Public Report Bachelor Thesis

MOD12 Industrial Engineering & Management

Due to confidentiality, this bachelor thesis is made anonymous, which means that all company specific information is excluded. This hidden information can be found in the Confidential Attachment. For questions regarding the thesis, please contact the author (see below).

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Preface

After three years of following courses and gaining experience in the field of Industrial Engineering and Management, time has come to put this knowledge into practice during my bachelor's assignment. I conducted my research at Company X. The facility in the Netherlands develops, renews, produces and distributes several electrical products.

I have learned a lot from working with my colleagues and getting familiar with the rhythm of working from "nine to five". In my opinion, doing an internship at a company during one's studies is an invaluable experience, which cannot be compared to the skills one attains at university. I am very curious what my research will yield for Company X in the long term.

Firstly, I would like to thank my principal at Company X Manager Marketing Product Management for the opportunities offered to complete my graduation program. Although he is a very busy man, he always wanted to help me and discuss new insights. He was curious about my opinion and stressed the importance of the research. Because of the chance he gave me, I was able to learn a lot about business.

Secondly, I would like to take this opportunity to thank my supervisor Ahmad Al Hanbali at the University of Twente for his constructive feedback and personal involvement. I also would like to thank my second supervisor Reinoud Joosten for his feedback on my research.

Casper van Ginneken

December 2016, Enschede

Management Summary

Currently, Company X is making a loss. In 2019, the plant should operate at a break-even revenue, but much must be done to achieve this goal. Demand for the upcoming years has been forecasted: sales are projected to grow 23% per year. This poses a huge challenge for everyone at the facility. Increasing just the capacity will not be a long-term solution, because currently there are too many problems with meeting delivery times. Company X must increase the efficiency of its entire order process. Therefore, this assignment has been formulated to gain more insight in the problems and provide solutions.

The main goal of this report was to provide Company X an answer to the question: *"How should we manage our growth plans?"* To find the core problem for this question, we started off with a problem analysis on every problem related to the scope of our research and conducting a problem cluster. This analysis revealed that the main problem for Company X is the rigidity of the value chain capacity, or to be more specific: *"The current capacity is too low to handle the future growth strategy."* This led us to determining our leading research question, which is:

What is a better value chain set-up for the Product Y product family in order to cope with more fluctuations, variations and future growth plans?

A sales growth of 23% per year results in an enormous bottleneck for value chain capacity, because with equal efficiency the current capacity is by far sufficient for the future. In order to calculate the future value chain capacity and provide suggestions for the organizational structure of Company X, we first need to determine the current situation. We broadly divided this into analyses about the market, Company X's value proposition, and future perspectives, in terms of sales growth, changes in product portfolio, and delivery times.

The market, which Company X is operating in, is business-to-business, with prices only being established after negotiations or via tenders. To be successful in this business, it is essential to be highly involved in the offering process. Company X offers highly customized solutions for a broad range of market segments, including utilities, oil and gas, industry, utility construction, critical assets such as hospitals and last but not least data centers. After conducting interviews with several stakeholders in the order process, we concluded that Company X's value proposition should be Customer Intimacy, since customers require specific solutions and are willing to pay more than for so-called "brochure products".

Sales are projected to grow 23% per year for the Product Y product family, while most sales growth originates from the growth of Product Z. This growth is explainable by a change in segment proportions. The focus will be put on the private segment, which is characterized by low volumes and high margins. A comparison between contract and non-contract orders is made, since this better reflects the proportion assemble-to-order (ATO) versus engineer-to-order (ETO) orders. We found that the percentage of non-contract orders is currently 61% for Product Y and 95% for product Z. These proportions will respectively be 61% and 80% in 2019. ETO-orders are responsible for most variations and fluctuations in the process, so comparing the future ratio to the current ratio is essential for calculating the future value chain capacity. We introduced the late-point definition (LPD) concept, which is about manufacturing standard barebones in the plant in Hengelo and ship them to a partner that finishes the assembly to save both time and costs. This could help Company X in lowering the degree of variations and fluctuations for the factory in the Netherlands.

We studied the actual delivery times over the years to detect the neglect of customer focus. Actual delivery times have increased at almost 20% per year, due to the dysfunction of the internal feeder sheet metal manufacturing, a lack of engineering capacity, and a lack of skills of employees working in assembly. Moreover, we compared the current, current competitive and future competitive promised delivery times. If Company X wants to stay competitive, promised delivery times need to be reduced to the level of 2013. This reduction is about 60% of their current amount of time. The average OLT_{Actual} 2016 for Product Y is 83% and 71% for Product Z. In November 2016, the OLT_{Actual} for Product Z was even 49%. This implies that more than half of the orders was not delivered on time. This is, of course, extremely low and must be dealt with as soon as possible.

Determining the current situation also means mapping the order process for Product Y, Product Z, and the barebone production. We have done this on the basis of a Value Stream Map, in which we established the scope of our capacity calculation analysis. We could not scale the current capacity for every department, since data is not always tracked in the same manner. We transformed the raw data of all Product Y family orders year to date into a number of man hours used per task per EUR 100K. This way, we were able to scale the current capacity with the sales growth and changed order specifics to calculate the capacity per department in 2017, 2018, and 2019. We took variability on the man hours used into account to determine the minimum and maximum capacity growth on a 95% confidence level.

The analysis made clear that the capacity of the order process needs to increase enormously, because the discrepancies will cause major problems for the future order flow of the company. The departments Order Management, Planning and Production need to increase their capacity to some extent equal to the projected total sales growth of 129% until 2019. Engineering, however, is the biggest bottleneck in the order process. An increase of 1064% in Electrical Engineering capacity may seem unrealistic, but Engineering overall is already lacking capacity. Lead times will only increase further, if this bottleneck is not solved in the short term. Thus, the need for extra capacity is becoming imposingly urgent.

Several options may reduce lead times without increasing man capacity at unrealistic rates. A capacity increase for the relevant departments is, however, vital for meeting the objectives set by management. Our recommendation is to standardize parts of Product Y and Product Z to make reduction of both lead times and costs possible, since there will be less variation in the process. These parts should not be customer order winning factors. Department managers should invest efforts in possibilities to increase efficiency to shorten lead times and save costs. We recommend decreasing the number of variations and fluctuations by collaborating with LPD-centers and -partners as well, so perseverance to make a success of the LPD-initiative is crucial in this matter. Perhaps a different organizational structure, for instance by forming teams responsible for a product type or family, could be a suitable solution for the problem. This way, knowledge is brought together, so the flows of information will run much more smoothly. We recommend the implementation of a new planning system to overcome the various sophisticated and complex issues of today, but in particular the ones of the future. Furthermore, we suggest reducing the power of production departments by focusing on Customer Intimacy. Lastly, we highly recommend to better collect data, both in terms of quantity and quality, especially to make capacity calculations for all departments possible.

We conclude that the challenges for Company X are great to achieve its growth objectives. However, the growth objectives for 2016 are being achieved, so they are far from unrealistic. Everyone at Company X should be critical about his or her own work, and work cooperatively to achieve the joint growth goals. We truly believe that Company X can strengthen its competitive position, if it succeeds in achieving its goals.

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List of Acronyms

Acronym	Description
AE	Application Engineering
Assy.	Assembly
ATO	Assemble-to-order
Avg.	Average
CODP	Customer Order Decoupling Point
CONC	Costs of Non-Conformance
CSO	Country Sales Organization
Dep.	Department
EE	Electrical Engineering
EMEA	Europe, Middle-East & Africa
ERP	Enterprise Resource Planning
ETO	Engineer-to-order
FTE	Full-Time Equivalent
LPD	Late-Point Definition
ME	Mechanical Engineering
MPSM	Managerial Problem-Solving Method
MTO	Make-to-order
MTS	Make-to-stock
NACA	Nacalculatie
OBIEE	Oracle Business Intelligence Enterprise Edition
OLT_{Actual}	Actual Order Lead Time
$OLT_{Requested}$	Requested Order Lead Time
OM	Order Management
OPEX	Operational Excellence
OTD	On Time to Delivery
OTP	On Time Planning
Plan.	Planning
Prim.	Primary
PSA	Power System Automation
R&D	Research & Development
ROI	Return on Investment
Sec.	Secondary

Ship.	Shipping
SIOP	Sales, Inventory, Operations & Planning
Test.	Testing
VSM	Value Stream Map
WP	Work Preparation
YOY	Year On Year
YTD	Year To Date

1. Research Proposal

This chapter deals with an introduction to the host organization, which includes the organizational structure and division of departments. Moreover, we will assess multiple problems, establish relationships between these problems and define the core problem. After that, we formulate research questions, determine the scope and establish deliverables.

1.1. Introduction to the Company

Due to confidentiality, company specific details are left out and can be found in the Confidential Attachment.

Company X has a matrix organizational structure, because individuals are managed by multiple reporting lines. Many times, specialists from different departments are temporarily deployed on a specifically defined project (Van Dam & Marcus, 2009). The specialist is accountable to several people. A pricing manager, for example, is functionally responsible for pricing, but the product line determines the price in practice. Then the offering is done by a sales team in the country of the customer, so there are three parties involved, which makes it very complex. The difference between a matrix organization and a projectized organization is the authority of a project manager. In a projectized organization the project manager has more authority, controls the project budget, and is always employed full time (Management Tutor, 2015). Since project managers at Company X do not comply with these specifications, but still work on specifically designed projects together, we define Company X as a matrix organization.

1.2. Problem Identification

1.2.1. Initial Problem

The main goal of the Manager Marketing Product Management, my principal at the same time, is to realize an increase in profit margin of 1%, which is roughly one million Euros, by active price management in combination with optimal usage of the production capacity in 2018.

Currently, the plant in the Netherlands is making a loss. In 2019, the plant should operate at a break-even revenue, which means that losses are not allowed. Demand for the upcoming years has been forecasted and sales are projected to grow 28% per year for the entire factory (Company X (9), 2016). This poses a huge challenge for everyone at the facility. Increasing just the capacity will not be a long-term solution, because currently there are too many problems with meeting delivery times. A lot must be done about the efficiency of production and the organization of the value chain. Therefore, this assignment has been drafted to organize the value chain in a more flexible way to cope with fluctuating order intake and meet future demand specifics.

1.2.2. Problem Assessment

In order to find the core problem of the situation the Managerial Problem-Solving Method (MPSM) of Heerkens and Van Winden is used (Heerkens & Van Winden, 2012). First, we compose an extensive list of all possible problems. However, not all of these problems are relevant for the research. The list was shortened and visualized into a problem cluster. In Figure 1.1, all relevant causes for the problem in their initial state are pictured. The problem cluster would become too extensive if all problems were taken into account. Therefore, we appoint irrelevant problems in the problem cluster, but do not elaborate them further. It is important to understand that only root causes have a color. Some root causes fall beyond the scope of the research and are depicted in orange. Causes which are dotted are completely excluded from the scope of our research. Causes which are depicted in red are causes which cannot be influenced at all. That means that they are caused by the type of business Company X is operating in or market specifics. Causes which are depicted in orange and green are causes which can actually be influenced, while, as mentioned before, the orange ones are excluded from our research. The entire list of problems can be found in Appendix C, which is in the Confidential Attachment.

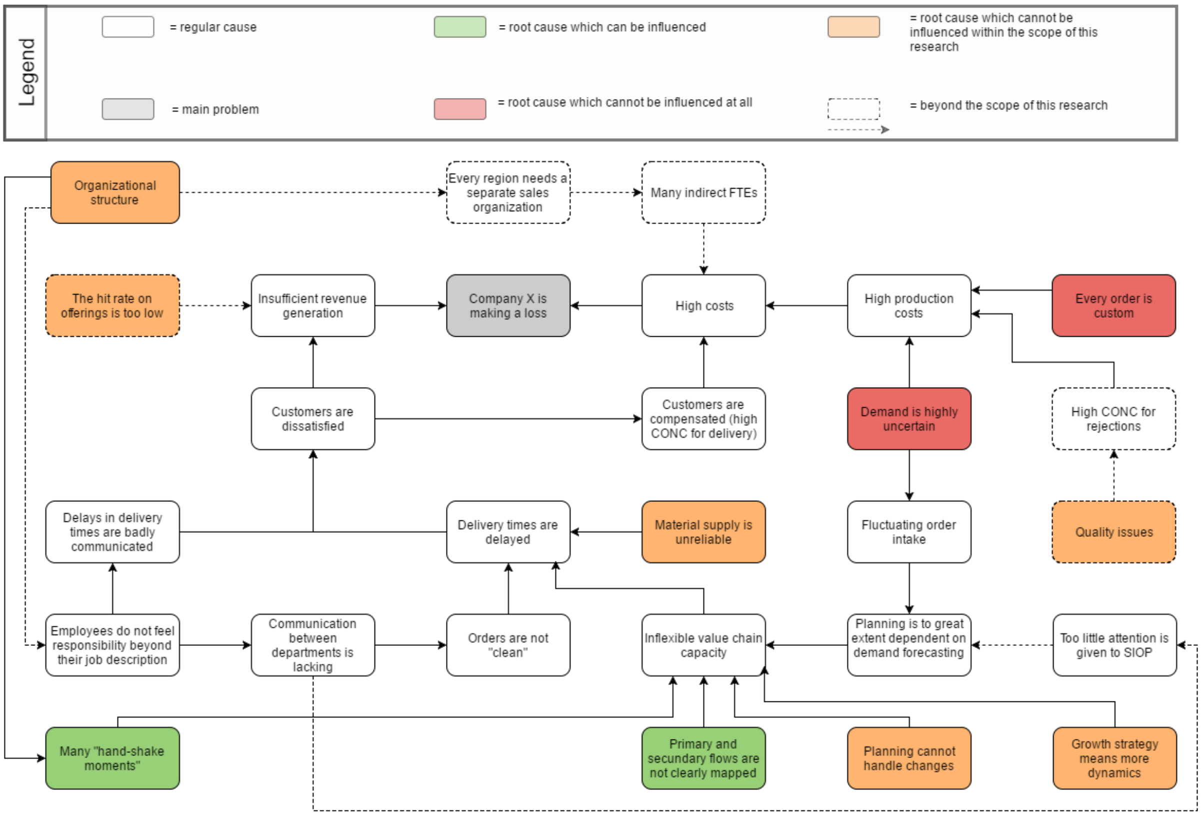

Figure 1.1: Problem Cluster.

As mentioned before, the main problem is that Company X is making a loss. On the one hand, this is because of insufficient revenue generation and on the other hand because of high costs. The uncertainty of demand and the customizable nature of Company X's systems are root causes that cannot be changed at all, because they are derived from the type of business. Although a major reason for the insufficient revenue generation is the fact that the hit rate of offerings is too low, this aspect falls beyond the scope of our research. Another root cause that cannot be influenced within the scope of our research is quality issues. The same is applicable for the organizational structure. This would trigger a totally different research and would have an enormous impact on the organization. A consequence of the organizational structure is the existence of many "hand-shake moments", i.e., the many steps in the order process that an order needs to pass before it can proceed. An order has to pass many departments and many different people until it finally hits the step assembly. Assembly itself takes approximately just one day, but the total delivery time can exceed ten weeks. Decreasing the number of "hand-shake moments" will have a big impact on the order process, but a minor impact on the organizational structure. Another influenceable cause is the mapping of primary and secondary flows of information. A clear description on paper of the routing through the order process is nonexistent. This is basic information that needs to be documented for any business that wants to standardize its processes.

Both causes (the ones depicted in green) will contribute to a more flexible organization of the capacity of the value chain. Solving them is crucial for solving the core problem in our opinion. Since order intake will increase the upcoming years and that the orders will entail more fluctuations and variations, the capacity of the value chain needs to be organized better in order for Company X to cope with future demand. Although there are multiple possibilities for conducting a research, the rigidity of the value chain is chosen as core problem in consultation with my principal. This core problem will be elaborated further in Section 1.2.3. Material supply and planning issues are mentioned, but fall beyond the scope of the research, because the research would become far too extensive. However, they are relevant for the core problem and we recommended to conduct further research on them in Section 6.3. As mentioned before, we will explain the core problem more in depth in the next section.

1.2.3. Core Problem

In our opinion, the core problem is the rigidity of the capacity of the value chain. The result of this rigidity is worrisome. Due to the fact that orders have to pass a great number of departments before entering production, chances are substantial that lead times are stretched and orders cannot be delivered, because of various delays in the order process or, in other words, value chain. These delays cause many customers to doubt Company X's capabilities and some even change their supplier. In first instance, customers are contented with long lead times, but that changes completely when short lead times are assured and delivery is postponed just days before shipping. Considering the nature of the business, i.e., customers ask for specific requirements and orders are project-based, which results in an extensive process of tendering and fluctuating order intake, the capacity of the production should be organized in such a way that it can cope with periods of both high and low demand. Not only production should be arranged as such, but other steps in the ordering process (e.g., Order Management, Engineering and Planning) need to connect in the process as well. Moreover, the growth strategy leads to a more dynamic order process, both in terms of fluctuations (quantitative) and variations (qualitative). The core problem could be summarized by the following description: *"The current capacity is too low to handle the future growth strategy."*

1.2.4. Norm versus Reality

In order to give a decent foundation for the core problem, the norm and reality should be determined (Heerkens & Van Winden, 2012). Without this gap, there would be no reason to change the current situation.

The norm for On Time Delivery (OTD) performance is 95%. At Company X Industries in the Netherlands the term OTD is used for measuring the time between the entry and delivery of an order, but the term Actual Order Lead Time (OLT_{Actual}) is used in literature and will be used from now on (Cousens, Szwejczewski, & Sweeney, 2009). Currently, the average OLT_{Actual} 2016 for Product Y is 83% and 71% for Product Z. In November 2016, the OLT_{Actual} for Product Z was even 49% (Company X (5), 2016). This implies that more than half of the orders is not delivered on time! This is, of course, extremely low. The reason that the Product Y family is chosen is argued in Section 1.3.3. The OLT_{Actual} for Product Y is an indicator for measuring the delivery performance. The question is, however, whether the OLT_{Actual} is the right indicator for measuring delivery performance. The Requested Order Lead Time ($OLT_{Requested}$) represents the difference in time between Order Entry Date and the Requested Delivery Date. This way, a company can get a better understanding of customer behavior and it helps fulfilling customer needs in terms of delivery times. We will derive the Requested Order Lead Time from conducting interviews with sales managers, because they have a good understanding of customer behavior and are able to tell what delivery times are requested.

Furthermore, the flexibility of the value chain for Product Y is to be increased. It is not clear, however, what this so-called flexibility currently is. The flexibility can be determined by measuring the relative stretch and pace of the stretch of the capacity per department as a percentage. Stretch of capacity means altering the capacity, e.g., man power or FTEs, so all orders can be processed within the specified lead times. Hiring external people to manage an increased work load is an example for altering the stretch of the capacity. In case they require training the extra capacity cannot be put into practice immediately, but may take several months. This is what is meant by the pace of the stretch of the capacity.

Waste of time in the process is a problem as well. The norm should be no waste of time at all, although in practice this is hardly possible. The reality though is unknown. This can be measured by looking at the bottlenecks in the order process, which we have expressed as a research question in Section 1.3.2.

1.3. Problem Description

Now we have defined the core problem, the research needs to be elaborated. The goal of our research has been stated, so now we will formulate research questions to guide the research in the intended direction. Furthermore, this section deals with the limitations and constraints that must be set in order to narrow the scope of the research, since the research should at all times be directed at the core problem.

1.3.1. Research Aim

The research should at all times be directed at the core problem. Therefore, it is of great importance to determine the scope of the research. Danger lies in conducting interviews, because every person has a different interest regarding the research and may try to push the research in a direction that falls beyond the scope. Communication is the key in this matter, to avoid uncertainties and misunderstandings.

1.3.2. Research Questions

First, we need to determine the leading research question. This question follows from the core problem and is stated as follows:

What is a better value chain set-up for the Product Y product family in order to cope with more fluctuations, variations and future growth plans?

Now we can determine our sub-questions. These will act as guidelines for answering the overall research question. To begin, it is essential to define the current situation and future perspectives. Without knowledge of the current situation, it is impossible to justify proposed changes. We have incorporated specific questions in the following sub-question:

1. *What is the current situation and what are the future perspectives for Company X?*

- *How is the market defined, which Company X is operating in?*
- *What is Company X's strategy for the future and what are the perspectives?*
- *What is the increase in revenue for the upcoming years for the Product Y product family?*
- *What are competitive delivery times ($OLT_{Requested}$)?*

These questions include, for instance, the determination of the market that Company X is in, including its competitors and market specifications, strategy, and demand growth specifics. Now the value chain needs to be mapped and analyzed. The following questions about the order process are both qualitative and quantitative:

- *What does the order process look like?*
- *What is the current OLT_{Actual} for Product Y and Product Z?*
- *What is the total lead time of an order?*
- *What is the lead time per department?*
- *What is the fixed capacity per department?*
- *What are bottlenecks in the value chain?*

When we have resolved the questions regarding the market, organizational structure and value chain, we will conduct literature study to provide our research a scientific foundation. The following sub-question deals with this part.

2. *What literature is needed to support the research questions?*

Sub-questions that deal with literature study are the following:

- *What does literature say about value propositioning?*
- *What does literature say about value chain capacity?*
- *How should the quantitative variables of sub-question 1 be modeled?*

Literature about value propositioning will help finding an answer on the qualitative question about strategy of sub-question 1, whereas literature about value chain capacity will guide us on the topic of mapping the order process. The third question will give an answer on how to use the quantitative variables for value chain capacity calculations.

We have identified problems, analyzed the current situation and determined what kind of literature study is required to provide a framework for improvements and validation. Now we will use the results of the analysis to study the impact of proposed changes.

3. *In what way could the capacity of the value chain be improved to meet future demand and what are the implications?*

The corresponding questions that will help answering sub-question 3 are stated below:

- *What should the future capacity of the different departments in the value chain be?*
- *How can this capacity of the different departments in the value chain be organized better?*
- *What is the effect of using LPD-partners on managing variations and fluctuations?*
- *What are the implications (both costs and gains) for changes in the value chain capacity?*

We will calculate the future capacity of the different relevant department and nominate improvements for a better value chain organization. What are the implications of these changes and what is the effect of using LPD-partners on managing variations and fluctuations? We will answer these questions in Chapter 6. An explanation on LPD-partners will follow in Section 3.3.4.

In the next section, we will determine the scope of our research.

1.3.3. Scope

Due to the fact that the research has to be covered in ten weeks, a clear and concise scope needs to be determined. In consultation with my principal, a handful of constraints have been stated. These are visualized in Table 1.1.

Table 1.1: Scenarios for Assumptions.

Scenario		A	B	C	D
Assumption	*Revenues*	↑	↑	↑	↑
	Capacity	→	↑	→	↑
	Delivery Times	→	→	↑	↑
Impact	*Commercial*	+	+	–	–
	Financial	+	–	+	–

In Table 1.1, four scenarios are stated. Every scenario has its own assumptions and implications. The assumptions are done using arrows. An arrow pointing up indicates an increase, whereas an arrow pointing to the right indicates no change. The plus sign implicates that the impact is positive, while a minus sign implicates that the impact is negative.

The first assumption is that revenues will increase. This is based on a long-term financial projection (Company X (9), 2016). The second assumption is that delivery times should not increase in terms of time. The delivery times should be in accordance with the market. The implication of this so-called accordance is a sub-question and will be determined during the research. This means that scenario C and D are not an option. The best scenario would be scenario A, because both the financial and commercial impact will be positive, in contradiction to scenario B. The question, however, is, whether capacity can stay the same when revenues are increased and delivery times stay the same. In consultation with my principal, the constraint has been determined that the fixed capacity should be maintained, but the variable capacity may be increased if necessary. Fixed capacity can be explained as capacity that is fixed for the long term, in this case the support departments, such as HR, IT, Marketing, Quality and R&D. Variable capacity is capacity that is dependent on the sales volume. Therefore, variable capacity is defined as the capacity of the production, engineering, and order management departments (Financial Analyst, 2016). Flexible capacity creates all sorts of difficulties, e.g., it could consist of external workforce and temporary workers, who are more expensive, because of training costs and agency compensations.

The capacity and flexibility for the assembly of Product Y and Product Z are assumed from the research of another graduate intern, who has looked into these aspects deeply. It would be a waste of time, if we figured that out ourselves.

We make another assumption about the delivery times. Competitive delivery times are necessary for future growth. However, these need to be determined. We will ask the sales manager to provide these numbers, because investigating the optimal delivery times for the market would be too time consuming.

Regarding the determination of the scope, we have set a limitation on the product portfolio. The research focusses on the Product Y product family. This is a relatively new product with promising perspectives. For more information about Product Y and Product Z (Extendable), the brochures are added to this report in respectively Appendix D (Company X (16), 2014) and Appendix E (Company X (17), 2015), which can be found in the Confidential Attachment. Looking at this specific product family is of greater importance than any other product line, because of its specific growth perspectives. Large parts of both systems are produced on the same product line. Their volume mix is important, because they follow a different order process, even though they are the same in the basis. We will perform a benchmark on this product family in order to test the concept or theory. If successful, Company X could put the results of the research into practice for other product lines or tweak them to get optimal results.

1.3.4. Knowledge Gap

As mentioned before, determining the scope of the research is essential for the time span of ten weeks and the prevention of getting lost in a maze of information. We have already determined the scope in previous sections. Now the knowledge gaps need to be identified in order to determine on which subjects further research is needed and how answers can be found on the corresponding sub-questions.

The research aims to modify an existing situation, for the reason that the value chain already has a particular organization with corresponding lead times, bottlenecks and capacity figures. That is to say that the current situation should be altered in such a way that there are significant improvements. A great deal of information is already available, however unorganized. As a consequence, it needs to be filtered before it is useful. Moreover, we will have to map the value chain, since there is no clear information about the value chain. We will visit the relevant departments to verify whether the lead times and bottlenecks we found match with reality and include their input in our research.

People that we need to involve in the problem-solving process are my principal at Company X, the heads of every department in the order process that is involved, the Product Manager Product Y and the director Market Development. They are in the end responsible for the changes and long-term overview. The heads of every department are essential in acquiring the right information to perform in-depth analysis on. All stakeholders are necessary for the implementation of the proposed solutions.

1.3.5. Deliverables

Due to the time constraints, the results of our research cannot be implemented directly. In the final report, we will among other things provide suggestions for further research and propose implementations for improvements. These deliverables include:

- Implications for capacity due to increasing demand.
- Implications for capacity due to using a LPD/barebone strategy to manage variations and fluctuations.
- An advice for organizing the value chain in a better way.
- A written report with the problem statement, methodology, analysis of the current situation, conclusions and recommendations.
- Suggestions for further research.

2. Theoretical Framework

Analyses cannot be done without verifying the results through the use of literature study. It is crucial to find the required literature in advance, because literature study is time-consuming and acts as a guideline for the research. This chapter, therefore, aims to provide a theoretical framework for the research questions of sub-question 2 of Section 1.3.2, which is:

2. ***What literature is needed to support the research questions?***

We will describe the literature about the value proposition of Company X, value chain capacity and modeling of the quantitative variables of sub-question 1 in respectively Section 2.3.1, Section 2.3.2 and Section 2.3.3.

2.1. Theoretical Perspective

Although our research is capacity-oriented, we will conduct it from a market perspective. Because orders are customer-driven, it is essential to base the whole value chain on market demand. Company X is following a produce-to-order strategy, which means that manufacturing does not start before the customer has placed the order. The capacity of the value chain has to be organized in such a way that it is able to cope with market demand, which includes fluctuating order intake in terms of both time and volume. Capacity should on the one hand be flexible and on the other hand cost-effective. All these factors make it a very challenging and uncertain business.

2.2. Relevance for Science and Practice

Because we conduct our research within a company, the relevance for science is limited, but definitely present. Due to the fact that the research is done at a company, it acts as a real case for scientific literature on flexible capacity in the value chain. The relevance for practice, however, is absolutely substantial, because the outcomes and recommendations will hopefully benefit the achievements of the organization as a whole. A more flexible organization of the value chain and an increased flexible capacity will aid Company X in establishing itself as a future-proof and powerful competitor.

2.3. Theoretical Model

2.3.1. Strategy

We will determine the market, which Company X is operating in, mostly by conducting interviews with employees from different departments with different functions in order to get a complete and objective view. This view is supported by the theory of the strategic planning matrix of Igor Ansoff. In 1957, Mr. Ansoff came up with a concept to devise strategies for future growth. The idea behind it is that a business has four basic growth alternatives, namely growth *"through market penetration, through market development, through product development, or through diversification."* (Ansoff, 1957). Below, the four quadrants of the Ansoff Matrix are explained. The theory is graphically depicted in Figure 2.1 to the right (Ansoff, 1957).

Figure 2.1: Ansoff Matrix.

"Market penetration, in the lower left quadrant, is the safest of the four options. Here, you focus on expanding sales of your existing product in your existing market: you know the product works, and the market holds few surprises for you." (Mindtools, 2016).

"Product development, in the lower right quadrant, is slightly more risky, because you're introducing a new product into your existing market." (Mindtools, 2016).

"With market development, in the upper left quadrant, you're putting an existing product into an entirely new market. You can do this by finding a new use for the product, or by adding new features or benefits to it." (Mindtools, 2016).

"Diversification, in the upper right quadrant, is the riskiest of the four options, because you're introducing a new, unproven product into an entirely new market that you may not fully understand." (Mindtools, 2016).

In Section 3.2, we will discuss the value position of Company X. Furthermore, we will link the growth for the Product Y product family to the four quadrants of the Ansoff Matrix.

Target/Market Scope	***Advantage***	
	Low Cost	***Product/Service Uniqueness***
Broad (Industry Wide)	Cost Leadership Strategy	Differentiation Strategy
Narrow (Market Segment)	Focus Strategy (low cost)	Focus Strategy (differentiation)

Figure 2.2: Porter's Generic Strategies.

Another well-known founder of strategic management is Michael Porter. According to Porter, competitive advantage can be divided into three different strategies, as can be seen in Figure 2.2 (Porter, 1980). When the market scope is broad, a company can achieve competitive advantage through low cost (Cost Leadership Strategy) and through the uniqueness of its products and/or services (Differentiation Strategy). In case a company chose to focus on a market segment, it could achieve competitive advantage through low cost and differentiation, which would both enable a company to pursue a Focus Strategy. In Section 3.2, we will discuss Company X's strategy in relation to Porter's Generic Strategies.

Treacy and Wiersema expanded Porters view on the market and came up with a new model called the Value Disciplines Model (Treacy & Wiersema, 1993). This model helps companies to define their value proposition in a strategic manner. Where Porter's model focuses on the market, Treacy and Wiersema emphasize the customer view. The Value Discipline Model considers three different areas of focus, namely Operational Excellence, Product Leadership and Customer Intimacy. Treacy and Wiersema believe that a company should be competent in all three areas in order to be competitive, but master one area in order to become a market leader. Developing all three value disciplines as much as possible is unfeasible, due to the fact that they are inconsistent with each other in terms of a company's basic structure and culture (Treacy & Wiersema, 1993). We will use the model to verify Company X's strategy. The model itself can be seen in Figure 2.3 (Treacy & Wiersema, 1993). Below, the three different value disciplines are explained.

Operational Excellence: *"The value discipline Operational Excellence describes the term "operational excellence" describes a specific strategic approach to the production and delivery of products and services. The objective of a company following this strategy is to lead its industry in price and convenience. Companies pursuing operational excellence are indefatigable in seeking ways to minimize overhead costs, to eliminate intermediate production steps, to reduce transaction and other ''friction''* *costs, and to optimize business processes across functional and organizational boundaries. They focus on delivering their products or services to customers at competitive prices and with minimal inconvenience. Because they build their entire businesses around these goal, these organizations do not look or operate like other companies pursuing other value disciplines."* (Treacy & Wiersema, 1993, p. 85).

Customer Intimacy: *"While companies pursuing operational excellence concentrate on making their operations lean and efficient, those pursuing a strategy of customer intimacy continually tailor and shape products and services to fit an increasingly fine definition of the customer. This can be expensive, but customer-intimate companies are willing to spend now to build customer loyalty for the long term. They typically look at the customer's lifetime value to the company, not the value of any single transaction. This is why employees in these companies will do almost anything – with little regard for initial cost – to make sure that each customer gets exactly what he or she really wants."* (Treacy & Wiersema, 1993, pp. 87-88).

Product Leadership: *"Companies that pursue the third discipline, product leadership, strive to produce a continuous stream of state-of-the-art products and services. Reaching that goal requires them to challenge themselves in three ways. First, they must be creative. More than anything else, being creative means recognizing and embracing ideas that usually originate outside the company. Second, such innovative companies must commercialize their ideas quickly. To do so, all their business and management processes have to be engineered for speed. Third and most important, product leaders must relentlessly pursue new solutions to the problems that their own latest product or service has just solved. If anyone is going to render their technology obsolete, they prefer to do it themselves. Product leaders do not stop for self-congratulation; they are too busy raising the bar."* (Treacy & Wiersema, 1993, pp. 89-90).

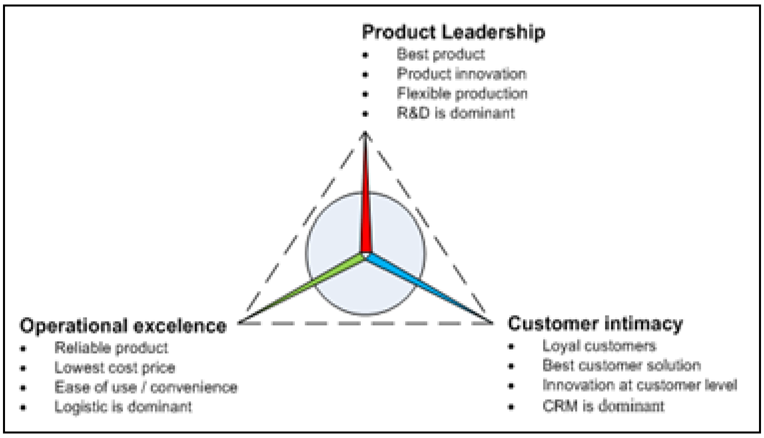

Figure 2.3: Value Disciplines.

2.3.2. Capacity Planning

In order to justify the conclusions we will give on capacity changes, we first need to define capacity on the basis of literature. The capacity of an operation is defined by Slack et al. as follows:

"The maximum level of value-added activity over a period of time that the process can achieve under normal operating conditions." (Slack, Brandon-Jones, & Johnston, 2013, p. 324).

The goal for every organization – and in this case the research for Company X – is on the one hand to make sure demand is sufficient to utilize capacity efficiently and on the other hand to have enough capacity to be able to quickly respond to new orders. The output of our research will be used to organize the value chain's capacity in order to cope with the projected sales volume and mix. It is important to take the whole value chain into account, because in order to operate efficiently, all stages of the order process must have the same capacity. Otherwise the capacity of the network as a whole will be limited to its weakest link (Slack, et al., 2013, p. 171). Therefore, the operation needs to run smoothly. An optimum has to be found between the operation's flexibility and the costs and gains implicated by the same flexibility. Slack, et al. gave the following definition for flexibility:

"The degree to which an operation's process can change what it does, how it is doing it, or when it is doing it." (Slack, et al., 2013).

There are several ways to deal with demand fluctuations. Most organizations will use a mixture of the following plans, although one plan might dominate in practice (Slack, et al., 2013, p. 334). These plans are:

- Level capacity plan: ignore fluctuations and keep capacity constant.
- Chase demand plan: follow fluctuations by adjusting the capacity.
- Manage demand plan: try to influence demand to fit available capacity.

Company X's strategy clearly is to follow fluctuations by adjusting the capacity, due to the nature of the products it is offering (highly customizable, fluctuating order intake). Therefore, we will only describe the chase demand plan here.

A chase demand plan is the exact opposite of a level capacity plan and much more difficult to achieve. A pure chase demand plan is, for instance, appropriate for customer-processing operations, such as Company X Industries. Although it might seem difficult to achieve large variations in capacity from period to period, there are several methods for adjusting capacity availability. We will state the most obvious below:

- **Overtime and idle time:** changing the number of working hours by working overtime in periods of high demand and engaging in other activities than direct production in periods of low demand is one of the most convenient and quickest methods of capacity adjustment. Both options, however, implicate higher costs for the operation. Moreover, there is a limit to the hours to be worked overtime and the idle time reduction (Slack, et al., 2013, p. 338).

- **Varying the size of the workforce:** adjusting the size of the workforce by hiring extra staff during periods of high demand and fire them once demand falls might seem an easy option to adjust capacity availability. This way of working would question the ethics of the company and would be highly harmful for the morale of workers and goodwill in the local labor market. Hiring external staff is expensive, because the subcontractor needs to be compensated as well. Besides, the complicated nature of Company X's systems requires staff to be trained well, which can take several months in this case. Other risks of hiring subcontractors are less motivation to deliver the desired quality of working and the exposure of valuable information (Slack, et al., 2013, p. 338). Allow employees to work part-time could be an option as well.

- **Job design and demarcation flexibility:** variations and fluctuations in the production capacity could be (partly) absorbed by exchanging workforce of different steps in the process. This is relatively easy for production, because some tasks are to a large extent the same. The exchange of workforce can even be applied on different product lines that have characteristics or steps that require no or little extra training of staff.

A mixed plan for Company X could be to offer certain discounts in periods of low demand to keep the capacity flow (manage demand plan), adjust capacity to cover demand changes (chase demand plan) and build up inventories in periods of low demand (level capacity plan).

2.3.3. Quantitative Model

The required value chain capacity needs to be calculated with a model. Different options are possible. We will state the most relevant options in this section. Making a simulation model would definitely be the best option by using, for instance, Siemens Plant Simulation. This way, we could simulate future orders by inserting real life variables as accurately as possible, in terms of variability, arrival rate, current capacity and lead times. This option would, however, be extremely time consuming and is sacked due to this time constraint.

Other options are designing a simple mixed integer or queuing problem. These are relatively easy to implement options, but will not approach the level of detail we are looking for. They are both quite mathematical and will give conclusions at a high level.

The final option is to scale the current capacity by using the sales growth. The current capacity can be expressed in a certain variable and serve as a scaling factor for the sales growth. Because this option approaches real life better than a multi-integer model or queuing problem and is less time consuming than making a simulation model it is chosen for the capacity analysis. We will calculate the required capacity of the value chain in Excel. First, we gather the quantitative data of sub-question 1 and make it ready for use. The processing of the data will be done in Excel. We will explain the data gathering, data processing and capacity calculation methods in Section 4.2.

2.4. Conclusion

In this chapter, we have stated the theoretical perspective and relevance for science, as well as theory about value proposition. We have divided the theory about value proposition into theory about the Ansoff Matrix, Porter's Generic Strategies, and the value disciplines of Treacy and Wiersema.

Furthermore, we explained theory about capacity planning. Definitions for the capacity of an operation and flexibility are quoted from Slack, et al. and three plans for dealing with demand fluctuations are given. These plans are about offering certain discounts in periods of low demand to keep the capacity flow (manage demand plan), adjusting capacity to cover demand changes (chase demand plan) and building up inventories in periods of low demand (level capacity plan). We chose to only elaborate the chase demand plan, because this clearly follows from the strategy of Company X. We have described the most obvious methods for adjusting capacity availability with respect to the situation of Company X.

In Section 2.3.3, we have presented several options for a quantitative model. These options included making a simulation model, a simple mixed integer problem, queueing problem, or scaling the current capacity. Eventually, we chose to scale the current capacity as the method to perform our analysis on.

3. Analysis of the Current Situation

In this chapter, we will state the current situation, according to the qualitative sub-questions about the market of research question 1 in Section 1.3.2, which is:

> **1.** ***What is the current situation and what are the future perspectives for Company X?***

First, we will discuss the market, which Company X is operating on, and Company X's value proposition. Subsequently, we will determine the future perspectives, with respect to the projected sales growth, change in segment proportions, and other influences on the future sales mix.

3.1. The Market

Primarily, it is essential to create a clear picture of the market Company X is operating in. Without extensive knowledge of the market, a grounded strategy simply cannot be composed. Company X needs to know in which field it is playing, i.e., who its competitors are. Thus, this section is dedicated to the identification of the market.

The market traditionally consists of a relatively small number of major suppliers and a few smaller ones. Company X is mainly active in EMEA and the Americas. Company X's role in Asia is insignificant. This will be by far the biggest market in the future though. With the advent of digitalization, such as the Internet of Things, numerous small parties have taken the opportunity to benefit from these developments. They all have a certain expertise, which they try to launch into the market. Just like everything else in society, products are getting more and more software-driven. Now the question for suppliers, such as Company X, is what their role in the chain they are going to fulfill in the future. This may force them to change their whole business model and strategy. Company X needs to adapt to the future demand, if it wishes to stay competitive.

Traditionally, Company X was a Dutch specialist in small markets that offered complete solutions complex situations. Customers used to come with a problem and Company X would find and build the solution for it. When Company X Corporation took over Company X as part of a whole series of acquisitions to increase its market share, the management tried to standardize more and more and change Company X into a functioning part of the big organization. This did not work, because Company X is a component manufacturer with an organization that is completely focused on Operational Excellence. Products were simply sold to the distributor, so there was no need for Customer Intimacy, while the opposite applies to Company X. As a result of being part of a big organization, the management of Company X pushed the plant in the Netherlands towards Operational Excellence. The internal optimization of processes (focus on cost out) has overruled the maintaining of a close customer relationship. The plant in the Netherlands is, however, still very important to Company X due to the segment strategy. In order to compete with the big players, Company X needs to differentiate from the straightforward component manufacturers and keep delivering custom solutions.

The market is business-to-business, with prices only being established after negotiations or via tenders. In order to be successful in this business, it is essential to be highly involved in the offering process. The key for sales persons is to enter this process as early as possible. That way they can fine-tune the customer's requirements to their own interest. If the sales person is able to convince the customer of the advantages of Company X's products, chances are substantially that the customer will buy from Company X eventually, because naturally it will be harder for competitors to offer the exact same specifications (Sales Manager, 2016). The solution is already specified to Company X's possibilities. Customers that choose for Company X are often ones that have done business with Company X before. Trust is absolutely important in the market, because companies look for reliable products when they spend thousands or even millions of euros. Besides, many companies approach Company X when a specific solution (a solution is the sum of service and product) is required. For standard products customers are better off with cheaper brochure products from other companies. Customers are increasingly looking for sustainable products and new developments, such as smart grids and zero emission technologies (Company X (3), 2015).

The most important segments for Company X are utilities, oil and gas, industry, utility construction, critical assets such as hospitals and last but not least data centers. Due to the digitalization of many products data centers have become a booming business. However, most revenue is still made in utilities. A shift in the importance of Company X's segment proposition is expected, namely a lower market share in the utility segment and an increase in other, more project-based segments. We will elaborate on these developments in Section 3.3 on future perspectives.

In the next section, we will give the value proposition for Company X, with respect to the market, which Company X is operating on, and other relevant business characteristics.

3.2. Value Proposition

3.2.1. Literature

In Section 2.3.1, we explained the Ansoff Matrix. Company X EMEA has got the target to double its revenues by the year 2018. For the Product Y product family this target is even higher, as can be seen in Table 3.1. The easiest way of increasing revenues is through market penetration, because the existing customers are already familiar to the existing products. Selling new products to new customers, which is diversification, is the hardest way to generate future growth. The increase in revenues for the Product Y product family is targeted at Market Development, i.e., placing existing products in new markets (Company X (3), 2015).

In Section 2.3.1, we explained the theory on Porter's Generic Strategies. In our opinion, Company X is currently acting according to a Differentiation Strategy, because it has a broad perspective on the market and offers custom solutions for specific customer problems. These solutions consist of a wide range of products and services. This is analogous to the growth alternative Market Development of the Ansoff Matrix. Intensifying the sales in current segments or introducing Company X's solutions in new segments is part of a broad perspective on the market. Due to the fact that the solutions Company X offers are highly customizable, a cost strategy cannot be followed. A differentiation strategy is more obvious, because Company X's systems are unique and customer specific.

Because of the low market share outside the Netherlands, competing on price is more or less impossible. In our opinion, Company X should therefore focus on Customer Intimacy (Treacy & Wiersema, 1993). This means that building a solid relationship with the customer and focusing on specific orders and projects (more engineering) is the key to success. In the next section, we will provide more foundation for this conclusion, by means of conducting interviews.

3.2.2. Interviews

The conclusion of the previous section, which was building a solid relationship with the customer and focusing on specific orders and projects (more engineering) is the key to success, is supported by several interviews with employees in different functions within Company X. The statements derived from these interviews are outlined. Due to confidentiality, only the functions of the interviewees are shown.

Director Business and Market Development: *''Currently, Company X is between Product Leadership and Customer Intimacy. Some products of Company X are quite innovative and we try to give the best solutions to our customer. Operational Excellence is only possible if you increase your volume and standardize your production."* (Director Business and Market Development, 2016).

Strategic Pricing Manager: *"Currently Company X is a bit stuck in the middle, there is no clear vision on which strategy to follow. In the future Company X should focus on Customer Intimacy. Product leadership is not possible, because the quality and innovation of products cannot reach that level. OPEX is also not possible, because the costs cannot reduce to a level to compete with the competitors."* (Strategic Pricing Manager, 2016).

Customer Experience Manager: *"During the last years Company X has shifted from Customer Intimacy towards Operational Excellence. This is not where Company X should be. Product Leadership is not an option, because Company X follows the market and is not innovative. Company X has to return to Customer Intimacy."* (Customer Experience Manager, 2016).

Regional Marketing Manager: *"At this moment Company X is between Product Leadership and Customer Intimacy. Company X has a broad knowledge and is customer focused. Operational Excellence is moderate; this causes a lot of complaints about the quality of the product. In the future Company X has to shift to Operational Excellence in order to survive."* (Regional Marketing Manager, 2016).

Sales Manager: *"Company X has shifted from Customer Intimacy and Product Leadership towards Operational Excellence. The plant has too much power here and planning does not know how to plan. For the future, Company X should position itself on Customer Intimacy, because Company X cannot compete on price or product."* (Sales Manager, 2016).

Manager Marketing Product Management: *"Currently for Product Y they try to pursue the OPEX strategy, but due to the low market share it is not possible. Company X cannot compete on price, but should use a premium price. This premium price is based on good product quality and environmental friendliness."* (Manager Marketing Product Management, 2016).

Supply Chain Manager: *"Currently, Company X is stuck in the middle of the triangle. In the future, they should pursue a Customer Intimacy strategy, because Company X does not have such innovative products and OPEX is not possible, because there is too little standardization."* (Supply Chain Manager, 2016).

Front End Engineer Systems: *"At this moment, Company X does not pursue a clear strategy. Due to that fact, they are quite stuck in the middle. Customer relationship is very important for Company X, so they have to follow the Customer Intimacy strategy in the future."* (Front End Engineer Systems, 2016).

Project Manager: *"At the moment, Company X is quite stuck in the middle. They are a bit Customer Intimacy and Operational Excellence and a little bit Product Leadership. In the future Company X has to shift more to the Product Leadership side, because their products are of good quality and connect with the market."* (Project Manager, 2016).

Key Account Manager: *"Customer relationship is important in selling the products and services for Company X. Company X has to use a higher price than competitors."* (Key Account Manager, 2016).

The conclusion can be drawn that opinions about the value proposition of Company X differ a lot depending on the function of the interviewee. According to the model, a business should choose one value discipline as its core strategy and optimize the other two (Treacy & Wiersema, 1993). Yet none of the interviewees believe that Company X currently pursues a clear strategy. Three interviewees place Company X between Customer Intimacy and Product Leadership. Two of the interviewees says Company X has shifted towards Operational Excellence during the last few years, but not totally. Three interviewees position Company X as being stuck in the middle. With these statements, it can be concluded that Company X is stuck in the middle at the moment. It is crystal clear that everyone has different ideas about Company X's current and future value proposition. This creates a major problem, which should be solved by higher management.

Due to the slight alienation of Customer Intimacy, customer satisfaction has become a problem for Company X. Moreover, customers are mainly dissatisfied with the fact that Company X fails to fulfill its promises, especially in terms of lead times. Especially the communication with the customer plays a major role, as well as getting in contact with the customer from the beginning of the process. Therefore, it is of great importance that the management pronounces the strategy to get all noses in the right direction and provide everyone a clear view on the right direction. Since Company X is currently stuck in the middle, an assumption must be made about the future strategy of Company X. As can be concluded from the interviewees, most people believe that Customer Intimacy is the way to go. The reason for this is the fact that Company X cannot compete on price. Moreover, the Power Distribution Division of Company X does not have the capabilities to follow an Operational Excellence strategy, because it does not have the economies of scale and there is too little standardization. Currently, the other possible strategy, Product Leadership, is also no option for Company X. The products are of good quality, but there is too little innovation to follow a Product Leadership strategy. Furthermore, the market share is just far too low to set the price for the market and compete with the big players in the market. Thus, the value discipline Customer Intimacy is assumed to be the future strategy for Company X. Although customization is important, standardization would still not be such a bad idea for some steps in the process, for instance the ones that cause a lot of delays.

3.3. Future Perspectives

3.3.1. Sales Growth

The Product Y product family is one of the future key products of Company X. The Product Y product family is one of the newest within Company X and is the successor of other products that are gradually moved to the aftermarket. In Figure 3.1, the sales growth of Product Y and Product Z is projected (Company X (7), 2016). The data for 2016 is of course not yet complete, so both the sales figures of 2016 up to October and the forecasted sales volume for 2016 are projected. We conclude that the growth strategy succeeds until now, so there is currently no need to question the feasibility of the sales projections. Product Y is currently the biggest product within the Product Y product family, but an increase in Product Z sales is clearly visible since its introduction in late 2012. Sales for Product Z are projected to grow at an enormous rate of 65% per year, as can be seen in Table 3.1.

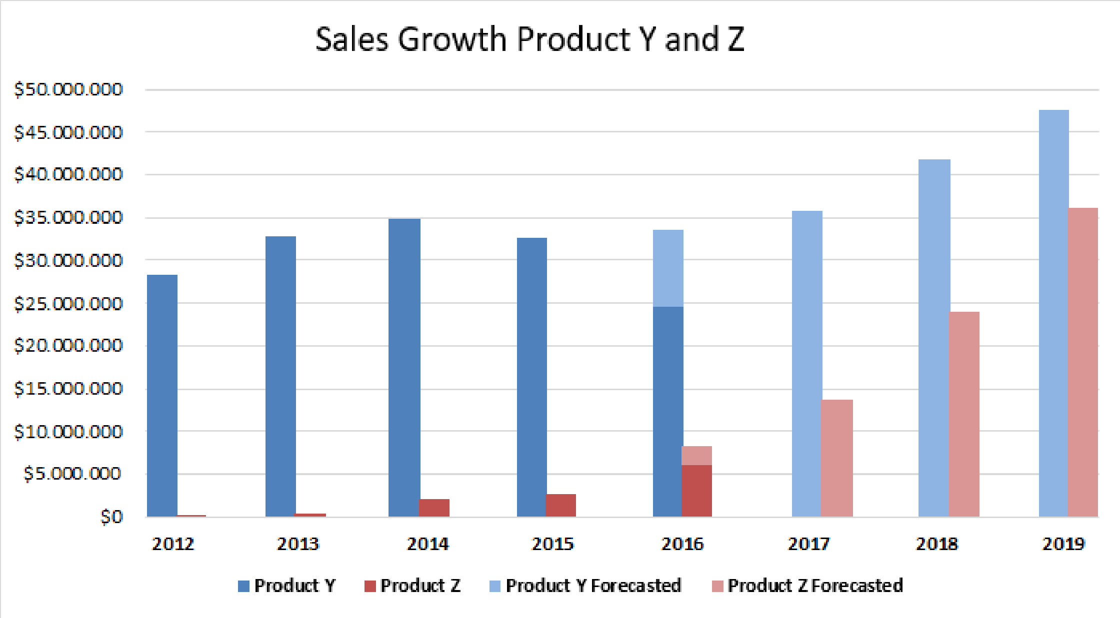

Figure 3.1: Sales Growth Product Family.

This increase in Product Y and Product Z sales is given by the financial projection per key product for 2015 – 2019 (Company X (9), 2016). The decrease in sales volume in 2015 may seem illogical, but can be explained by the loss of a few major contracts worth millions. In Table 3.1, the exact projections on sales growth for Product Y and Product Z in M$ per year are shown.

Table 3.1: Projected Sales Growth.

Product	**Sales (M$)**					**2015-2019 Growth**	**YOY Growth**
	2015	2016	2017	2018	2019		
Product Y	31.7	33.0	35.7	41.8	47.5	50%	11%
Product Z	4.9	8.3	13.8	24	36.2	639%	65%
Total product line	36.6	41.3	49.5	65.8	83.7	129%	23%

Sales for Product Y were 31.7 M$ in 2015 and are projected to grow 11% year on year (YOY). The projected sales growth for Product Z, however, is 65% per year. This is an enormous increase in sales, so it is not hard to understand that this has a massive impact on the capacity of the order process. The proportion of sales volume over time is projected in Figure 3.2 (Company X (9), 2016). For 2016, both the proportions of Product Y versus Product Z year to date and forecasted are taken, in order to measure the feasibility of the projections. 79% Product Y was projected and the current proportion is 80%, so it seems that the projections are realistic.

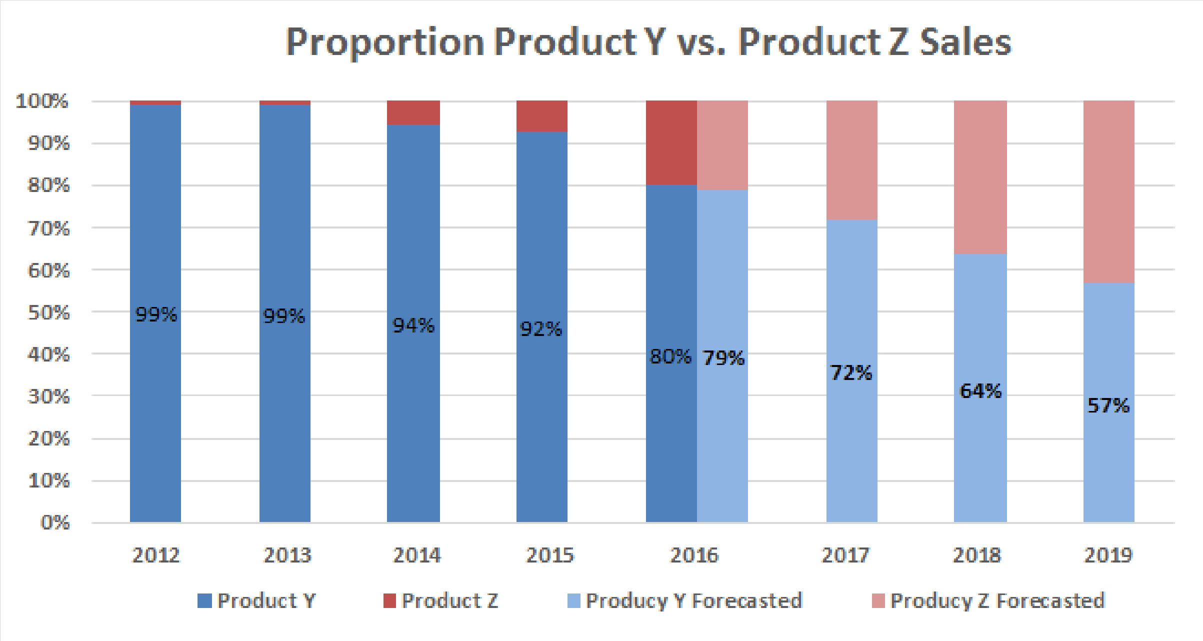

Figure 3.2: Proportion Product Y vs. Product Z Sales.

The current proportion of Product Z is, as of 2016, 20%. Due to the massive increase in sales volume, this proportion will rise to 43% by the end of 2019. This means many more variations and fluctuations in order specifications, because Product Z is mainly ordered in the project business. Again, it is not hard to understand that this has a massive impact on the capacity of the order process. Although production is projected to double in the next years, there is enough production space, because the factory in the Netherlands is rather spacious (Manager Marketing Product Management, 2016).

3.3.2. Segment Proportions

In order to calculate the change in variety, it is essential to know both the current and projected proportion of projects versus tenders. Tenders are long-term contracts with low margins and high volumes, usually commissioned by utilities. Utilities are public organizations that maintain the infrastructure for a public service. In this case, utilities are active in the electric power industry and engage in the electrical generation and distribution of electricity. From now on, tenders will be called contracts. Company X will put the emphasis on projects (non-contracts) for the Product Y family, although the contract business could be beneficial as well. This will be elaborated later in Section 3.3.5. Projects tend to have high margins and low volumes, and are commissioned by all sorts of companies in varying segments. This explains the enormous increase in the Product Z sales volume, because Product Z is designed to cover a broad spectrum of solutions. Logically, this highly customizable system is aimed at the project business (private segment). Within Company X Product Z is classified as an engineer-to-order (ETO) product, which means that it requires engineering work before it can enter production. Product Y is both an assemble-to-order (ATO) and an ETO-product. The Product Ys manufactured for projects are in general ETO-products. The Product Ys for contracts are mostly ATO, because its design has already been made and only needs to be copied every time an order is placed by – most of the time – the utility company. Most utility companies have a contract with Company X; however, not all utility orders are contract orders and vice versa. Therefore, we compare both types in this section.

Another type of product is a make-to-stock (MTS) product. These are standard components or products that are literally made to stock, which means that they follow a push strategy. Examples of such businesses are the food industry and consumer goods. When contract orders enter the system the first time, they are classified as ETO, but once they are standardized they become ATO. Because contracts are closed deals for three to five years, demand is already roughly known. Company X could decide to produce the orders in advance to cover fluctuations in production capacity and decrease delivery times for the contract partner. Therefore, it may be wise to eventually classify the contract orders as MTS instead of ATO (Manager Marketing Product Management, 2016). This would, however, result in an increase in inventory costs, since products are kept in inventory for a long time. Further research needs to be conducted on this subject to determine the impact of classifying the contact orders as MTS instead of ATO.

First, we compare public sector sales to private sector sales. In order to say something about the future proportion of public and private segment sales for the Product Y product family, it is essential to know the current distributions. These are displayed in Figure 3.3 (Company X (7), 2016). The public sector is dominated by utilities, but there are some so-called substation builders and system integrators as well, private parties that act as an intermediary for utilities. These are added to the proportion of public segment sales. The proportion of public sector sales for Product Y is slightly greater than the proportion of private sector sales. For Product Z the proportion of public versus private sector sales differs a lot each year. We will take the averages of respectively 51% and 19% to perform the analysis on.

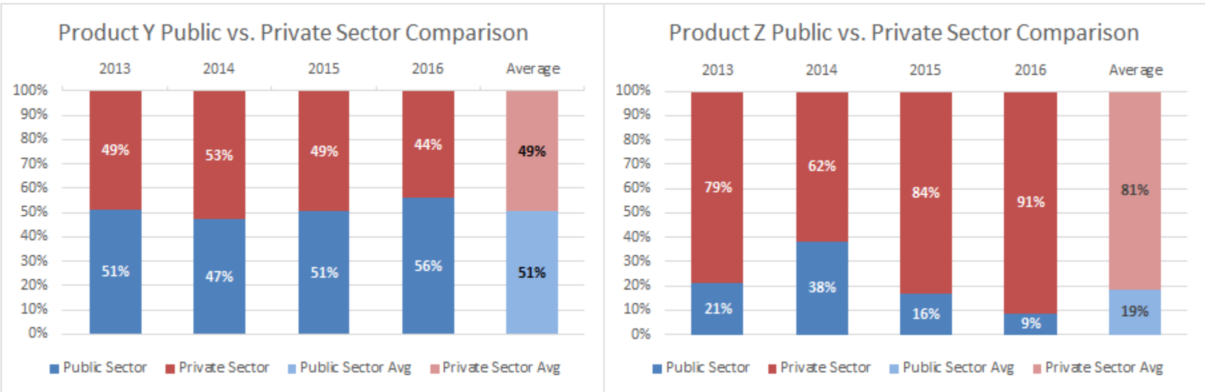

Figure 3.3: Public vs. Private Sector Comparison.

Another comparison can be made between contract and non-contract orders. Contracts can be seen as ATO-orders, non-contracts as ETO-orders. Most utilities have a contract with Company X to deliver a certain number of systems for successive years. In Figure 3.4, we compare the proportion of contract sales volume to the proportion of non-contract sales volume for both products (Company X (7), 2016). Again, we will take both averages to perform the analysis on.

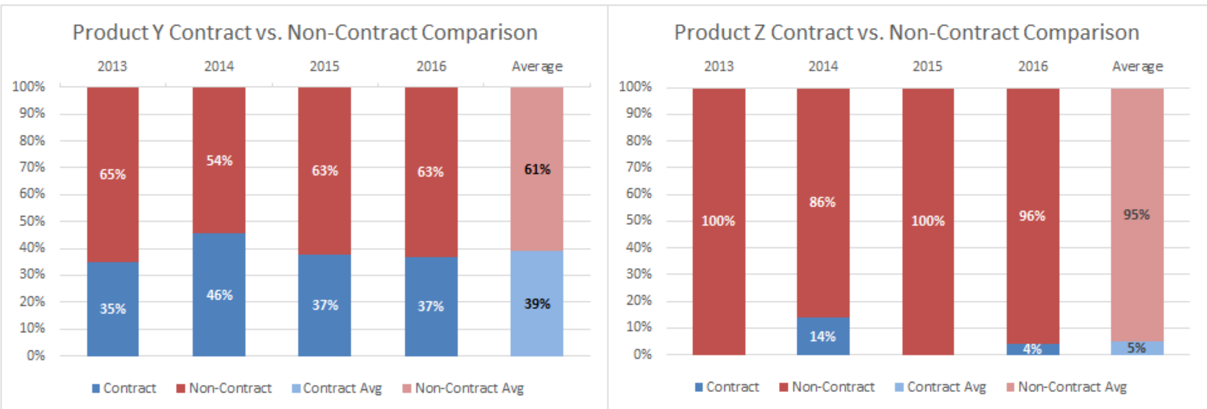

Figure 3.4: Contract vs. Non-Contract Comparison.

The data used for the analysis pictured in Figure 3.3 and 3.4 is, however, not a hundred percent accurate. Company X is a volumous organization with multiple plants and offices, so for some applications an overarching ERP-system is necessary to combine the data of all these different locations. The data in the ERP-system used for marketing analyses (*OBIEE*) is not always a hundred percent correct, but it will do for this analysis (Commercial Marketing Analyst, 2016).

In Figure 3.5, the current and future proportion of contract versus non-contract sales value is compared for both products (Company X (7), 2016). The current proportion non-contract orders for Product Z is assumed to be 100% in contrast to the 95% in Figure 3.4. The reason for this assumption is that Product Z is assumed to consist fully of ETO-orders (Manager Marketing Product Management, 2016). Further explanation will follow in the next section.

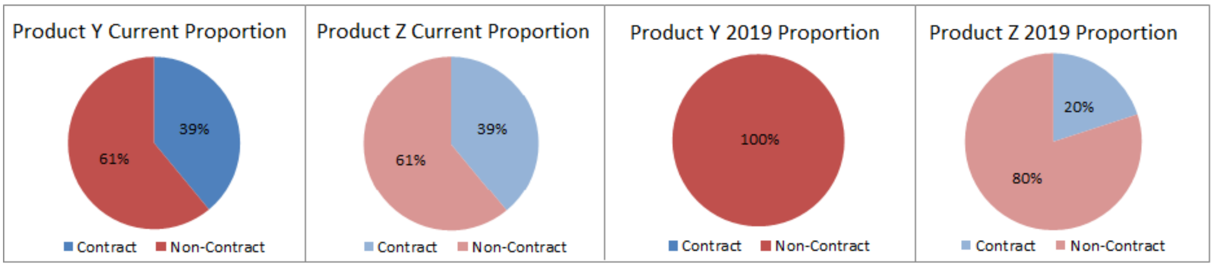

Figure 3.4: Sales Proportion Contract vs. Non-Contract Comparison.

In Section 3.3.5, we will elaborate on the changes in segment proportions in relation to the influence of using LPD-partners to decrease the impact of variations, as described in Section 3.3.4.

3.3.3. Variations and Fluctuations

First, it would be wise to define the terms variation and fluctuation. As explained before, the Product Y product family is split up in three categories: Product Y (ATO), Product Y (ETO) and Product Z (ETO). ETO-products require extra engineering work, because they are highly customized and never the same. This highly customizable nature results in more variation for the order process, especially engineering and prodcution, than ATO-products, which are much more standardized. These variations are mainly induced by non-contract orders, which are assumed to be fully ETO. We have stated this in Section 3.3.2.

Fluctuations are caused by the rate of order intake. Non-contract orders (or ETO-orders) are short-term orders with low volumes and high margins. More ETO-orders means more fluctuation for the order flow. For instance, the order intake for projects can fluctuate between one and one and a half million Euros per month. This obviously creates a huge challenge for the capacity. Therefore, the capacity of the value chain needs to become more flexible in order to cope with more variations and fluctuations.

3.3.4. Introducing the LPD/Barebone Concept

For certain markets a growth strategy based on a LPD/barebone concept is set. The LPD/barebone concept is a strategic concept for lowering the variations and fluctuations for Company X. LPD stands for Late-Point Definition. This is the term Company X uses for well-known literary term Customer Order Decoupling Point (CODP), which *"…identifies the point in the material flow, where the product is linked to a specific customer order."* (Olhager, 2012). This stock point needs to be strategically aligned to the market requirements. At this certain point, the customer order process starts, which means that the order is assigned to a specific customer from now on. In Section 3.3.2, we have already mentioned the division between ATO, ETO, and MTS. These are the terms Company X uses for the degree of customization of its products. In Figure 3.6, four different types of customer order decoupling points are pictured (Olhager, 2012). It is notable that Olhager defines another type of CODP, namely make-to-order (MTO). Because Company X does not use this term, the same CODPs as before are taken (MTS, ATO and ETO).

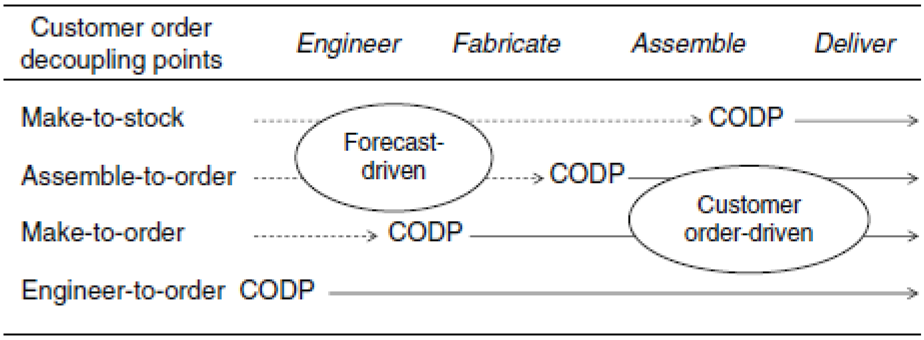

Figure 3.6: Customer Order Decoupling Points.

The intention of the barebone concept is to only manufacture the barebones of Product Y and Product Z by classifying a certain percentage of the total sales volume in the Netherlands of ETO as ATO and eventually MTS, in order to lower the variations and fluctuations of the factory in the Netherlands. Then, these barebones are shipped to, for instance, an LPD-partner in Brazil, which takes on the remainder of the assemblies (Manager Marketing Product Management, 2016). A barebone product is a partially assembled product or an unassembled kit of components allowing more customization and lower costs than a fully assembled product, for example the chassis of a car. By making use of barebones, a lot of import taxes are avoided and the LPD-partner can manufacture the custom parts itself, which means that much time and effort is saved by reducing the unnecessary communication between both parties. The percentage of LPD/barebone sales is estimated at 20% in total. This percentage equals a projected total sales volume of 9.5M$ for Product Y and 7.2M$ for Product Z by the end of 2019 (Company X (7), 2016).

A visual representation of the LPD/barebone concept for Product Y is depicted in Figure G.1 (Company X (8), 2016) in Appendix G, which can be found in the Confidential Attachment. It shows that only the tank is produced in the Netherlands and all options are to be produced by the LPD-partner or -center. The barebone tank would be classified as MTS, whereas the options manufactured by the LPD-partner make the order ATO or ETO. The barebone tank for Product Y currently has six different options (think of size and voltage). This means that Company X should produce six types of barebones and keep every type on stock. This implies relatively high inventory costs in comparison to one or two options. Plans are made to decrease the number of options from six to four. Product Z currently has two options (Manager Marketing Product Management, 2016).

The LPD/barebone concept will take remove much of the variations and fluctuations for Company X. We have depicted this impact in Figure 3.7. The barebone production will be 5%, 10%, and 20% of total sales volume for 2017, 2018, and 2019 respectively (Manager Marketing Product Management, 2016). The proportion Product Y versus Product Z sales does not change, since the LPD-strategy has equal impact on both product types.

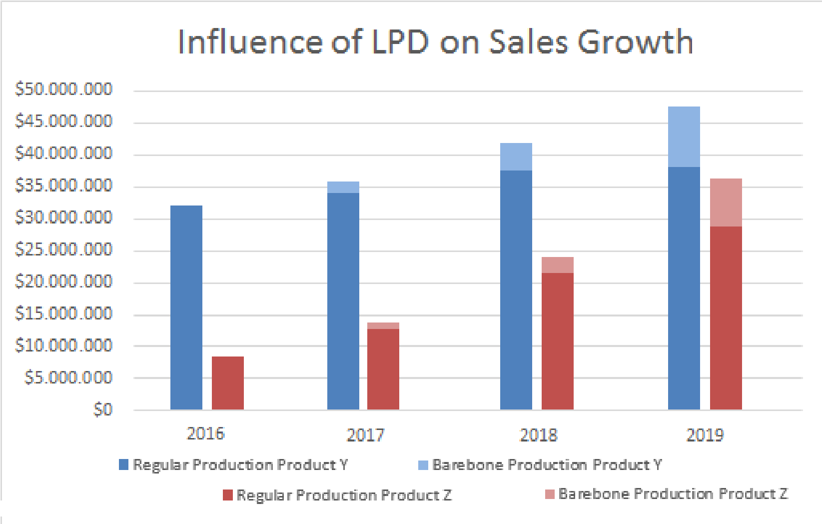

Figure 3.7: Influence of LPD on Sales Growth.

The barebone production will take away much of the variations for the Netherlands and could therefore be beneficial to keep a more constant value chain flow. Even the fluctuations could be taken away, if the barebones are produced up front and stocked at Company X, the Company X LPD-center or the LPD-partner. Plans are being made to work together with other LPD-partners in Brazil, Poland, Russia, Romania, and Australia, and Company X LPD-centers in South Africa, the Middle East, and Central America (Manager Marketing Product Management, 2016).

3.3.5. Impact of Variations and Fluctuations

The proportion of contracted sales is projected to stay the same the upcoming years for Product Y. Although there are a few utility tenders that are probably going to leave Company X's portfolio, there is high chance to close new deals with utilities. The closure of such a deal entails much variation in the order process, because orders are generally highly customized and need to be engineered by Company X engineers before they can be produced. Once this is done the order status is changed from ETO to ATO. This change in order status is only possible if a contracted company gets a customer profile (Manager Marketing Product Management, 2016). Narrowing down the order status to MTS could be beneficial as well. This would make it possible to reduce delivery times further and better manage fluctuations in production flow. For Product Z the assumption is made that the future proportion of contracts sales volume will be 20% (Manager Marketing Product Management, 2016). Although Product Z is a project-based system, a few contracts with utilities are projected to be signed. However, more sales for Product Z do imply more fluctuations and variations for the value chain than a sales increase for Product Y. We will elaborate on this in the next paragraphs.

According to the current strategy, the proportion of contract versus non-contract orders is projected to stay the same for Product Y and increase slightly for Product Z, as can be seen in Figure 3.5. Note that contracts make it possible to have secure business and demand projection for a long period. Therefore, increasing the proportion of customers as contract partners could benefit the whole value chain. For now, we assume the future proportions of contract versus non-contract sales.

The impact of the sales growth of the Product Y product family and outsourcing of customization to LPD-centers and -partners can now be calculated. We evaluate the change in variation and fluctuations between the current situation and the projected sales level in 2019. The current proportion of ATO is 31.0%. This is calculated by taking the proportion of Product Y and Product Z of the 2016 sales volume YTD. By assuming that Product Y currently consists of 39% ATO and Product Z is fully ETO (we explained this in Section 3.3.3), we found this proportion. This proportion will be 30.8% in 2019, so the proportion of ETO-orders will increase by 0.4%, which means that the degree of variation and fluctuation will effectively stay the same.

As mentioned before in Section 3.3.4, 20% of the total sales volume for the Product Y product family will be assembled by LPD-centers and -partners. The barebones will still be manufactured in the Netherlands. By regarding this percentage as ATO, the proportion of ATO will increase from 31.0% to 44.6% in 2019. This means that the degree of variation and fluctuation will decrease, because the proportion of ETO-orders will decrease by 19.7%, Eventually, the barebone production should become MTS. It can be concluded that the impact of the LPD/barebone concept should be taken seriously. The impact of these changes is included in the capacity calculation, which we will elaborate in Section 4.2.

To conclude, the variations of utility and contract orders might be managed by creating specific customer profiles and using an LPD or barebone partner to manufacture the customizable part of the order. In the next section, we will analyze the delivery times.

3.4. Delivery Times

Currently, the delivery times for the products manufactured at Company X are relatively high. For Product Y (ATO) these are seven weeks on average and for Product Y (ETO) and Product Z (ETO) even more than fifteen weeks (Company X (12), 2016). In Figure 3.8, the actual delivery times through the years are projected. There is no specific data on the delivery times of Product Y (ETO), but since it is an ETO-product, the delivery times for Product Z (ETO) are assumed to be the same (Manager Central Planning Systems, 2016).

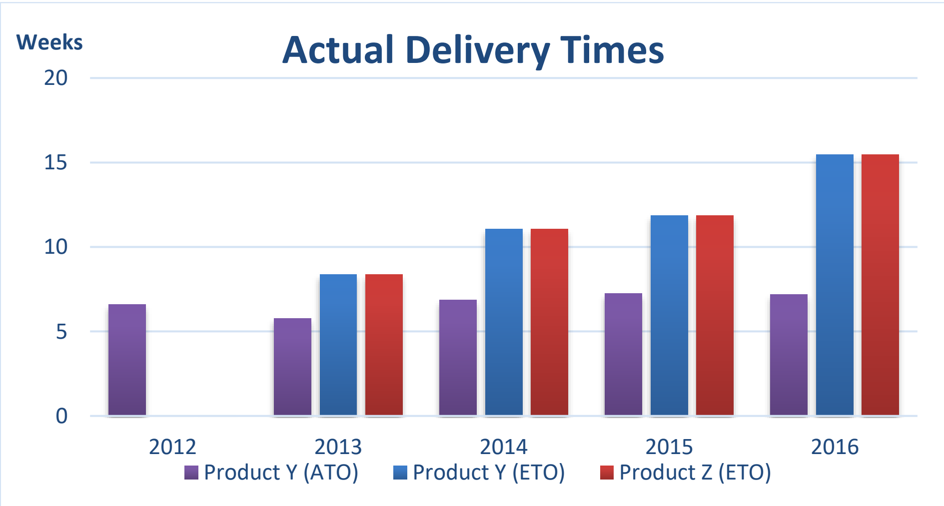

Figure 3.8: Actual Delivery Times.

We conclude that the actual delivery times have increased dramatically. This can be tracked back to several root causes. The most important one is sheet metal manufacturing. This internal feeder is not capable of delivering sheet metal on time for orders that go into production. Sheet metal manufacturing prioritizes large orders, which are often ATO-orders. As a result, lead times for ETO-orders are increased, because production for these orders cannot start until sheet metals are ready. Another reason for the increased delivery times is the lack of Engineering capacity. We will prove this in Chapter 5, where we calculate the future required capacity per department. Both causes explain the enormous increase in actual ETO-order delivery times. The third reason for the increased delivery times is the lack of skills of employees working in assembly (Manager Marketing Product Management, 2016).

The increased delivery times do not correspond to the competitive nature of the business at all. Therefore, the delivery times should decrease for Company X to be more competitive. In Table 3.2, the current promised delivery times are compared to competitive delivery times (Company X (10), 2016) (Company X (11), 2013). These competitive delivery times are equal to the promised delivery times of 2013, because at that time they were assumed to be competitive (Sales Manager, 2016). The promised delivery times used to be three to four weeks for Product Y ATO, six to eight weeks for Product Z and eight to ten weeks for Product ZTO (Company X (11), 2013). The increase is worrisome to say the least. In 2013 just the total lead time for an order was taken; however, this has been split up in drawings for approval and manufacturing lead time. When a customer places an order – the whole specification and quotation process has already been dealt with – Company X gives itself four weeks to specify the specifications and make sure the order can be manufactured, before the customers receives the order specification for a final check to assure everything is correct. This stage is called drawings for approval. Customers are given one week to give their approval, but one can imagine that this often takes much longer. This all adds up to the total lead time. Since customers can cause a lot of delay, it would be more fair to start measuring the delivery times after the drawings for approval stage. The drawing for approval stage used to be included in the total lead time in 2013. Customers though only want to know one thing: when do I get my delivery? (Sales Manager, 2016). Therefore, it is advisable to communicate just the total lead time to the customer and tell them it is dependent on their responsiveness speed.

Table 3.2: Comparison Promised Delivery Times.

Product	Competitive Lead Time	Drawings for Approval (2016)	Manufacturing Lead Time (2016)	Total Lead Time (2016)	Discrepancy
Product Y (ATO)	3-4 weeks	min. 2 weeks*	4 weeks	min. 6 weeks	+71%
Product Y (ETO)	8-10 weeks	5 weeks	7 weeks	12 weeks	+33%
Product Z (ETO)	6-8 weeks	5 weeks	7 weeks	12 weeks	+71%

** Information not available, but estimated* (Manager Business Development, 2016).

The manufacturing lead time in Table 3.2 is different for the different products. Product Y specials and Product Z are ETO-products, which means that they require extra engineering work by the Engineering department. Therefore, the manufacturing lead time for Product Y (ETO) and Product Z (ETO) is much longer than for Product Y (ATO). Still four weeks of manufacturing lead time seems very high for a product that does not need to be engineered before it enters production. In the next chapter, we will go more into detail on the lead times per process step.

Another problem is that the delivery times are determined by the capacity of the factory. Salesmen get a monthly update on the current delivery times and that is what they can tell customers. An often-heard issue though is that customers place an order months after they have first got the offer, while in the meantime the delivery times have changed. The offer, however, is still valid with the old, promised delivery times (Sales Manager, 2016). The delivery times for the Product Y product family have increased significantly, ranging from an increase of 33% to even 71% (the average of the Competitive Lead Time is taken for the comparison). Besides, the delivery performance has decreased as well. Company X has not been able to fulfill its promises regarding the delivery times, which has resulted in a current OLT_{Actual} of just 83% for Product Y and 71% for Product Z. In November 2016, the OLT_{Actual} for Product Z was even 49% (Company X (5), 2016). The OLT_{Actual} is even lower in practice, because when Company X cannot live up to the promised delivery times a new OLT_{Actual} is agreed with the customer, which means that 51% of the final delivery agreements with customers was not met in November. We have also seen in Figure 3.8 that the actual delivery times are much higher than the promised ones. Consequently, the increase of 33% to 71% is much higher in practice. All in all, Company X has made things quite difficult for itself.

In consultation with different interviewees and in accordance with the determined value proposition of Section 3.2, Company X should change its way of thinking and replace the OLT_{Actual} by the $OLT_{Requested}$, if it wants to follow a Customer Intimacy strategy. Delivering what the customer requests instead of giving the customer no other option than to accept the offered delivery times or leave should be the norm (Cousens, et al., 2009). According to the Sales Manager of Company X, the delivery times of 2013 were good enough to compete with the delivery times of competitors. This means that the delivery times should be reduced to the level of 2013 if competitive delivery times are wanted for the Product Y product family (Sales Manager, 2016). If Company X wanted Product Y to compete with competitive systems in the future, this level should be reduced even further to two weeks for ATO and four to six weeks for ETO (Manager Marketing Product Management, 2016). In Figure 3.9, the current, currently competitive and future competitive promised delivery times are projected.

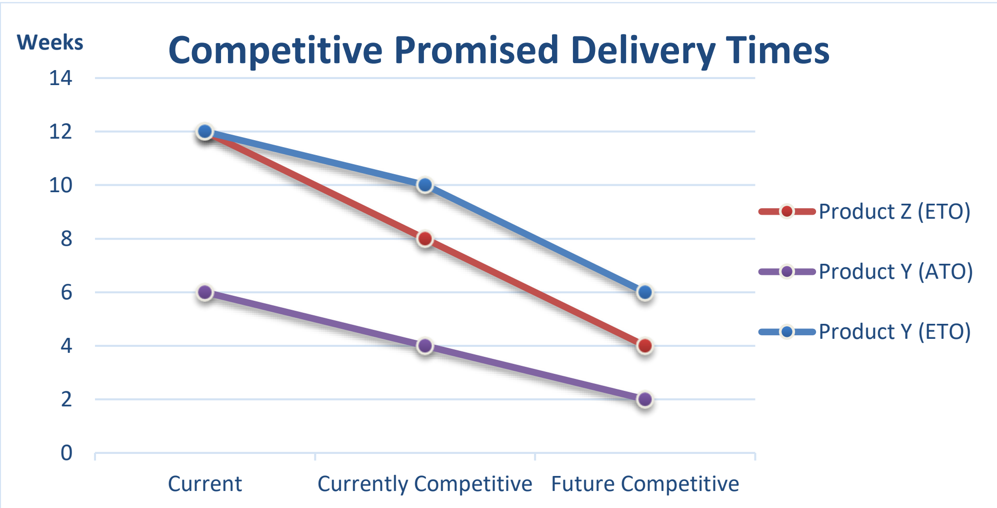

Figure 3.9: Competitive Promised Delivery Times.

3.5. Conclusion

In this chapter, we have discussed the current situation with respect to the market and value proposition, as well as the future perspectives for Company X. The organization of the value chain is dependent on the sales growth, degree of variations and fluctuations in the process and the partnerships with LPD-centers and LPD-partners to outsource a part of the customization.

The market is business-to-business, with prices only being established after negotiations or via tenders. To be successful in this business, it is essential to be highly involved in the offering process. Company X offers highly customized solutions for a broad range of segments, including utilities, oil and gas, industry, utility construction, critical assets such as hospitals and last but not least data centers. Company X's value proposition should be Customer Intimacy, since customers require specific solutions and are willing to pay more than for so-called "brochure products".

As we have seen in Table 3.1, sales are projected to grow 23% per year for the Product Y product family, while most sales growth originates from the growth of Product Z. This growth is explainable by the shift in segment proportions. The focus will be put on the private segment, which is characterized by low volumes and high margins. The comparison between contract and non-contract orders is made, since this better reflects the proportions ATO and ETO. ETO-orders are responsible for most variations and fluctuations in the process, so knowing this current and future ratio is essential for calculating the future value chain capacity. Introducing the LPD/barebone concept could help Company X in lowering the degree of variations and fluctuations for the factory in the Netherlands.

Finally, we studied the actual delivery times over the years. These have increased at almost 20% per year, due to the dysfunction of the internal feeder sheet metal manufacturing, a lack of Engineering capacity, and a lack of skills of employees working in assembly. Moreover, we compared the current, future and future competitive promised delivery times. If Company X wants to stay competitive, promised delivery times need to be reduced to the level of 2013. This reduction is about 60% of their current amount of time.

4. Analysis of the Value Chain

This chapter deals with both qualitative and quantitative questions of sub-question 1 in Section 1.3.2, which are about the mapping of the order process. To repeat, this question is the following:

1. *What is the current situation and what are the future perspectives for Company X?*

We will map the order process in a visual way and explain it for different situations, describe the roles of the relevant departments, and reveal and clarify the set-up of the calculations on future value chain capacity.

4.1. Mapping the Order Process

4.1.1. Value Stream Map

In this section, we discuss the mapping of the order process. To make it more clear, we have created a value stream map (VSM) for Company X. In 1985, Michael Porter came up with the concept of a value stream map. He states that the value stream map is a graphical display of the collaborations between departments within an organization and that every department can be regarded as a link in the value chain of the company (Porter, 1985). The VSM is defined as follows: *"A mapping process that aims to understand the flow of material and information through a process or series of processes, it distinguishes between value-added and non-value-added times in the process."* (Slack, et al., 2013, p. 712).

In Figure 4.1, we have visually mapped a derivative of the VSM for Company X. Where the theory focuses on the value chain and value-added steps in the process, the VSM of Figure 4.1 is meant to show the order flow of the products manufactured in the Netherlands. The arrows represent the primary activities, while the support activities are represented by the boxes above the arrows.

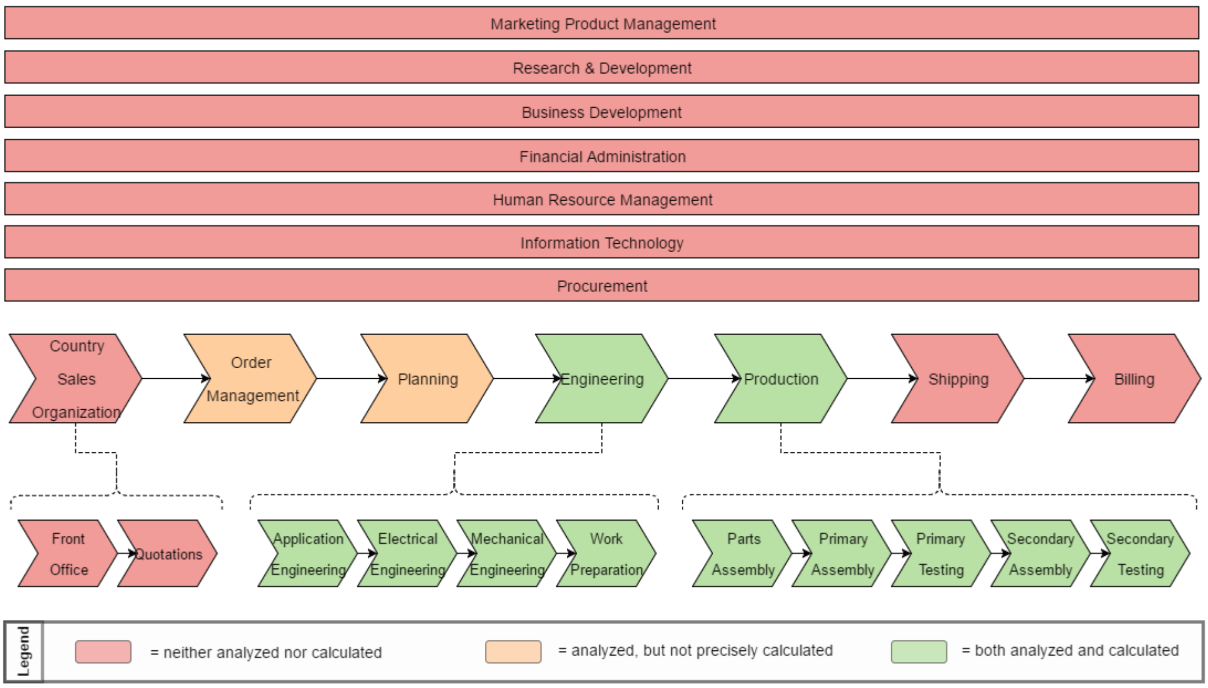

Figure 4.1: Value Stream Map.

As described in the legend in Figure 4.1, the steps depicted in green are the ones that will be used in the capacity calculation. Steps depicted in orange are excluded from the capacity calculation, but still analyzed in our research. Steps depicted in red are appointed, but neither analyzed nor calculated. More about the capacity calculation set-up will follow in Section 4.2. Some departments consist of multiple sub-departments and are therefore split-up into smaller sections.

The process starts at a Country Sales Organization (CSO). Every country or region in EMEA – at least where Company X's products are sold – has its own CSO. These salesmen are in contact with customers and move the possible order to a quotation manager, who translates the customer's specifications into an offer. If the customer decides to do business with Company X, the order enters the system and is picked up by an order manager. This person checks whether the order is "clean" (incomplete). Does it need extra engineer work or is it ready for production? The order file is prepared and planning checks whether the required delivery time is realistic. The order management provides this feedback to the customer. In case of a "go", planning executes and monitors the complete planning of the order, including engineering work (Project Manager, 2016).

Not every order is the same. As we have described in Sections 3.3.2 until 3.3.5, Product Y is divided into ATO and ETO. An ATO-product does not need the step Engineering, because it is already standardized for production. The barebone production for Product Ys manufactured overseas will be done in the Netherlands. This includes order management (OM), planning (Plan.), the production of parts (Parts Assy.), primary assembly (Prim. Assy.), primary testing (Prim. Test.) and shipping (Ship.). All engineering work and secondary assembly and testing will be executed by the LPD-partner or -center. In Table 4.1, the relevant process steps for the different types of products are given, in order to create a clear picture of the different order flows. We exclude the department CSO from the analysis, since this step can be seen as an external party. The same is applicable for the departments Shipping and Billing, which are outside the scope of our research.

Table 4.1: Relevant Process Steps per Product Type.

Main Dep.	OM	Plan.	Engineering				Production					Ship.
Sub Dep.			AE	EE	ME	WP	Parts Assy.	Prim. Assy.	Prim. Test.	Sec. Assy.	Sec. Test.	
Product Y (ATO)	X	X		X*		X	X	X	X	X	X	X
Product Y (ETO)	X	X	X	X	X	X	X	X	X	X	X	X
Product Z (ETO)	X	X	X	X	X	X	X	X	X	X	X	X
Barebone Production	X	X				X	X	X	X			X
LPD-partner			X	X	X	X				X	X	X

** In case of no customer profile (MTS), EE still needs to prescribe the electrical components, such as current transformers and relays* (Manager Marketing Product Management, 2016).

In the next sections, we will discuss the role of every department in relation to our research.

4.1.2. Order Management

As described in the last section, the process starts with the order specification and quotation phase. This is, however, irrelevant for our research, so we start with the entry of an order. The order manager checks whether the order is “clean” and communicates possible problems and the progress to the customer. Unfortunately, no hours are recorded for OM, so the future capacity of this department can only be estimated. The current capacity is eight FTE per day, distributed over Product Y (ATO), Product Y (ETO) and Product Z (ETO) (Company X (14), 2016). The next step in the order process is Planning.

4.1.3. Planning

Currently, planning is a primary activity instead of a support activity. Once an order is planned, its planning is quite fixed. Rescheduling causes trouble, because the planning of all other orders also needs to be altered. Orders are planned backwards, which means that the date on which the order should be ready is taken as the point in time to base the rest of the planning on. One week margin is included, but when a significant delay occurs – and this happens a lot – the order already gets delayed. An OLT_{Actual} of just 83% for Product Y and 71% for Product Z is shameful to say the least. The On Time Planning (OTP), which is the average lead time of the step Planning, is 1.4 days (Manager Central Planning Systems, 2016). Unfortunately, no hours are recorded for Planning, so the capacity of this department can only be estimated. The current capacity for the Product Y product line is one FTE per day (Manager Central Planning Systems, 2016). The next step in the order process is Engineering.

4.1.4. Engineering

When an order is ETO, it needs to be engineered before it can be produced. An ETO-order is customer-based and in practice every time different. ATO-orders have once been ETO as well, but since they are standardized its format (drawings, specifications) already exists in the system. Engineering is split-up in four different departments. These are Application Engineering (AE), Electrical Engineering (EE), Mechanical Engineering (ME) and Work Preparation (WP). Every order needs to pass WP, because it needs to be prepared for production. For some ATO-orders EE is also required, because the electrical components need to be prescribed in case there is no customer profile, which would specify the order as MTS (Manager Marketing Product Management, 2016).

At the moment, the engineering department already lacks capacity (Manager Manufacturing Engineering Systems, 2016). The average capacity of 2017 is taken as the current capacity, because it is very similar to the capacity of 2016. Moreover, the original capacity of 2016 cannot be tracked anymore, due to the many changes that have occurred (Analyst Materials Planning, 2016). The current capacity (for 2017) is specified as 0.88, 0.51, 0.44 and 2.55 FTE per day for respectively ME, AE, EE and WP (Company X (15), 2016).

Currently, the different sub-departments within the department Engineering are not very flexible. Small projects are being engineered sequentially, while bigger orders are handled rather in parallel, because of the variety of work. In Figure 4.2 (Manager Manufacturing Engineering Systems, 2016), the current state of the Engineering Dep. is compared to a new proposed state by the Manager Manufacturing Engineering Systems. Tasks are now function-based, while they should be project team-based if lead times are to be reduced. The consequence of this is that engineers of sub-departments have to wait until they can start their part of the job, though many tasks can be performed in parallel. Power System Automation (PSA) is a part of AE, but executed at a different moment than the rest of AE. ME and WP are excluded from Figure 4.2, because their role in the future state has not yet been devised. Low-Voltage (LV) and Medium-Voltage (MV) work is currently being separated as well, but for many tasks engineers could work for both departments. It is clear that there is much more overlap between tasks in the future, so working more in parallel is made possible by basing the organization of the department on project teams (Manager Manufacturing Engineering Systems, 2016).

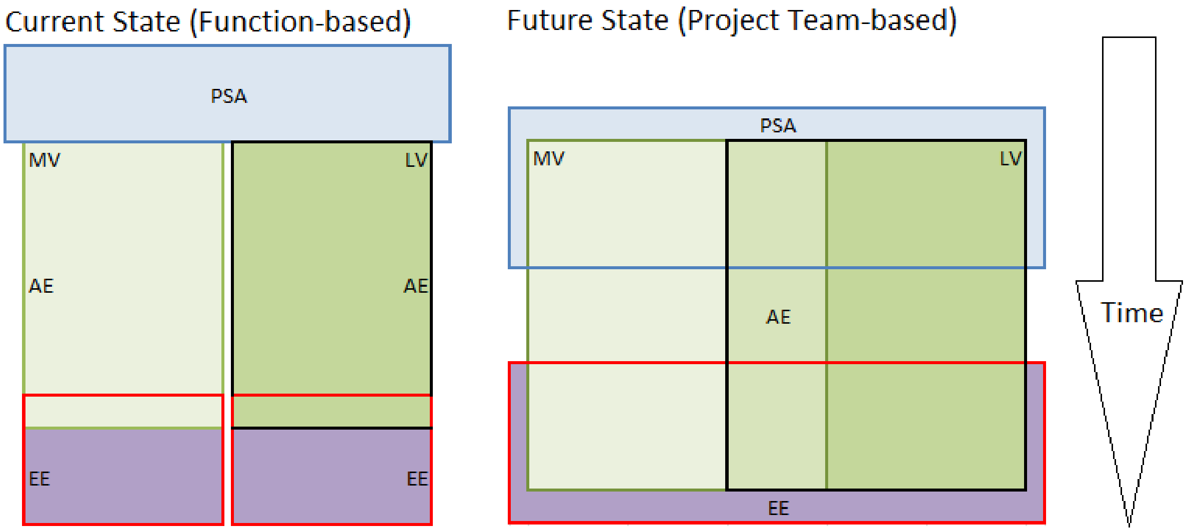

Figure 4.2: Current vs. Future Lay-Out Engineering.

4.1.5. Production

The production department is highly important for the order process, considering the fact that Company X is a production business. For the mapping of the production part of the order process, we have used input from another graduate intern that has considered the production process of Product Y on a very detailed level (Graduate Intern Production Modeling, 2016). We divide Production into five different stages, which are Parts Assembly, Primary Assembly, Secondary Assembly, Primary Testing and Secondary Testing. All standard work of Product Y (ETO) and Product Z (ETO) is done on the standard line, as well as the total production of the Product Y (ATO). Barebone manufacturing will only use the sub-departments Primary Assembly and Primary Testing, so that is why assembly and testing are split-up for the capacity calculations. We make a distinction between Product Y (ETO) and Product Z (ETO) within the sub-department Secondary Assembly to go more into detail on the Secondary Assembly line. Some tasks are only performed for a single product type, as can be seen in Figure A.2 (Graduate Intern Production Modeling, Production Line Lay-Out Product Y, 2016) in Appendix F, which can be found in the Confidential Attachment.

It is hard to say what the lead times for the production of an average Product Y system are, because every order is different. We make the assumption that the average lead time for total production is two days (Graduate Intern Production Modeling, 2016). Because actual production is such a small part of the total lead time, this assumption can easily be justified.

A big issue for Production is the readiness of an order. It often occurs that production should start, but no order map is available, because it is still at some desk of Work Preparation. It also happens that an order is not “clean”, which means that the order map is available, but the information in it is incorrect or incomplete. This causes a lot of delays for Production. The result is that an operator will take an order map that is available and start production of another order, instead of following the planning. This ruins the planning completely. A solution for this problem could be introducing frozen orders. This means that after a certain point in the order process is passed, the order gets a frozen status, which means that no more changes are allowed, both internal changes and external (customer) changes. This way, Supply Chain would get much more time to anticipate. The fact that this has not happened yet is because of the difficulty of getting an order frozen. Often there are too many important changes required to ignore them, e.g., changed customer specifications. A solution could be to communicate the frozen status to the customer and increase the sales price or deviate from the agreed delivery date. Other issues for Production are the unreliable material supply and rework, but our research will not go into detail on these issues.

Although Planning plans the orders based on capacity, the team leaders of the Product Y production allocate the actual capacity, because they know exactly who is capable of what tasks and which operators are versatile. We do not take team leaders and supervisors into account in the capacity optimization, because they do not conduct work that is directly related to the production of orders.

4.1.6. Shipping

The final step in the order process is shipping. This step is done both for Company X and the LPD-partner. By shipping the barebones overseas to, for instance, Brazil, significant lead time reductions can be accomplished. The reduction of lead time is at least six weeks, because this time is required to ship the goods overseas.

In the next section, we will explain the set-up of the capacity calculation.

4.2. Capacity Calculation Set-Up

In this section, we will state the man hours capacity calculation set-up and its corresponding assumptions, with respect to data collection, processing and usage. The general idea is to calculate an average amount of time (man hours) assigned to a specific task per unit of value. This way, the current capacity is expressed as a certain number of man hours per task. Subsequently, the future capacity can be calculated by using the future sales volume and delivery times as input.

The first step was to take the recalculations of every Product Y and Product Z order of 2016 YTD, in order to get the actual number of hours per task instead of the estimated amount. These recalculations are called “NACAs” and were extracted from the ERP-system *Baan* (Financial Analyst, 2016). They include production interruptions, such as finding the right parts for assembly. Because the size of an order may be of influence on the performed tasks and the hours used, we formulated an Excel function to divide the Product Y and Product Z orders into three categories of size: high, middle and low. Generally, a relative small proportion of orders will account for a large proportion of the total sales volume. This principle is called the Pareto law, sometimes referred to as the 80/20 rule, because roughly 80% of the effects come from 20% of the causes (Slack, et al., 2013, pp. 293-395). The Pareto law is merely an approximation and applies to typical distributions, and is depicted in Figure 4.3 (Teh & Associates, 2010). The Pareto law is used for many subjects, ranging from inventory control to the distribution of income. We sorted the orders on sales value and use the Pareto law to determine the bin sizes. 20% of total sales volume can be attributed to the 4% largest orders, while 80% of total sales volume can be assigned to the 55% largest orders. Hence, based on the Pareto law the bin sizes are determined to be high > 41000, 41000 < middle > 8150 and low < 8150.

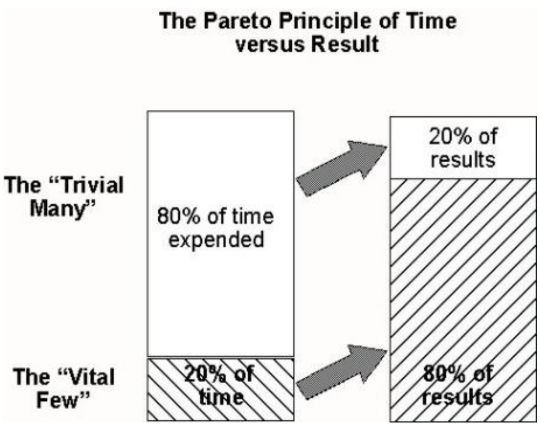

Figure 4.3: The Pareto Law.

Secondly, a way must be found to divide Product Y into ATO and ETO. Because some production steps are only run by ETO Product Ys, we put a filter on the total list of tasks, in which all booked hours for Product Y and Product Z are listed. The production step used for the filter is derived from Figure F.1 in Appendix F, which can be found in the Confidential Attachment. Implementing this function in combination with the order size function resulted in nine categories, which are all combinations of product type (Product Y (ATO), Product Y (ETO) and Product Z) and order size (high, middle and low).

The third step was to relate every booked task to a project using the functions explained in the paragraphs above. The data was raw, so we have cleared it for usage by deleting spare parts, incomplete data, and modifications and revisions. Modifications and revisions cannot actually be regarded as orders, due to their small sales value. We summed the man hours per task per category in a pivot table and took them as the current division of hours per task per category. Because many tasks have barely been recorded this year, we will only apply the top 99% of used hours in the analysis. Some tasks, for example, were only used a few hours on a total of many thousands of hours this year.

In order to determine the future capacity, the current man hours used need to be made computable. Thus, the fourth step was to divide the total sales volume of every category by a factor to get the man hours used per 100K EUR. This way, every task is expressed in a number of man hours per category per 100K EUR.

The LPD/barebone concept has already been pointed out several times during our research. For 20% of the total sales volume just the barebone structure will be made in the Netherlands, so this cannot be ignored in the capacity calculation. Therefore, we have multiplied every task that is excluded from the barebone production by a factor to compensate for the hours saved. We have determined this factor to be 0.95 in 2017, because for the tasks that have nothing to do with barebone production 5% of the man hours used needs to be deducted from the total. This factor is 0.90 in 2018 and eventually 0.80 in 2019 (Manager Marketing Product Management, 2016).

Now the number of hours per 100K EUR used in 2016 YTD have been paired with the tasks and categories, scenarios for the capacity calculation can be formulated. We will execute the capacity calculation for three different scenarios, which are the current, current competitive and future competitive lead times. These lead times are depicted in Table 4.2. The analysis on the foundation of these figures can be found in Section 3.4. The sales projections explained in Section 3.3.1 are used as input for scaling the capacity. Unfortunately, scaling the capacity with demand will result in the same lead times, because the sales volume per year is divided equally over the months. This is a drawback of the analysis, since the aim of our research is to calculate the implications of a change in sales growth and its corresponding lead time reduction. We will go more into detail on this drawback in Section 5.1. Nevertheless, Table 4.2 is inserted in the capacity calculation set-up, because it is an important part of the discussion in our research.

Table 4.2: Lead Time Input Capacity calculation.

Product Type	Current	Current Competitive	Future Competitive
Product Y (ATO)	6 weeks	4 weeks	2 weeks
Product Y (ETO)	12 weeks	10 weeks	6 weeks
Product Z (ETO)	12 weeks	8 weeks	4 weeks

Because the number of hours is expressed per 100K EUR and the sales projections are in USD, we used a conversion rate of 1 EUR = 1.09405 USD to express the sales projections in EUR (Company X (13), 2016).

We will express the capacity as a number of FTEs per task or department per day. One FTE is determined to be 35 hours per week, or 6.8 hours per day, because a person does not spend hundred percent of his time purely on function-specific tasks (Analyst Materials Planning, 2016). We divide the capacity per month by the number of working days of that specific month, in order to give accurate capacity figures per day. The number of working days differs for each month, since we deducted weekends and holidays from the total number of days for each month in the period of January 2017 until December 2019.

The capacity calculation will provide the future workload and capacity requirements in FTE for the Product Y product line, based on the sales projections and man hours used per task per 100K EUR in combination with the current capacity, i.e., we use the input of current man hours used per 100K EUR as a factor to calculate the future capacity. In short, we will scale the current workload with the increase in sales volume and the change in product type proportions. The bottlenecks in the process can be found by mapping the difference in current and future capacity. The departments with the biggest differences are the ones that lack the most capacity. This way, bottlenecks in the process become apparent. We will check these with the relevant people afterwards to verify whether they are correct or not.

Because we want to say something about the future expected capacity, we need to take variability into account. In order to do so, the mean and standard deviation of the total amount of man hours per relevant task is calculated. Using this information, we determined a 95% confidence interval per task and expressed it as the percentage of deviation from the mean of each task. The mean is the average value for all booked hours of a task. A 95% confidence interval means that a random value of the used population sample lies within the determined interval with a confidence of 95%. The smaller the population sample size, the larger the interval and hence the more inaccurate the conclusion will be (Montgomery & Runger, 2011). The formula for the 95% confidence interval for the man hours used per task or combination of tasks for the standard normal distribution is as follows:

$\bar{x} - z_{\frac{\alpha}{2}} \frac{\sigma}{\sqrt{N}} \leq \mu \leq \bar{x} + z_{\frac{\alpha}{2}} \frac{\sigma}{\sqrt{N}}$ (Montgomery & Runger, 2011), where:

- $\bar{x}$ = sample mean;
- μ = population mean;
- z = value for the selected confidence level from the standard normal distribution, in this case z = 1.96, because a 95% confidence level is used (α = 5%);
- σ = standard deviation;
- N = population size.

(Sub-)departments consist of multiple tasks, so in order to calculate the combined confidence interval, the sample mean, standard deviation, and population size are changed as well. These calculations are given below:

- Sample mean: $\bar{x} = \sum_{i=1}^{n} \bar{x}_i$, where $\bar{x}$ is the sample mean of the combined tasks;
- Standard deviation: $\sigma = \sqrt{\sum_{i=1}^{n} \sigma_i^2} * \sqrt{G_T}$, where σ is the standard deviation of the combined tasks, multiplied by the sales growth factor G_T per year T, with T = 1, 2, 3. T = 1 corresponds with 2017, et cetera. We suppose growth is certain and samples are independent;
- Population size: $N = \sum_{i=1}^{n} N_i$, where N is the population size of the combined tasks.

We should mention critical notes with respect to the capacity calculation. We will use the capacity calculation to determine the future capacity of the value chain, but not every department is included in the capacity calculation, because hours are booked differently for some departments. Therefore, we have estimate the future capacity of OM and Planning. Moreover, for the departments that book their hours, tasks are not tracked in the same manner and degree. It is important to understand that the current total number of man hours used is not necessarily correct, but is meant to reflect the current capacity. This is also the reason that we have expressed the hours in a ratio of 100K EUR per category. By simulating the future sales volume, the total number of hours will increase enormously, but the ratio of used hours per task and category stays the same. Subsequently, these ratios can be linked to the current capacity and a magnification factor per (sub)department can be found. Therefore, the calculations can be seen as an extended capacity plan for the upcoming years, based on the current capacity and future sales figures. Also, we have seen in Section 3.3.5 that 20% of Product Z will become ATO in 2019, but this cannot be included into the calculations, since the current man hours used for Product Z (ATO) are unknown.

4.3. Conclusion

The purpose of this chapter was to map the order process and explain the roles of the relevant departments. We have made a value stream map to visualize the value chain and have determined the scope of the capacity calculation. Not every department within the order process is analyzed and within the analysis not every department is simulated. Moreover, we have presented the relevant process steps per product type, including the ones for the LPD-partner or -center, to show that the order process is not always the same.

With respect to the capacity calculation set-up, we explained the transformation from raw data to usable data step-by-step to make clear how the input has come to existence and which assumptions had to be made. These steps include the application of the Pareto law, the insertion of several functions to differentiate categories, some calculations methods, the clearing of raw data, the LPD/barebone concept and a conversion rate. Also, we have taken variability into account. We formulated a formula for a 95% confidence interval to explain the influence of variability. At the end of Section 4.2 we have made critical notes to elucidate the assumptions and flaws in the model.

We have answered all qualitative and quantitative questions of sub-question 1, which was *"What is the current situation and what are the future perspectives for Company X?"* in this chapter, except for the question about bottlenecks in the value chain. The answer on this question follows from the capacity calculations. In the next chapter, we will provide an answer on this question and state the results of the capacity calculations. Moreover, we will discuss the required capacity change per department and the implications for the organization.

5. Implications for Company X

In this chapter, we will state the results of the capacity calculations for the relevant departments. We will go into detail on the calculated capacity to provide answers on the following sub-question of Section 1.3.2:

> **3.** ***In what way could the capacity of the value chain be improved to meet future demand and what are the implications?***

In addition, we will discuss the bottlenecks of the order process, as well as the application of LPD-partners on managing variations and fluctuations, and we will give an advice for organizing the value chain capacity in this chapter.

5.1. Future Capacity

We have explained the methods of calculating the future capacity per department in the previous chapter. The required capacity per product category is calculated for every task for the period of January 2017 until December 2019. Because the sales volume is equally divided over the months, we have taken the average capacity per year for the comparison with the current capacity. The sales volume will not be equal every month in reality, but will fluctuate each month due to fluctuating order intake. Because the order intake fluctuation was moderate in 2016, the effects would not be great for the calculations (Analyst Materials Planning, 2016). As a result, the different lead times do not influence the capacity, because the same sales volume must be covered eventually, albeit in a shorter period of time.

Analysis of the current capacity indicated that for some sub-departments the future capacity cannot be calculated, because the current capacity is not defined specifically for Product Y. For instance, all parts assembly tasks are the same for all manufactured products, so the used capacity for Product Y, which is computed in the analysis, is much lower than the current parts assembly capacity for the whole plant. Therefore, we choose to exclude these internal suppliers from the analysis. The internal suppliers displayed in Table 5.1 are not nearly all internal suppliers, since we excluded most of them from the analysis when we took only the top 99% of used hours. Examples of internal feeders are casting, welding, punching, bench working, powder coating, bending and sheet metal manufacturing.

We calculate the capacity per department by scaling the man hours used per 100K EUR in 2016 with the future sales figures. The required capacity per sub-department is calculated per month, in terms of FTEs per day. We compare the current capacity to the computed average per year. The result of the analysis is depicted in Figure 5.1. For every (sub-)department the average capacity growth for 2017, 2018, and 2019 is given. We use error bars to depict the variability in growth per department. The increase for Engineering is very high, so to go more into detail, we have displayed the required future capacity growth for Engineering and Production in two separate figures. The capacity growth for Order Management and Planning is the same, because we have used the same growth in sales volume for both departments, since no data was available for these departments (Company X (9), 2016). It is clear that every department needs to scale up its capacity. This should not be surprising, seeing that the year on year sales growth for the Product Y product family is projected to be 23%. It is, however, notable that the growth is not the same for every department. This might indicate that the current capacity is not balanced well. The bottlenecks will be analyzed more into detail in Section 5.2. The relevant departments are defined in terms of sub-department, sub-department code, sub-department description and task in Table 5.1. This way, it is clearer which tasks belong to which department.

Table 5.1: Defining the Relevant Departments.

Main Dep.	Sub-Dep.	Sub-Dep. Description	Comments
OM			Capacity is estimated
Planning			Capacity is estimated
Engineering	Mechanical Engineering	Product Y Engineering Primary	
	Application Engineering	Product Y Engineering Sec.	AE long lead times AE before approval AE testing
		Product Y Engineering Sec.	AE after approval
	Electrical Engineering	Product Y Drawing	
	Work Preparation	Product Y WP	
		WP Sheet Metal new	
Production	Parts Assembly	Current Transformer	Internal Supplier Internal Supplier
		Current Transformer Testing	Internal Supplier
		Punching new	Internal Supplier Internal Supplier
		Brake Press new	Internal Supplier
		Bench Work new	Internal Supplier
		Welding Manual new	Internal Supplier
	Primary Assembly	Product Y Assembly Primary	
	Secondary Assembly	Production Wiring	
		Product Y Assembly Secondary	Only Product Y (ETO) Only Product Z (ETO)
	Testing – Primary Testing	Product Y Testing	
	Testing – Secondary Testing	Product Y Testing	

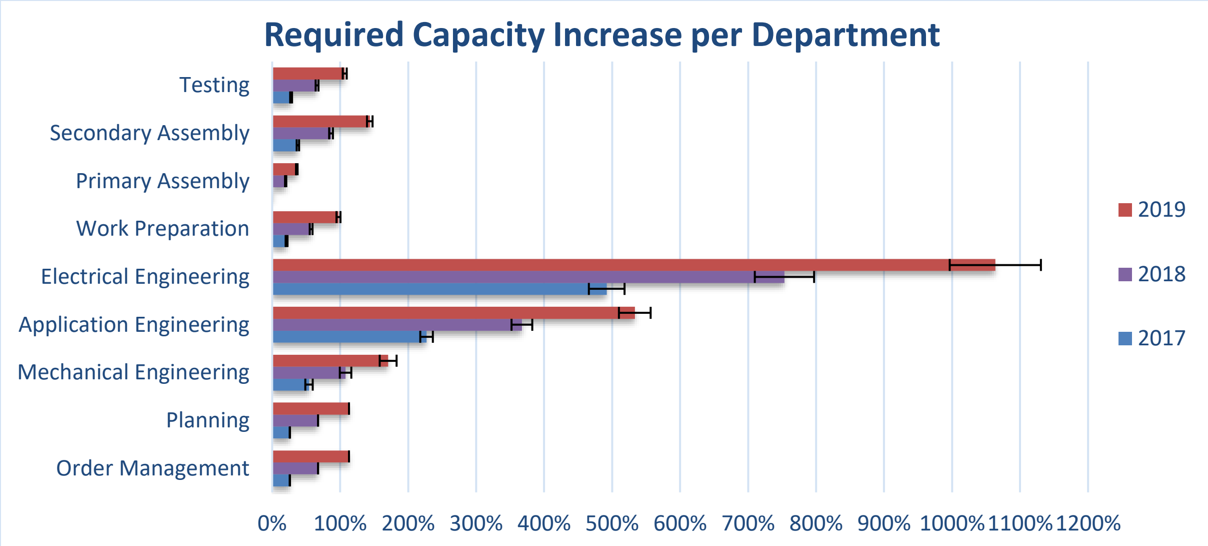

Figure 5.1: Required Capacity Increase per Department.

In Figure 5.2 and 5.3, we have displayed the required capacity increase for Engineering and Production. We have split-up both Engineering and Production into smaller sub-departments to see the bottlenecks within the departments and define specific strategies for the various relevant sub-departments. As mentioned before, it was not possible to calculate the required capacity increase for the different lead time scenarios, because we divided the sales volume per year equally over the months. This means that the required capacity increase in Figure 5.1, Figure 5.2, and Figure 5.3 would be sufficient for a scenario in which lead times stay the same. We expect that shorter lead times would be expressed in more capacity fluctuations, since an unexpected large sales volume would have to be processed in a short amount of time. Unfortunately, we could not compute such effects. Thus, we conclude that the actual required capacity increase should be higher than the required capacity increase we calculated here.

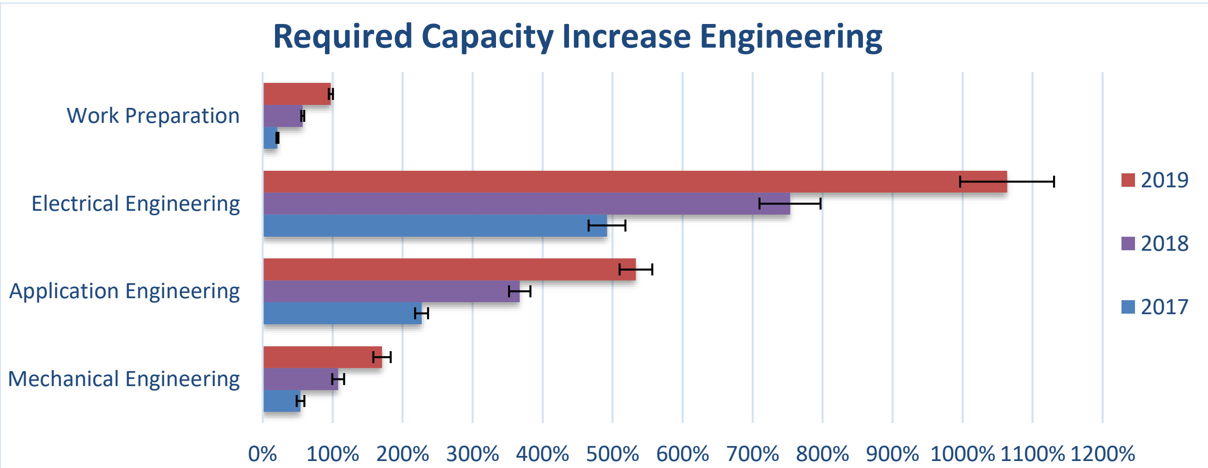

Figure 5.2: Required Capacity Increase Engineering.

It is remarkable that Engineering lacks so much capacity, given the enormous required capacity increase. The gap may seem unrealistic, but Engineering already lacks capacity at the moment (Analyst Materials Planning, 2016). If the current capacity was increased by a few FTE per day, the required capacity increase would be around 200% for 2019, to some extent similar to the required increase of the other departments. In Table 5.2, we added the actual capacity figures in FTEs per day for clarification purposes. A current capacity of two FTE per day for Electrical Engineering instead of 0.44 would already result in a required capacity increase of 155% instead of the seemingly implausible 1064%. The gap in current capacity can, however, not be ignored. Since the department is lacking capacity as of now, the urgency is high to increase capacity as quickly as possible to overcome the current gap and close the gap to the future required capacity. The urgency is clearly the greatest for Electrical Engineering and the least important for Work Preparation.

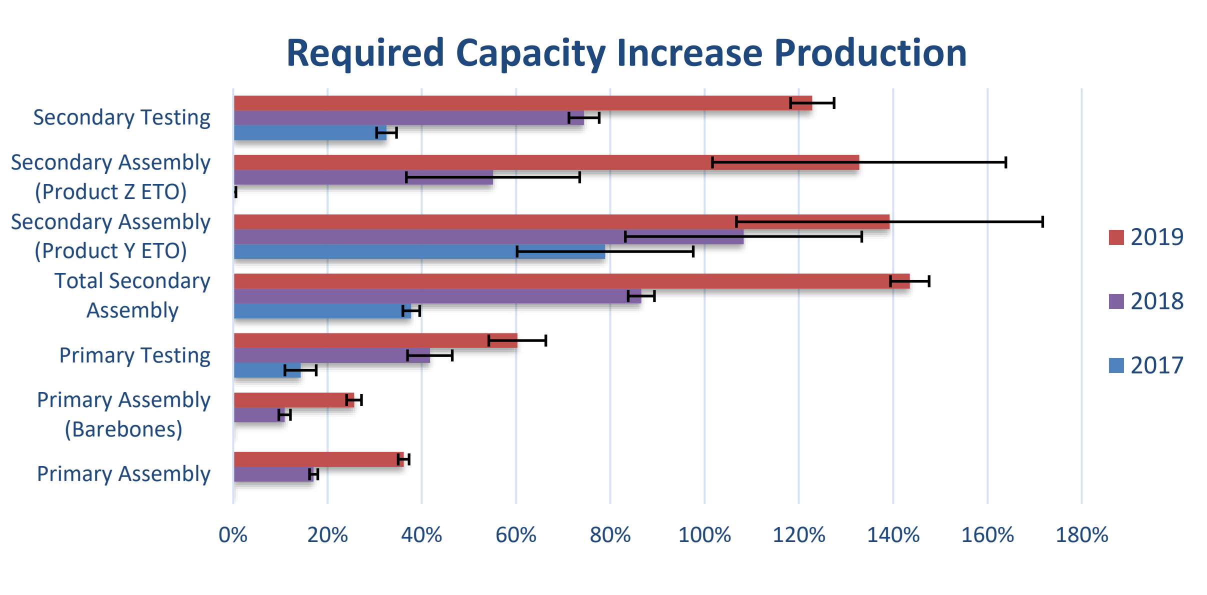

Figure 5.3: Required Capacity Increase Production.

In Table 5.1, two comments are placed at Secondary Assembly. This is done to specifically map the capacity change for tasks 5326 and 5329, because these tasks are only performed for one product type. This way, the effects of the changes in ATO versus ETO become visible. Total Secondary Assembly requires a bigger capacity growth than Secondary Assembly (Product ZTO) and Secondary Assembly (Product Z ETO). In Section 3.3.5, we have seen that the proportion of ATO-orders will increase from 31.0% to 44.6% by the end of 2019. This explains the fact that Secondary Assembly for ETO-orders does not require the same growth in capacity as Total Secondary Assembly. The 95% confidence intervals of these two departments are extremely large in comparison to the ones of the other departments. This is, because single tasks were taken to specifically analyze the required capacity increase for Secondary Assembly (Product ZTO) and Secondary Assembly (Product Z ETO). Consequently, the population size was relatively small, so the variability on these departments is much greater.

Because Product Z is projected to grow enormously and to a large extent ETO, Secondary Testing requires much more capacity in proportion than Primary Testing. All employees working at the Testing department are capable of testing both primary and secondary assembled products, so we have taken the capacity for Testing as one.

The percentages in the figures earlier in this section may not say everything about capacity, so we added Table 5.2 to display the actual growth per department. The need for Engineering capacity becomes even clearer, because the discrepancy between the current and future required capacity is alarming. We have not taken efficiency measures into account for the required capacity in 2019, so it is up to the department managers how they intend to accomplish these thoughts. We will go more into detail on the implications of the capacity changes in Section 5.3 and Section 5.4.

Table 5.2: Capacity Comparison per Department.

Department	Capacity (in FTEs per day)			
	Current	Required		
	2016	*2017*	*2018*	*2019*
Order Management	8.00	10.08	13.40	17.04
Planning	1.00	1.26	1.68	2.13
Mechanical Engineering	0.88	1.36	1.84	2.39
Application Engineering	0.51	1.66	2.37	3.22
Electrical Engineering	0.44	2.59	3.74	5.10
Work Preparation	2.55	3.09	4.01	5.04
Primary Assembly	22.24	22.24	26.65	30.29
Secondary Assembly	11.76	16.20	21.94	28.63
Testing	14.27	18.04	23.69	29.50
Total	61.65	76.52	99.32	123.34

In the next section, we will evaluate the bottlenecks within the value chain.

5.2. Bottlenecks

The bottlenecks for the future required capacity of the value chain are clearly visible. Engineering, and especially Electrical Engineering, already lacks capacity. Engineering should increase its capacity to overcome the current gap, let alone the gap for the upcoming years. In order to work more efficiently, it is recommended that tasks become less dependent on certain knowledge of employees. This would be beneficial for reducing the lead times of Engineering, since work will be executed more in parallel. Plans have already been made to implement this, as we have seen in Figure 4.2, but it has become clear that the urgency of continuing this goal is very high.

We conclude that a bottleneck for Production is the Secondary Assembly sub-departments. An increase in production capacity does not just justify an increase in FTEs. Due to barebone production and an increase of ATO versus ETO, one needs to look at machinery as well. The next section will go more into detail on this subject. Another bottleneck is the supply of parts. Internal feeders, such as sheet metal manufacturing, have caused many delays in lead times the last year. Large orders are prioritized, which means that ETO-orders are postponed in general. This is also the reason that the lead times for Product Y (ETO) and Product Z (ETO) have increased to greater extent than the lead times for Product Y (ATO), which we have seen in Figure 3.9.

Another bottleneck within the value chain is the way orders are planned. The system is not capable of handling changes once orders are planned, to say the least. However, changes occur often, since orders sometimes need more engineering work, after they have been given approval for production. If an order is not “clean” (incomplete), which can be due to the problem stated previously, the absence of the order map, or unreliable material supply. These problems are responsible for many delays in lead times, so fixing them would be highly advisable. Solving just one problem already relieves Planning of much re-planning issues. A solution for this problem could be to introduce frozen orders. This means that after a certain point in the order process is passed, the order gets a frozen status, which means that no more changes are allowed, both internal changes and external (customer) changes. This way, Supply Chain would get much more time to anticipate. The fact that this has not happened yet is because of the difficulty of getting an order frozen. Often there are too many important changes required to ignore them, e.g., changed customer specifications. A solution could be to communicate the frozen status to the customer and increase the sales price or deviate from the agreed delivery date. Orders Managers play an important role in this matter. In the end, an Order Manager is responsible for an order, so he or she should show much more commitment to the process. Working in business units could be a solution for many problems. We will go more into detail on such organizational changes in Section 5.3.

5.3. Organizational Capacity

Hiring extra people would be the easiest way to increase value chain capacity. This is, however, not the most favorable solution. In Section 1.3.3, we devised a constraint for the increase in capacity. We divided capacity into fixed and variable, and stated that only increasing the variable capacity would be allowed. Variable capacity is capacity that is dependent on the sales volume. Therefore, we defined variable capacity as the capacity of the production, engineering, and order management departments. Fixed capacity can be explained as capacity that is fixed for the long term, in this case the support departments, such as HR, IT, Marketing, Quality and R&D. The constraint implicates that increasing the capacity of the departments, which we used in our analysis, is allowed, but capacity for support activities should be maintained.

Following a chase demand plan, as we have explained in Section 2.3.2, would be in coherence with Company X's strategy, since the nature of the products (highly customizable, fluctuating order intake) requires sufficient capacity to follow fluctuations and meet delivery lead times. Varying the size of the workforce by hiring extra staff during periods of high demand and lay them off when demand drops may seem an easy option, but would be highly harmful for the morale of workers and goodwill in the local labor market. Moreover, training staff is time consuming and therefore costly. The subcontractor needs to be compensated as well. Other risks of hiring subcontractors are less motivation to deliver the desired quality of working and the exposure of valuable information. All in all, these options would not be the best possible solution for the flexibility problem. Exchanging workforce between different assembly stations or product lines, however, could be an excellent solution. The factory is already familiar with this way of working, since this is currently done, for instance on LV-production lines, to overcome capacity issues. Extra training may be required to increase the usage of this method.

We are by now familiar with the projected doubling of sales volume the upcoming years, which probably results in many changes for the factory lay-out and people working at Company X. As of now, production is done in one shift, starting at half past seven and finishing at four o'clock in the afternoon. The doubling of sales volume might create the need for working in two, or even three shifts. This would cause many changes for the organization. Moreover, the goodwill of employees will be subjected to a severe test.

To overcome the bottleneck of internal feeders, which we have discussed in Section 5.2, we advise to look at another layout for material flow. The deployment of separate internal feeders for key products may be a solution for the lead time problems caused by these internal feeders. Currently, the internal feeder sheet metal manufacturing, for instance, serves as a supplier of parts for every product line. Thus, chances are great that the entire production jams in case something goes wrong here. As this is currently the case, lead times for ETO-products have increased dramatically.

One also needs to look at chances to improve efficiency, for example by working more in parallel, which we have concluded to be an excellent solution for Engineering. Not only Engineering needs to look at its efficiency. A lot can be done to improve the efficiency of production as well. Since the proportion of ATO-orders is projected to increase and 20% of total sales volume will be barebone production, deeper levels of standardization, such as automating certain processes and reducing customization for standard products, could be implemented in the production process rather easily. The LPD-strategy of manufacturing 20% of total sales volume in the Netherlands can be a great way to increase revenues on one hand, but lower variations for the production process on the other hand. Not only variations are reduced, lead times will profit from this strategy as well. By manufacturing barebones, fluctuations in order intake can be partly covered. If barebones were produced on stock and put both in the LPD-partner's and Company X's warehouse, lead times for the LPD-strategy can be reduced by at least six weeks, since not only the shipping lead times can be covered, but also the assembly of components and barebone can be done in advance. Warehousing is not free unfortunately, because space need to be reserved, organized and maintained, and capital lies dormant. Nevertheless, the plant in the Netherlands has a surplus of space, which is now paid for anyways. Building up inventories in periods of low demand is advisable to overcome a factor of the fluctuations in order intake.

Another approach to lowering variations is raising the percentage of customer profiles. When a customer signs a contract with Company X, which happens only if the sales volume justifies the investment, the order is standardized for future purchases and becomes ATO. Such a customer profile implies that engineering work will not be necessary anymore in the future, which saves Company X a lot of time and money. The order should, however, be large enough to justify the investment in adding it to the different ERP-systems. Since the demand and order specifications for contract customers are known, these orders could be produced on stock as well. This would further narrow down the variations and fluctuations in the production process of Product Y.

As we have mentioned previously in Section 5.2, order managers currently underestimate their responsibilities. Many problems occur when orders hit production and lead times are delayed significantly as a result. Working in business units could be advantageous for the reduction of lead times, because all relevant employees become closely connected to each other and the exchange of information will harmonize more easily. A group of employees with different functions, think of an order manager, an engineer, and a purchaser will be made responsible for a certain product type. Because they work together on the same orders all day, the flow of information is enhanced and problems can be discussed immediately. This would require a completely different organizational structure, so further research on the effects is a great necessity, if this option is going to be treated seriously.

5.4. Implications

The proposed organizational changes in the previous section do imply extra costs and gains. Besides the hiring and salary costs of extra employees, there are some other factors to consider.

Standardizing the barebone production requires people to put time and effort in this, which implies costs. Most of the barebone specifications have already been done, but the production line may probably need altering as well. The same is applicable for the warehouse, because space must be reserved and maintained for keeping barebones on stock. Factory investment might be required for the barebone production, because some tasks of the highly-standardized production may be automated to reduce labor costs and lead times. The benefits of less variations and fluctuations for the order process, however, are estimated to outweigh the costs by far. The cost price can be lowered and production can continue outside office hours, if automation of standard processes is carried through. Further research can be done on factory investment, for instance on return on investment (ROI) calculations.

The financial impact on maintaining fixed capacity, but increasing variable capacity is positive. Revenues will increase at a much higher rate than costs will, since indirect labor is used more efficiently and the large amount of fixed costs, among other things consisting of too much overhead, is divided over a greater sales volume. These economies of scale will significantly strengthen Company X's competitive position in the market.

Currently, a great deal of time, and thus money, is spent on engineer-to-order tasks. Costs are only going to increase, but one should not underestimate the gains of more than a doubling in revenues for the Product Y product family. The factory is too big for its current sales volume, so we are convinced that more sales volume is the solution for Company X. People tend to forget that the effect of direct costs on the total costs are substantial and the best way to lower them, is to increase factory absorption. A greater sales volume distributed over the same direct costs results in a lower hourly tariff that is charged to the costs of an order, i.e., economies of scale are achieved.

An investment in an ERP-system that is capable of handling the various sophisticated and complex issues of today, but in particular the ones of the future. The current ERP-system *Baan* is outdated, so a significant investment is required. In the long-term, however, this investment is going to save the business much trouble.

We highly recommend Company X to put its focus on Customer Intimacy, which we have concluded in Section 3.2, to keep offering custom solutions to customers that desire more than just a regular system. The value chain capacity should be organized in such a way that there is always surplus capacity to satisfying all customer needs, since *"…markets that value responsiveness and service quality may justify a more generous provision of operational capacity."* (Slack, et al., 2013, p. 327). In order to meet all customer needs, the organization should be able to meet the competitive delivery times, stated in Table 4.2., and handle changing demand with great flexibility. Moreover, volume flexibility is enhanced by surplus capacity (Slack, et al., 2013).

5.5. Conclusion

In this chapter, we have stated the required future capacity. The required capacity increase and the corresponding variability for the whole order process are depicted in Figure 5.1. Engineering and Production are divided into several sub-departments to analyze the implications for the capacity growth more in detail. The division of departments and sub-departments is displayed in Table 5.1. The bottleneck for the value chain clearly is the capacity of the engineering department. For Electrical Engineering, for instance, capacity needs to increase by 1064% in order to meet the demand of 2019. This growth may give a distorted image, because the current capacity is too low. Nevertheless, the capacity needs to increase enormously, because such a discrepancy will cause major problems for the order flow of the company.

In order to cope with future demand and changing specifications, some organizational changes may be required. Firstly, department managers should question their current efficiency and look for other, more efficient ways of working. We have seen that working in parallel could be an excellent solution for Engineering, for example, because much engineering labor does not require a fixed sequence of tasks to be performed. By working more in parallel, engineering can be given more flexible jobs and thus lead times can be reduced.

Another approach to lowering the amount of variations is raising the percentage of customer profiles. Orders become more standardized, which results in more efficiency for the order process, because many tasks do not have to be performed anymore. Investments in more automation could be beneficial for lowering the cost price of many standard parts, such as barebones. Another option could be to work in two or even three shifts to maximize machine efficiency.

Such changes obviously require additional investments. Examples of such investments are the implementation of a new ERP-system, increase in keeping spare parts and other items on stock, and hiring extra workforce. Further research on RIO maximization should tell which changes are the best for Company X.

6. Conclusions and Recommendations

6.1. Conclusions

The main goal of this report was to provide Company X an answer to the question: *"How should we manage our growth plans?"* To find the core problem for this question, we started off with a problem analysis on every problem related to the scope of our research and conducting a problem cluster. The main problem for Company X is the rigidity of the value chain capacity, or to be more specific: *"The current capacity is too low to handle the future growth strategy."* This led us to determining our leading research question, which is:

What is a better value chain set-up for the Product Y product family in order to cope with more fluctuations, variations and future growth plans?

We split up our leading research question into three different questions, each consisting of specific sub-questions. We conducted literature study to determine Company X's strategy, get more insight in theory about capacity planning, and evaluate different quantitative models to calculate the future capacity.

A sales growth of 23% per year results in an enormous bottleneck for value chain capacity, because with equal efficiency the current capacity is by far sufficient for the future. In order to calculate the future value chain capacity and provide suggestions for the organizational structure of Company X, we first need to determine the current situation. We broadly divided this into analyses about the market, Company X's value proposition, and future perspectives, in terms of sales growth, changes in product portfolio, and delivery times.

The market, which Company X is operating in, is business-to-business, with prices only being established after negotiations or via tenders. To be successful in this business, it is essential to be highly involved in the offering process. Company X offers highly customized solutions for a broad range of market segments, including utilities, oil and gas, industry, utility construction, critical assets such as hospitals and last but not least data centers. After conducting interviews with several stakeholders in the order process, we concluded that Company X's value proposition should be Customer Intimacy, since customers require specific solutions and are willing to pay more than for so-called "brochure products".

Sales are projected to grow 23% per year for the Product Y product family, while most sales growth originates from the growth of Product Z. This growth is explainable by a change in segment proportions. The focus will be put on the private segment, which is characterized by low volumes and high margins. A comparison between contract and non-contract orders is made, since this better reflects the proportion ATO versus ETO. We found that the percentage of non-contract orders is currently 61% for Product Y and 95% for Product Z. These proportions will respectively be 61% and 80% in 2019. ETO-orders are responsible for most variations and fluctuations in the process, so comparing the future ratio to the current ratio is essential for calculating the future value chain capacity. We introduced the LPD/barebone concept, which could help Company X in lowering the degree of variations and fluctuations for the factory in the Netherlands.

We studied the actual delivery times over the years to detect the neglect of customer focus. Actual delivery times have increased at almost 20% per year, due to the dysfunction of the internal feeder sheet metal manufacturing, a lack of engineering capacity, and a lack of skills of employees working in assembly. Moreover, we compared the current, current competitive and future competitive promised delivery times. If Company X wants to stay competitive, promised delivery times need to be reduced to the level of 2013. This reduction is about 60% of their current amount of time. The average OLT_{Actual} 2016 for Product Y is 83% and 71% for Product Z. In November 2016, the OLT_{Actual} for Product Z was even 49%. This implies that more than half of the orders was not delivered on time. This is, of course, extremely low and must be dealt with as soon as possible.

Determining the current situation also means mapping the order process for Product Y, Product Z, and the barebone production. We have done this on the basis of a VSM, in which we established the scope of our capacity calculation analysis. We could not scale the current capacity for every department, since data is not always tracked in the same manner. We transformed the raw data of all Product Y family orders YTD into a number of man hours used per task per EUR 100K. This way, we were able to scale the current capacity with the sales growth and changed order specifics to calculate the capacity per department in 2017, 2018 and 2019. We took variability on the man hours used into account to determine the minimum and maximum capacity growth on a 95% confidence level.

The analysis made clear that the capacity of the order process needs to increase enormously, because the discrepancies will cause major problems for the future order flow of the company. The departments Order Management, Planning and Production need to increase their capacity to some extent equal to the projected total sales growth of 129% until 2019. Engineering, however, is the biggest bottleneck in the order process. An increase of 1064% in Electrical Engineering capacity may seem unrealistic, but Engineering overall is already lacking capacity. Lead times will only increase further, if this bottleneck is not solved in the short term. Thus, the need for extra capacity is becoming imposingly urgent.

Several options may reduce lead times without increasing man capacity at unrealistic rates. A capacity increase for the relevant departments is, however, vital for meeting the objectives set by management. Our recommendation is to standardize parts of Product Y and Product Z to make reduction of both lead times and costs possible, since there will be less variation in the process. These parts should not be customer order winning factors. Department managers should invest efforts in possibilities to increase efficiency to shorten lead times and save costs. We recommend decreasing the number of variations and fluctuations by collaborating with LPD-centers and -partners as well, so perseverance to make a success of the LPD-initiative is crucial in this matter. Perhaps a different organizational structure, for instance by forming teams responsible for a product type or family, could be a suitable solution for the problem. This way, knowledge is brought together, so the flows of information will run much more smoothly. We recommend the implementation of a new planning system to overcome the various sophisticated and complex issues of today, but in particular the ones of the future. Furthermore, we suggest reducing the power of production departments by focusing on Customer Intimacy. In the next section, we will elaborate on these recommendations and plead for several more.

The proposed changes obviously require additional investments. Examples of such investments are the implementation of a new ERP-system, increase in keeping spare parts and other items on stock, and hiring extra workforce. Further research on ROI maximization should tell which changes are the best for Company X. We will go more into detail on follow-up research in Section 6.3.

Finally, we conclude that the challenges for Company X are great to achieve its growth objectives. However, the growth objectives for 2016 are being achieved, so they are far from unrealistic. Everyone at Company X should be critical about his or her own work, and work cooperatively to achieve the joint growth goals. We truly believe that Company X can strengthen its competitive position, if it succeeds in achieving its goals.

6.2. Recommendations

The required capacity increase may entail some organizational changes. These are different for every department. Moreover, we have explained the constraint of maintaining fixed capacity. This means that the support departments need to work more efficiently to handle the same workload as before for a sales volume twice as large.

The biggest problem for the factory in the Netherlands is that the current sales volume is too low for the size of the plant. Indirect costs are relatively high, so it is obvious that more sales would help lowering hourly rates, which are allocated to the cost price of a product, and gaining more efficiency in terms of economies of scale. Thus, we suggest to continue the sales growth and pursuit the projected sales growth, because that is what the factory is currently lacking. To realize the objectives, we recommend several changes and directives, on which Company X should put its emphasis.

We have concluded that the power of the production departments is currently too big. We have seen that the lead times are determined by value chain capacity instead of customer demand. We stress our recommendation for Company X to focus on Customer Intimacy, which means that every employee should look at his or her own processes in a customer-oriented way and the order process as well. This means that only the total lead time should be communicated to the customer. Moreover, lead times should be reduced by 60% if Company X wants to stay competitive in the future and keep offering custom solutions to customers that desire more than just a regular system. The value chain capacity should be organized in such a way that there is always surplus capacity to satisfy all customer needs, since *"…markets that value responsiveness and service quality may justify a more generous provision of operational capacity."* (Slack, et al., 2013, p. 327). To meet all customer needs, the organization should be able to meet the competitive delivery times, and handle changing demand with great flexibility. Moreover, volume flexibility is enhanced by surplus capacity (Slack, et al., 2013).

We highly recommend raising the percentage of customer profiles to lower the number of variations. Orders become more standardized, which results in more efficiency for the order process, because many tasks do not have to be performed anymore. This would be beneficial for Engineering, e.g., orders require less specific engineering work, and Production, e.g., processes could be automated. Investments in more automation could be beneficial to lower the cost price of many standard parts, such as barebones. We recommend Company X to lower the number of order variations by researching what the order winning specifics of its products are, and standardize the unnecessary variations. Moreover, we suggest that Company X continues its LPD/barebone strategy, because it enhances standardization in the production. Variations and fluctuations can partly be covered by this strategy. We further propose the production of parts or barebones on stock to reduce lead times. This would enhance the management of order intake fluctuations as well. Also, Company X should explore the options of working in two or even three shifts to maximize machine efficiency.

We recommend the deployment of separate internal feeders for key products as a solution for the lead time problems caused by these internal feeders. Numerous orders are delayed, because of the dysfunction of these departments. Deploying separate internal feeders per product line may increase costs, but from the viewpoint of Customer Intimacy, all processes must be designed in such a way that competitive delivery times can be achieved.

Order managers currently underestimate their responsibilities. Many problems occur when orders hit production and lead times are delayed significantly as a result. If an order is not "clean" (incomplete), which can be due to planning issues, the absence of the order map, or unreliable material supply, production cannot start. These problems are responsible for many delays in lead times, so we highly recommend fixing them. We suggest a frozen order status. This means that after a certain point in the order process is passed, the order gets a frozen status, which means that no more changes are allowed, both internal changes and external (customer) changes. This way, Supply Chain would get much more time to anticipate. Orders Managers play an important role in this matter. In the end, an Order Manager is responsible for an order, so he or she should show much more commitment to the process. We recommend in general that employees should show more commitment to the entire process instead of only their own job. This way, people feel more responsible for a smooth order flow.

Working in business units could be advantageous for increasing this responsibility, because all relevant employees become closely connected to each other and the exchange of information will harmonize more easily. Moreover, this will result in a reduction of lead times. A group of employees with different functions, think of an order manager, an engineer, and a purchaser will be made responsible for a certain product type. Because they work together on the same orders all day, the flow of information is enhanced and problems can be discussed immediately. This would require a completely different organizational structure, so we highly recommend to conduct further research on the effects.

The current ERP-system *Baan* is currently not capable of handling changes in the planning of orders and is outdated. Many planned tasks must be rescheduled in case of a change in the planning, which undermines the entire logic. The result is that rescheduling does hardly occur and delivery times are delayed extremely. We recommend the implementation of a new ERP-system for Planning that automatically schedules new orders and reschedules all planned orders in case of a change to overcome the various sophisticated and complex issues of today and the future. A significant investment is required, but in the long term we expect this investment to save the business much trouble. We recommend to conduct follow-up research on the execution and ROI of such a rigorous plan.

We have seen that Engineering should increase its capacity by far the most of all departments. This is difficult to achieve, so department managers should question their current efficiency and look for other, more efficient ways of working. We have seen that working in parallel could be an excellent solution for Engineering, because much engineering labor does not require a fixed sequence of tasks to be performed. By giving engineers more flexible jobs, products can be produced faster. Consequently, lead times can be reduced. The same idea is applicable for the other departments, since increasing just the capacity will not solve the many inefficiencies in the process. Therefore, we do not only recommend Engineering to continue its attempts to further develop working in parallel, but the other departments that are highly dependent on variations and fluctuations in the order process as well.

Our final recommendation is to track data much and much better. During our research, we did not only have to deal with the problem statement and all its difficulties, but also with the lack of data availability and consistency. Engineering and Production, for instance, keep track of their data in quite a good way, but Order Management does not track hours at all. Moreover, departments track data differently and most people do not see the advantages of tracking their own data for other departments. The availability and consistency of data is crucial for performing analyses. To quite a great extent, assumptions had to be done due to these problems. Better tracking data would enhance the success and accuracy of future analyses.

6.3. Further Research

In this section, we state the possibilities for further research. We have already seen in Section 1.2 that there are problems closely related to, yet beyond the scope of our research. Examples of these are the unreliable material supply, quality issues, low hit rate on offerings and organizational structure. Further research on these topics is necessary to overcome these problems and increase value chain efficiency. The largest efficiency gain can be achieved in Engineering, since current capacity slows down the order process and is responsible for the largest sub-lead times. Assembly only takes two days for instance. Engineering time should be reduced enormously, if the future competitive lead times are to be achieved. We recommend to conduct follow-up research on improving communication, implementing new software, and making better use of data to decrease engineering lead times.

With regards to follow-up research on our research, a new ERP-system for Planning to cope with changes would be very welcome for the factory. A well working planning is vital for a smooth order process flow. The results of our research could be increased in terms of accuracy, if the order process capacity was simulated. Another graduate intern has considered the production department deeply and has made a simulation model in Siemens Plant Simulation. We recommend combining his model with the input of our research to simulate the entire order process. This would approach the real life future capacity of the order process most. The impact of decreasing lead times on the capacity could then be calculated in much more detail as well.

We further recommend follow-up research on the calculation of order absorption capabilities. If one were to set up lead times versus sales value, capacity flexibility could be mapped. This would result in recommendations on quickly scaling up and down.

To reduce delivery times by 60%, we highly recommend Company X to lower the number of order variations by researching what the order winning specifics of its products are, and standardize the unnecessary variations. Standardization might require machine investment, so the return on investment should be calculated for such decisions. The same is applicable for the implementation of extra workforce. We recommend considering working in two or even three shifts to maximize machine and floor utilization. Producing parts and barebones on stock would be highly beneficial for the reduction of lead times, in particular for the LPD-strategy. Another proposal for further research is considering a different organizational structure with, for example, business units or project teams. Obviously, there are many more options for follow-up research, but in our opinion the most important ones are stated in this section.

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