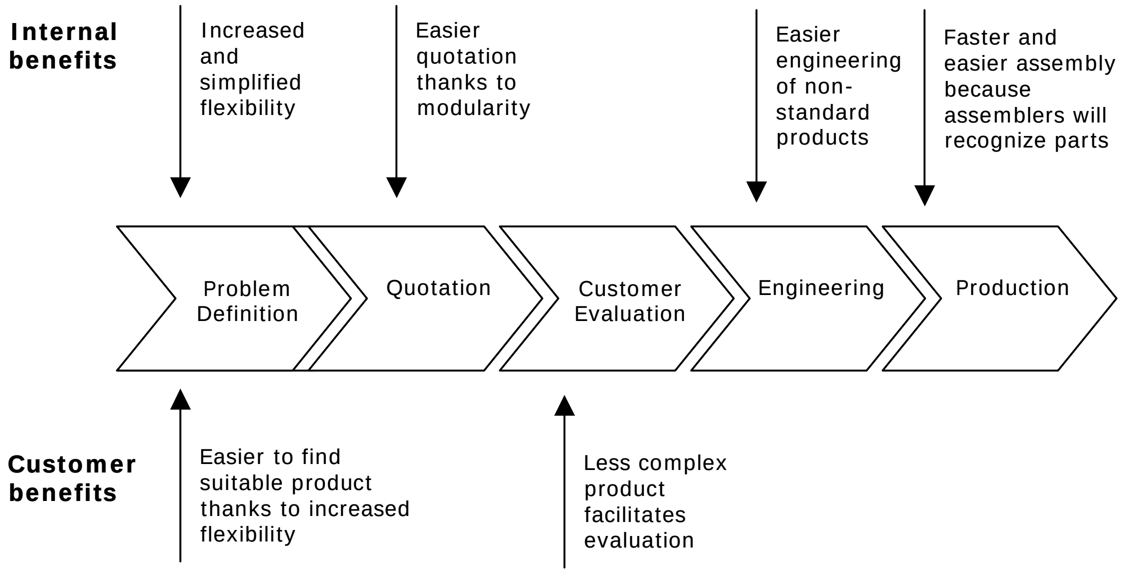

Figure 7-4. The implication on the process by standardized modules

7.2.3 Computerized configuration tool

In the analysis, we found that the sales support was poor. Fixtured products require more adaptation than handheld tools and one of the biggest problems is to get the correct information from the customer to the salesman and from the salesman to the APC. What is more, the products have very long lead times – quoting a system takes at least a week and designing it once it is ordered is another three to six weeks and we believe these long lead times are unnecessary. Another problem is the difficulties in tracing sold systems. We suggest that ACTA should implement a computerized configuration tool to solve these problems.

Internal benefits

Today the quotation takes between one and four weeks, but with a computerized configuration tool, the salesmen would be able to quote a customized system within minutes. Furthermore, if the customer orders the system, there would not be any need of designing it since that is already done by the configurator. This would lead to major cuts in costs and lead times once the system is set up. The shorter reply times would also mean that the hit rate of the quotes would be higher. Moreover, a configurator would work as a framework to do business within, which would reduce the repetitive work of the salesmen as well as work as a starting point for the quotation process. It would also facilitate the achievement of scope control of the quoted systems.

A computerized configuration tool would also ensure that the APC would get correct and sufficient information from the customer to build the system. There would also be a clearer agreement on what has been ordered. These two factors together with the shorter delivery times would reduce the number of OCR’s.

If the quoting were done in a computerized configuration tool, it would be possible to achieve traceability of both the quoted and the sold systems. Today such traceability is almost impossible, which makes it hard to transfer the information of good solutions to other parts of the world as well as keeping track of what has been sold all over the world. Not only quotes made in the configurator, but also quotes of special products made outside of it should be able to be incorporated in order to reach administrative traceability.

Customer benefits

A configuration tool would reduce the time it takes to get a quote for the customer. It would also reduce the delivery times of an ordered product. Both of these benefits are important to the customers, especially since the time to market is reducing (Japanese ministry of economy trade and industry, 2003). Furthermore, with a configurator, the salesman can give the customer more help in specifying the product. This would reduce the time spent by the customers to specify the product.

Difficulties and disadvantages

A configurator should be an aid for the organization in general and its users in particular. It is therefore of great importance to create interfaces that really do work, that contain what its users actually need, and to do so in a user-friendly way. Its interfaces with other systems of the organization are also important. ACTA already has experience from interacting organization-wide computer systems and therefore it should be possible for the company to foresee these problems.

Making sure a configurator really works does not only mean thinking of all of today’s problems – it also means thinking of future problems and changed needs. The risk that a configurator gets outdated or is not used because it does not fill the needs is evident, and something that need to be kept in mind.

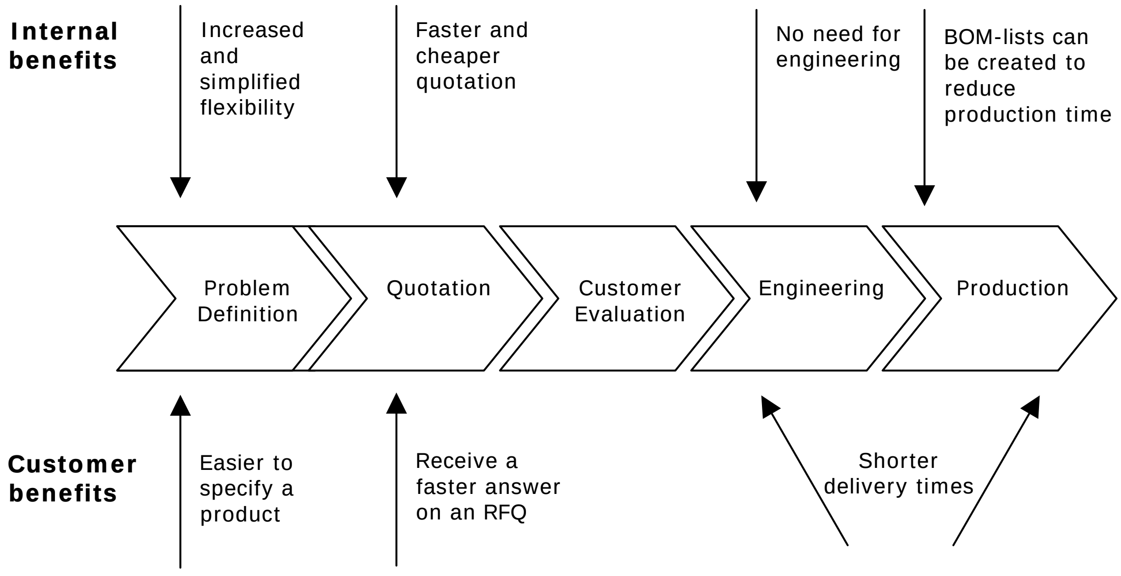

Figure 7-5. Effects of implementing a computerized configuration tool

7.3 Recommended way to implement the new market offer

In order to draw full benefits of our proposed offer as presented in the previous chapter, ACTA will need to introduce the offer in the entire organization. According to de Wit & Meyer (1998) there are different perceptions on the best way of changing a company's strategy. We believe that the possibility to keep a steady pace of change offered by a modularized concept corresponds best with what de Wit & Meyer present as *the continuous change perspective*. Since many of the benefits of traceability, cost and scope control, and economy of scale come from a large-scale introduction of our proposal there will need to be an element of *discontinuous change*, a revolution, in the beginning. This strategy with an initial revolution followed by continuous improvements corresponds to how Womack & Jones (1996) describes an introduction of lean production.

It is a very big step to change the market offer and the internal processes to become a mass customizer. According to the theories presented above, we believe that the only way to do this successfully would be to step by step introduce the proposal, and to introduce each change on a worldwide basis. If the goals were set too high, they would never be reached and the whole project would come to nothing. In this chapter, we will shortly elaborate on an implementation strategy on each of the three proposed measures.

There are interactions between all parts of our proposal, but in reality, they could be introduced one at a time, although that would imply the loss of many synergies. In order to make use of the benefits from the synergies, we believe it would be best to make a plan for the future steps. Maximum benefits would also need the making of an overall solution where the standard products make use of the standardized modules, and the configurator makes use of both the standard products and standardized modules. After the initial launch, the introduction of new standardized products and modules would demand a lot less effort. Many changes will surely need to be done as the project evolves because the increased scope control and traceability give better understanding of the business, something that further speaks in favor of a stepwise introduction.

7.3.1 Standard products

Before standard products can be designed, they must be identified. Engineering time is proportionally the largest part for applications with only a few spindles, which means that those applications are the most urgent to standardize. The reason for this is that it is easier to carry the costs of engineering when it can be split up on larger applications. We believe the best way to identify and design standard products is to group the different applications that have similar topology, although their use may differ, because it would facilitate the implementation of standardized modules. As an example, the wheel, clutch, and flywheel applications have similar topology.

We further believe that the introduction of the standard products should be stepwise and that ACTA should start with the most evident or easy applications. Several of the people we interviewed were of the opinion that the wheel nutrunner is such a product. If the introduction is stepwise, it will give the salesmen and customers time to understand the benefits of standard products. Moreover, the implementation would not be as costly in the beginning.

To design the standard products, a cross-functional group should be formed to perform benchmark studies on the different local solutions. We believe it is important that the person leading the group is unbiased to local solutions and can see what is sold on every market. It is further very important that the responsible person has a mandate that is recognized throughout the organization. Therefore, we suggest that the group is lead from Stockholm, but include members from the APC’s.

7.3.2 Standardized modules

In the frame of reference, we presented a method to modularize products called Modular Function Deployment (MFD, further explained in Appendix A) (Figure 7-6). This method has been developed in cooperation with several large Swedish manufacturing companies. One of the benefits of MFD is that the modules can be grouped in accordance to company specific reasons.

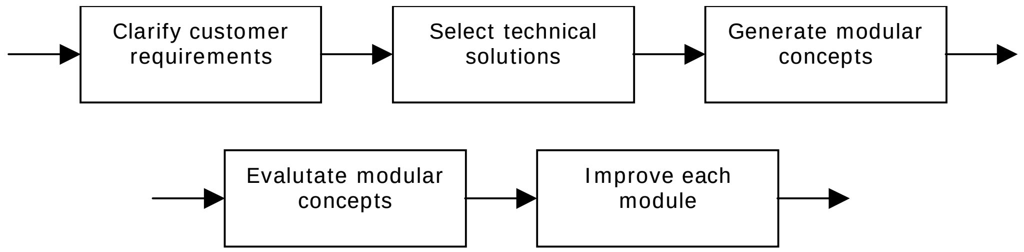

Figure 7-6. Modular Function Deployment. The first and last arrow symbolize that product development is an iterative and never-ending process

We believe that ACTA is somewhere between the second and third step of the process. The technical solutions have been identified, but they have not been grouped to modules. However, since MFD benefits from a complete modular approach to product development, and such has not been taken by ACTA before, the process will have to be repeated from step one. In order to make full use of a modularized concept any company that decides to use it will have to go trough the entire process each time a new product generation is being developed, and preferably, even each time a new module is being developed. This will ensure that the module satisfies the demands placed upon it and that it is optimized for its purpose.

7.3.3 Computerized configuration tool

The fixtured products of ACTA are today very complex in their structure. According to Bourke et al. (1999), a prerequisite to successfully implement a configurator is that the products must be simplified. One way to do that is to modularize the products.

The introduction of a configurator tool is an important change that has strategic implications on the operations of ACTA. It is therefore of great importance that the system is flexible, and is prepared for and can tackle future changes in the offer. Such flexibility could for example be the possibility of adding new rules on how to automatically construct an application.

7.3.4 Upgrading the offer

Our proposal is a continuous upgrading of the market offer (Figure 7-7). If a common application frequently reoccurs, it should be brought into the space of solutions that can be configured with the configurator. Such an introduction should if possible make use of existing modules. The construction of a module should be considered when similarities between standard products are seen, or when applications that do not fit inside the space of configurable solutions, special products, have similarities.

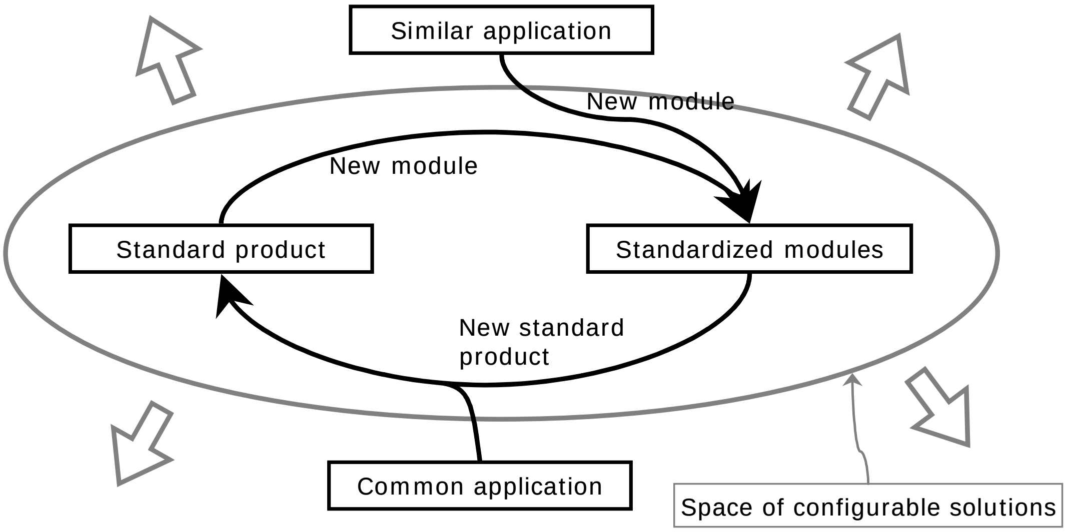

Figure 7-7. Continuous upgrading of the market offer

The framework consisting of standard products with exchangeable modules will in this way be growing as more and more of the Atlas Copco products are brought in and more and more of the sales will be constructed from those building blocks.

7.4 Implications of a new market offer for different actors

Changing the strategy of a company would not only have implications on the company, but on the whole business environment of the company. In this chapter, we will mention some of these implications on a few different actors.

7.4.1 Atlas Copco Tools & Assembly Systems

In chapter 7.1, we mentioned several of the implications on ACTA of changing the market offer. Below, we have listed some of the most important effects.

- Easier for salesmen to promote the products
- Facilitate the information flow from customer to APC
- Reduced lead times
- Economies of scale
- Achieve traceability of sold and quoted products

This means that there would be a more centralized control of everything from promoting to producing the products and the flow of information in and between the markets would be facilitated.

7.4.2 Customers

There would be many customer benefits if ACTA implemented our proposed market offer. Below we list some of the most important ones.

- Reduced risk and cost of buying a new product
- Reduced costs for service and maintenance
- Reduced delivery times and time to get a quotation

These three effects mean that the cost, risk, and time associated with buying a fixtured product would be reduced.

7.4.3 Competitors

We believe that ACTA can change the industry standard if they change the market offer. The result would probably be increased market share, but this would of course not pass unnoticed by the competitors. In order to stay competitive, the competitors would have to change their strategies in some way, or cut the prices. The easiest way to increase sales and market share is definitely to cut prices, but unless the increased sales result in lower internal costs, the consequence is reduced profitability. The other alternative to stay competitive, changing the strategy of a company, takes time. This means that ACTA could become market leader until the competitors have time to change their strategies.

7.4.4 Suppliers

Today, most suppliers are local. If standardized modules would be introduced, the modules would be produced centrally and kept in stock at PTD, the centralized warehouse of ACTA. A consequence of reducing the number of suppliers would be that some local suppliers would be replaced by central ones, unless the local suppliers can show why they are the best choice.

7.5 Concluding discussion

The purpose of this thesis was to propose a new market offer for the fixtured products of Atlas Copco Tools & Assembly Systems that would increase profitability and give more customer benefits. To reach this purpose, we started out with in-depth theoretical studies of several different areas, which provided us with a firm theoretical foundation. Through the many interviews that we conducted, we believe that we have reached a good understanding of the business environment and internal processes of ACTA. This is very important in order to fully understand how the processes affect the market situation of today and if the processes can be changed.

The knowledge from the interviews combined with the solid foundation of theories gave us the means to form a new market offer and judge its implications. We did not only estimate the implications of implementing the offer, but also difficulties that need to be considered. We believe that the new market offer presented in this chapter will increase profitability and give more customer benefits, which imply that the purpose is fulfilled.

7.5.1 Future research

During the time that we have written this thesis, several new areas of research has arisen. The most evident one is of course how the modules should be constructed. At some time during our work, we understood that it would not be possible for us to identify all the different modules. There are mainly two reasons for this; the first is that there are no records as of what has been sold and the second is that we do not possess the skill and knowledge needed to design the modules. Instead, we propose that this should be done by a cross-functional group led from Stockholm.

A second interesting area of research is how the supply chain should be designed in order to fit the new market offer and manufacturing strategy. If a part of the production will be centralized, there is a need to redesign the supply chain

A third area of research would be to calculate the costs of introducing and maintaining a part number. This would be interesting, since it would show how much time and effort that could be invested in introducing standardized modules.

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8.3 Personal Interviews

8.3.1 Atlas Copco personnel, Detroit

Salesmen

Todd Adams

Don Allar

Dan Beresh.

Lyn Birchard.

People working at the Application Center

Jim Caruso

Dwayne Dupuis

Michael Harrell

Tom Marcum

Merwin McKechnie

Chris Vizachro

Ben Warren

Bill Zabreski

Other ACTA personnel in Detroit

Hans Mandahl

Anders Hoberg

8.3.2 Atlas Copco personnel, Sweden

People working at the marketing department

Morgan Algarp

Jonas Andersson

KarlJohan Börjeson

Tom Englund

Ulf Finnman

Bo Hellmark

Salesmen and project managers

Bo Carmén

Stig Sjölund

Carina Öhlin

Product developers

Lars Halén

Christer Hansson

Tobias Lindbäck

Anders Melin

Johan Wallgren

8.3.3 Customers

Volvo personvagnar, Köping, Sweden

Volvo personvagnar, Torslanda, Sweden

Volvo personvagnar, Skövde, Sweden

Volvo Lastvagnar, Köping, Sweden

Volvo Lastvagnar, Torslanda, Sweden

Volvo Lastvagnar, Skövde, Sweden

Ford, Wayne Stamping & Assembly Operations, Detroit, USA

Ford, Michigan Truck Plant, Detroit, USA

Ford, Wixom Assembly Plant, Detroit, USA

General Motors, Detroit-Hamtramck Assembly Center, Detroit, USA

8.3.4 Sandvik Coromant

Mikael Pettersson

Leif Widin

8.4 Mail interviews

Mikko Vepsalainen, Metso Minerals

9 Glossary

ACTA	Atlas Copco Tools & Assembly Systems
APC	Application Center. There are two main Application Centers today, one in Germany and one in the USA. There is also a smaller one in Brazil. The APC's design and assemble the fixtured systems that ACTA sells.
Assembly system	An advanced system for assembly operations, usually involving several nutrunners and complicated tightening strategies.
BOM	Bill Of Materials. A list with all the components needed to produce a product.
CC	Customer Center. They handle customer contacts, take care of sales, and employ project managers to help sales personnel to construct customer-adapted products. Orders with a low level of complication, such as ordinary handheld tools, can be handled by the CC's alone.
Component	A product consists of several components. A component is anything from a TC or spindle to a screw.
EDI	Electronic Data Interchange.
Express	Express is a standardized fixtured system with the possibility to choose from a few different predetermined configurations and the components are always kept in stock. It is possible to add a few more customized features to the Express system (hand scanners etc.), but this is kept to a minimum.
Fixture	The system a spindle is attached to. Could be anything from a simple arm that works as a counterweight to complicated installed applications with no physical interaction with the controller of the machine.
GI	General Industry. All types of industries outside the MVI and the customers include aerospace, off-road, white goods and original equipment manufacturers
Market offer	The total product range that ACTA presents to its customers
MFD	Modular Function Deployment. A method used to modularize a product.

	The method is developed at the Royal Institute of Technology (KTH) in Stockholm.
MIM	Module Indication Matrix. A tool used in one of the steps in the MFD process.
MTB	Machine Tool Builder. Companies that an auto manufacturer contracts to build a new line
Multiple	When several nutrunners are fastened on a fixture, it is called a multiple.
MVI	Motor Vehicle Industry
Nutrunner	The actual tightening tool that is mounted on a fixture. An example of nutrunners is the QMX series of ACTA.
OCR	Order Change Request. If a customer asks for a change of an ordered product, it is called an order change request.
Part	see *component*
Power train	A generic name for all parts used for power transmission on vehicles.
Product	What the customer gets – i.e what leaves the APC (e.g. a wheel multiple)
PTD	Power Tools Distribution Center. The central warehouse for Atlas Copco Tools & Assembly Systems, placed in Hoeselt, Belgium.
QFD	Quality Function Deployment. A method used in product design. The first part of the method is used in MFD.
QMX	The nutrunner of former Assembly System. Is always mounted to a fixture.
RFQ	Request For Quotation. When a customer asks for a quote on a system, it is called a request for quotation.
Socket holder	The front part of the spindle.
Spindle	see *nutrunner*

TC	Tightening Controller. A computer connected to the tool, where for instance different tightening strategies can be chosen. It also includes parts for communication.
Tensor	An electric motor developed by former Tools that has a high power to weight ratio.
Transducer	The part of the spindle that translates the force needed to turn the bolt to a torque value.
Transplants	When a company builds a factory on another continent, it is called a transplant factory. For the first generation of lines and tools, the suppliers are decided in the home country.

Appendix A: Modular Function Deployment

Modular Function Deployment (MFD) is a process developed by Erixon (1998). The process offers a method to modularize a product and the modules are constructed in accordance to company specific reasons. The process involves five steps (Figure 1):

1. Clarify customer requirements
2. Select technical solutions
3. Generate modular concepts
4. Evaluate modular concepts
5. Improve each module

The method is described in an order from step one to step five to achieve causality in the process, but in reality, all product development is an iterative process. Below, we will describe the five different steps of the MFD.

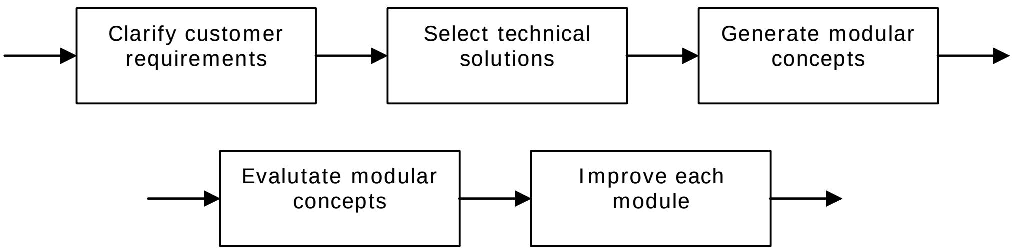

Figure 1. Modular Function Deployment, MFD. The first and last arrow symbolize that product development is an iterative and never-ending process

Step 1. Clarify Customer Requirements.

Clarify customer requirements is usually done through a method called Quality Function Deployment (QFD). QFD is a systematic method to identify customer demands and preferences and translate them into product specifications. The strength of QFD is that it can be used to evaluate abstract demands. According to Ottosson (1993), this means that it has limited use for products that are restricted by well-defined technical specifications or standards. However, with the generic strategies of Porter (1985) in mind, its value should not be ignored for such products as a mean to find competitive edge. Ottosson (1993) also states that the total number of demands can be up to three times the number companies believe, which proves the need for a scientific approach.

The concept of QFD grew out of the Japanese Total Quality movement. It was first introduced in 1966 by Yoji Akao as a theory about how to see to customer needs. A few years later, when it was completed with quality charts, its potential became evident and the method took the form presented here.

Ottosson (1993) has defined the following four steps that constitutes the processes outline:

1. Identification of customer needs, demands and wishes and translation of these into a product specification
2. Translation of product specification into a subsystem and component specification
3. Translation of component specification into a production process specification
4. Using the latter to plan and control support activities

When using QFD as a part of the MFD-process, it is only the first part that are used, i.e. "…the identification of customer needs, demands and wishes and the translation of these into a product specification" (Ottosson, 1993). Moreover, modularization should be taken into account as a product features. (Table 1). This makes it possible to evaluate the correlation between modularity and the product demands with the help of the generic module drivers (Erixon et al., 1994). Below is the first step of the QFD-process as defined by Ottosson (1993):

A QFD process should be carried out with a cross-functional team with members from all functions concerned; marketing, sales, production, development and service. This group should with help from brainstorms, in-house research and benchmarking studies, and customer interviews and surveys specify the demands and wishes of the customers.

Table 1. The QFD matrix. Adopted from Erixon (1998)

"What" / "How"	Modularity	Other Design Requirements					
Customer "wants"					○		
	●						
			◍			●	
	●			◍			
	●						
			○		●		◍
	◍						
Sum:	30	-	4	3	10	9	3

Strong relation (9) = ●
Medium relation (3) = ◍
Weak relation (1) = ○

Step 2. Select Technical Solutions

The design requirements from the QFD will generally be very customer oriented and to be able to proceed with the design, these have to be translated into technical solutions. The first thing is to identify functions and sub-functions that fulfill the identified customer demands. After that, technical solutions that correspond to the functions must be identified. The process of breaking down a product into functions and corresponding technical solutions is called functional decomposition and is a fundamental part of a good modular product design. A good tool to find the technical solutions that correspond to the functions is the design matrix from axiomatic design (Table 2). Integration of two or more functions in one module should not be considered here, since it will be tested later in a broader modularization perspective.

Table 2. The design matrix from axiomatic design. Adopted from Erixon (1998)

Function	Hub assembly	Spindle assembly	Brake assembly	Spring assembly	Shock absorber	Axle beam
Steer vehicle	X	X				
Allow rotation	X					
Brake vehicle	X	X	X			
Provide isolation				X	X	
Carry vehicle load	X	X		X		X

The next part is to translate the functions into technical solutions. A good tool for this work is the Pugh Selection Matrix (Erixon, 1998), which also facilitates the decision between the different technical solutions from the design matrix. The evaluation is made by comparing one reference solution (datum), which can be any of the suggested or the existing solution, with the other solutions. The comparison only gives better (+), worse (-) or the same (=). Summing them up gives a judgment of which solution is best. This should be repeated in an iterative manner, changing the datum from time to time. At the last iteration, one of the two best candidates must be the datum, because the judgment scale is rough (Table 3).

Table 3. Evaluation of solutions using the Pugh Selection Matrix. Adopted from Erixon (1998)

	Production Goals													
Technical Concepts and Solutions	Lead-time	Storage	Direct labor	Direct material	Purchase	Quality	Job-satisfaction	Balancing	Sales offers	Logistical costs	Company specific			
Exchang. gearbox	=	=	+	-	+	=	-	=	=	-			2+	3-
Reconstr. gearbox	+	+	-	=	+	=	+	=	=	+			5+	1-
Co-oper. gearbox	-	-	-	-	-	=	-	=	=	-				7-
Existing solution					**D A T U M**									

Step 3. Generate Concepts (MIM)

This step is where the actual identification of the modules comes into place. It is done by constructing and evaluating a matrix called “Module Indication Matrix” (MIM). In this step, it will also be determined what factors drive the modularization of a specific product.

The module drivers by Östgren (1994) and Gullander et al. (1999) can be used to set up a systematic evaluation of the technical concepts that were the result of the last step. By plotting the module drivers against the technical solutions in a QFD-like manner, each technical solution can be evaluated in terms of how suitable it is to form a module (Table 4). Many and/or unique module drivers with a high weight, indicate that the sub-function is complex and probably is suitable to form a module by itself. A rather unique module driver pattern indicates that the sub-function probably should be kept by itself as long as possible. A few and/or low weighted module drivers indicate that the sub-function should be easy to integrate with other sub-functions (as long as the module drivers are not contradictory, such as “carry-over” and “technology push”, which would disable the possibility of low-cost stepwise development).

Table 4. The Module Indication Matrix (MIM).

	Technical solution / Module driver	Subfunction 1	Subfunction 2	Subfunction 3	Subfunction 4	Subfunction 5
Company specific						
Devlopment and Design	Carry-over					●
	Technology push			●		
	Product plan					
Variance	Technical spec.				●	
	Styling					
Prod.	Common unit	●			◍	
	Process/Org.			●	●	
Quality	Separate testing			◍		
Purchase	Black-box eng.	◍				
After sales	Service/Maintenance	◍		●		
	Upgrading					
	Recycling				○	
Economical	Local content demands					
	Partnership demands					
	Protection of core comp.					
	Sum	**15**		**30**	**22**	**9**

Strong driver (9) = ●

Medium driver (3) = ◍

Weak driver (1) = ○

So far, each sub-function has been a single module, which in practice often has proven unsatisfactory (Erixon, 1998). The next part is to try to integrate one or more of the technical solution by evaluating the MIM horizontally. If a sub-function has the same module drivers as another, it is a candidate for integration and if it has contradictory module-drives, integration should be avoided. Now, the most creative phase of the process takes place with the purpose to generate different module concepts. To get a rough comparison and to easy exclude some of the concepts, the Pugh Selection Matrix (as was explained in step 2) can be used. It should also be noted that there is an ideal number of modules in which there is a balance between the time required to assemble the modules, and the time required to assemble the final products from the modules.

Step 4. Evaluate Concepts

When one or a few modular concepts have been generated, there is a need for further evaluation to find out how much better (or worse) they are than the existing design, what the impacts in production or development will be etc. Moreover, it is important to be able to measure the changes in some fashion. Erixon (1998) discusses what product characteristics should be evaluated for each of the wanted effects from modularization as well as what product characteristics are important for the measurements (Table 5). For each effect, either a metric value can be calculated to exactly compare two solutions, but for others, a “rule of thumb” only exists. For a deeper discussion about each of the effects, we refer to Erixon (1998).

Table 5. Effects to be evaluated, what product characteristics that corresponds to each effect, and if the evaluation is based on a metric value or a rule.

Effects (life phase)	Product characteristics	Metrics/rules
Development		
Lead time in development	Interface complexity	Metric
Development costs	Share of carry over	Rule
Development capacity	Share of purchased modules	Rule
Assembly		
Product costs	Assortment complexity	Metric
System costs	Share of purchased modules	Rule
Lead time	Number of modules in product	Metric
Quality	Share of separately tested modules	Metric
Sales/After sales		
Variant flexibility	Multiple-use	Metric
Service/Upgrading	Functional purity in modules	Rule
Recyclability	Material purity in modules	Rule

Step 5. Improve each Module

When a final design has been reached, each module should undergo design improvements in order to get a good final result. The modules should be designed in accordance to its purpose, e.g. a module mainly constructed because of service and maintenance should be design to ease disassembly. This shows that the MFD process is not a replacement of design improvements on a component level, but a method to design modularized products.

Appendix B: Interview guide

Generic questions

1. How would you judge the following features of Atlas Copco's tools in comparison to the competitors' tools? (Better, the same or worse)

    - Quality
    - Reliability
    - Ergonomics
    - Easy to maintain
    - Length of product generation
    - Compatibility with existing production systems
    - Flexibility in the use of the product
    - Flexibility in what can/is delivered

2. How important do you think the following aspects are when a company is buying fixtured tools like ACTA's?

    - Quality
    - Reliability
    - Ergonomics
    - Easy to maintain
    - Length of product generation
    - Compatibility with existing production systems
    - Flexibility in the use of the product
    - Flexibility in what can/is delivered
    - Delivery-time
    - Reliability of delivery
    - Service
    - The size of the selling company and its presence on the buyers markets
    - The control-function of a tool? (Traceability etc.)

3. What do you think about Express? How flexible is the product?

Selling / buying situation

4. What reputation does Atlas Copco Tools & Assembly Systems have among the customers?

5. Who influences the buying decision?

6. What is the most important thing for the customer, the price or the total cost of ownership?

Questions to salesmen

1. Have you ever been in a situation where you have decided to sell a tensor product instead of PowerMACS because of delivery times?

2. Is it possible to persuade or influent the buyer with things outside the specification?

3. Do the customers often inspect the product before deciding to buy it?

4. How do you persuade the customer to buy products from Atlas Copco Tools & Assembly Systems? (What features etc.)

5. How well do you think the products delivered by ACTA agree with the needs of the customers?

6. Why do the customers choose ACTA?

Ideas about the product

7. Which associations do the customers make when using fixtured nutrunners?

8. Which problems/defects/complaints do the customers associate with the use of fixtured nutrunners?

9. Which criteria do the customers take into consideration when buying fixtured nutrunners?

10. Which new features or services would better meet the customers' expectations?

11. How do you feel about standardized products?

Software

12. What do you see as the big benefits of PowerMACS and PowerFocus respectively?

13. Do you find PowerMACS to contain too much or are most of its functions being used?

14. Do you believe that the functionality of PowerFocus could have been used in any of the sold PowerMACS systems? If so, how many?

Questions to customers

1. What is more important: a fast delivery or an exact delivery?
2. How would you assess the competence at Atlas Copco Tools & Assembly Systems in comparison to the competence of the competitors? (Better, the same or worse)?
3. What is your experience of Atlas Copco Tools & Assembly Systems?
4. When buying a tightening application, what is most important: the price or total cost of ownership?
5. How well do the products your company has purchased from ACTA agree with your needs?
6. Why did/would you choose fixtured nutrunners from ACTA?

Questions to developers and personnel involved in project engineering

Modularization & standardization

1. To what extent is modularization being used?
2. Can modularization inhibit product development?
3. What are the possibilities of standardizing products?
4. What is preventing standard solutions?
5. Has it been any previous attempts of standardization?
6. Which products do you think are possible to standardize and which easiest?

Hardware & software

7. Is it possible to unite the PowerMACS with the PowerFocus?
8. Is it possible to share standard parts between the sub-modules of the products? E.g. a common nutrunner for fixtured and handheld tools?

Questions to ACTA personnel at the headquarters

1. What are the differences between the APC's in Germany and in the USA?
2. How much control do the headquarters have on the APC's?
3. At what stage does central project management get involved in a large-scale project?