Analysing organisational change due to market shifts

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Preface

The report that lies in front of you is the final version of my bachelor thesis about analysing organisational changes due to market shifts. I approached the host company, CIREX, approximately one and a half years ago with the question whether they could offer me a graduation assignment. A close friend of mine has been working there for almost 34 years. Through him, the contact was made with the technical director and we agreed on an assignment. However, due to an organisational matter at CIREX, this first assigned project was cancelled. Yet, CIREX is facing another issue that influences their future earnings. It is about market shifts, the topic I researched instead.

When I first visited CIREX for a guided tour through the company, the ambience was pleasant. The employees interacted with each other as friends do. Everyone was eager to get to know me and the topic of my research. They were enthusiastic to help me and I enormously appreciated this, especially during the outbreak of the COVID-19 virus. At that time, most employees were working part-time at the business but they still took the time to assist me. Altogether, I want to thank all of the personnel of CIREX that helped me during this period.

Moreover, I want to thank the supervisors of the University of Twente, Reinoud Joosten and Wouter van Heeswijk for the feedback during my research.

Finally, I want to thank my family and study buddy Mark for the support they provided. With the outbreak of the COVID-19 virus, the work that I could do was limited. I hope you will enjoy reading this report.

Kind regards and stay safe,

Wessel Smits, 21-08-2020

Management summary

Introduction

CIREX produces steel products by investment casting, also called lost-wax casting. In this method, the mould is injection moulded with wax. Then, the mould is covered with ceramic layers and the wax is melted out of the ceramic mould. Finally, the steel is poured in the ceramic mould and the ceramic is removed. Currently, CIREX produces the majority of its product portfolio in the diesel and gasoline market. CIREX believes that this demand declines due to the upcoming electrical market in cars. CIREX is specialised in high quantity production, a characteristic of the automotive industry, because of the lost-wax casting method. However, due to the market shift, they have to think about accepting more general industry projects to earn the same profit. General industry (GI) projects are characterised by low quantity production.

When CIREX accepts more general industry projects, this has an impact on the company. More projects mean more work for a lot of jobs at CIREX. Engineers need to design more products, sales need to process more orders, production needs to produce more products. To persevere this rise in the amount of work, changes must be made. Therefore, the main research question that needs to be answered is:

Which changes does CIREX need to make due to market shifts?

Current situation

First, I analysed the projects of the automotive and general industry and I sketched the view of the future. I compared the different industries in terms of profit, also named as added value. 22 low quantity projects of the GI bring in the same amount of profit as one automotive project.

With this information, I identified the bottlenecks per department regarding this market shift. For the sales department, no problems occur when accepting more projects so no bottleneck there. The engineering department will experience problems with the high number of requests coming in. For each request, the engineers make a quotation for the customer. These non-beneficial customers will drain time but they do not result in any profit. The production & logistics division will not run into direct problems. Therefore, the flow of the processes has been analysed to identify the bottlenecks. These processes are the new project and regular series production.

Literature review

To come up with solutions to each bottleneck mentioned in the previous paragraph, I consulted the literature. In this literature review, I searched for organisational changes in general and for solutions to address the bottlenecks per department. For the sales section, this means that the focus was on retaining employees instead of recruiting. The engineering division together with the sales department can use the project portfolio to tackle the issue of many requests coming in. This portfolio exists of criteria to critically analyse upcoming projects and to deny the non-beneficial ones. For production & logistics, value stream maps are used to identify the bottlenecks per production type.

Future situation

With the solutions found in the literature, I made the translations of these solutions to the needs of the company. I drew up the project portfolio together with the help of the engineers. This portfolio helps the sales department to specify the right quotation for the engineers. Then, together with the criteria of the engineers, the final score provides to see whether a project can proceed or not. For the production & logistics division, the flow between an order coming in and the moment that the product is wax moulded, is monitored. This is done for both production types, the series production and new

project production. The bottlenecks of both production types occur after the scheduling of the products. Next to this, the time between order and kick-off can be reduced. Unfortunately, the implementation of these plans could not be done due to limitation.

Conclusion

CIREX has to compensate an anticipated drop in demand for the projects in the automotive industry. The replacement of this loss has to be done with projects in the general industry. In this, 22 typical low quantity projects of the general industry are equal to 1 high quantity project of the automotive, compared in added value. In the upcoming years (2021-2023), CIREX will experience a drop in the number of automotive projects of respectively 7, 10 and 12. So in 2023, 12 * 22 – 12 = 252 more projects need to be accepted to maintain the same EBITDA as now, under the same circumstances.

All of the waiting times in the processes of series and new project production are reduced with a significant amount of days. In the series production, the total reduction in waiting time is from 17.95 days to 8 days, which is a reduction of the TTT by 55.43%. Compared to the arrival of 252 more projects, this saves more than 20,000 hours that are otherwise lost to useless waiting time.

For the analysis of the new project production, the total waiting time reduction is from 11.16 days to 8 days as well, which is equal to a reduction of the TTT by 28.32%. Compared to the 252 projects, this saved time is 6,370.56 hours, which are now lost to unusable waiting time.

With the project portfolio scorecard, for each request, 4 hours are saved on average. With the change of 252 more projects, 1,008 hours are saved when implementing the scorecard. These hours were, unlike now, lost to extra work for the engineer.

The saved time is yearly, based on the figures for the year 2023. After 2023, the assumption is that number of automotive projects keeps dropping. Therefore, even more time can be saved when implementing the scorecard and other recommendations. Also, the recommendations can be applied to all of the projects of CIREX, not only for the general industry.

Advice

The advice comprises the recommendations and topics that need further research, next to the conclusion above. Applying the changes for the production section, these have the most effect for CIREX. Ranked after that is the project portfolio scorecard.

Next to these points, CIREX needs to focus on the big projects of the GI, new markets which fit their casting method and the truck market. Then, to gain more profit of the low quantity projects, the calculation template needs to be adjusted. This can be done by making two more scales, defining a minimum number of products or money and registering the time of the engineer connected to an hourly rate. All of these ways result in a higher price for the customer, which results in a higher profit for CIREX.

Besides, the sales department can spend more time looking into new markets such as the defensive sector and parts for the ship industry. The project portfolio scorecard can help to seek for opportunities for new markets when following the criteria provided in there, such as growth potential and companies' products that benefit from investment casting.

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List of abbreviations & explanations

Abbreviations	**Explanation**
AE	Application engineer
EBITDA	Earnings Before Interest, Taxes, Depreciation & Amortization
GI	General Industry
JIT	Just-in-time
MPE	Machining & Process Engineer
MPSM	Managerial Problem Solving Method
MRP	Material Requirements Planning
PD	Product Developer
SAP	Software to manage business operations and customer relations, also known as an ERP system.
SLR	Systematic literature review
SMED	Single-Minute Exchange of Die
TTT	Total throughput time
V-AT	Value-added time

Table 1. List of abbreviations & explanations.

List of figures and tables

1. Introduction

In this introduction, the cause of my research is briefly described. Next to this, I state the set-up of the research. The set-up is paramount because the research is broad and needs to be limited. To start with describing the set-up, I identified the problems regarding the topic of my research in a problem cluster and I drew up research questions. Also, I give information about the hosting company, CIREX. This is a detailed explanation that includes information that is needed to understand my research. Then, the methodology that I chose to guide me through this assignment is explained. I need this methodology to give structure to the research. Since the future problem indicates organisational change, the whole corporation is involved. This cannot be overseen without a plan of action. In this plan of action, I elaborate on the set-up of the research questions. Furthermore, the research cycle is explained, this cycle helped when I formulated the research questions. Finally, I discussed the research design with a brief guide of the plan of action.

1.1 Problem identification

First, I give a brief introduction about CIREX and the topic of my research. The industries that CIREX focuses on are the general industry and the automotive industry. The general industry (GI) comprises low quantity production with medium/high complexity. On the other hand, automotive is a market of high quantity and medium/high complexity production. The latter is a declining market for CIREX due to the production of more electric cars. A big part of the products that CIREX produces, is built for the gasoline and diesel market. These parts, such as the parts of an engine, are not found in an electric car. Due to the assuming decline in the automotive, CIREX needs to compensate for this loss with a change to more general industry products. The general industry differs from tools, hoisting & transportation, industrial components, aviation and pumping & fluid technology to medical, petrochemical, and food & pharmaceutical (CIREX, 2019). This comes down to a shift from high to low quantity production.

CIREX caters various markets, the general industry and the automotive industry. The demand in these markets shifts constantly. CIREX expects that the demand for the general industry will be higher than the automotive. Therefore, organisational changes must be made to cope with this shift. The changes that I look into are operational. I identify the bottlenecks in most of the departments of CIREX that occur when making the shift mentioned before. An organisational change is a classic adaptation that occurs when market shifts happen. In recent years, there is more demand for low quantity production with medium/high complexity, also called customisation. CIREX is used to mass production techniques, which is not the way to proceed in the future. Demand for configurability and personalisation is growing in the marketplace and presents a threat to traditional mass-production techniques (Reynolds, 2014).

The problem mainly lies in the part of not knowing what the changes are coming for the company. Problems that occur when making the change are listed and put together into a problem cluster, which can be found in Figure 1. This problem cluster has the most important problems in it, linked with each other. In this way, the relations between the problems are clear and the causes of the problems can be solved. Furthermore, the core problem can be identified clearly when mapping the problem cluster.

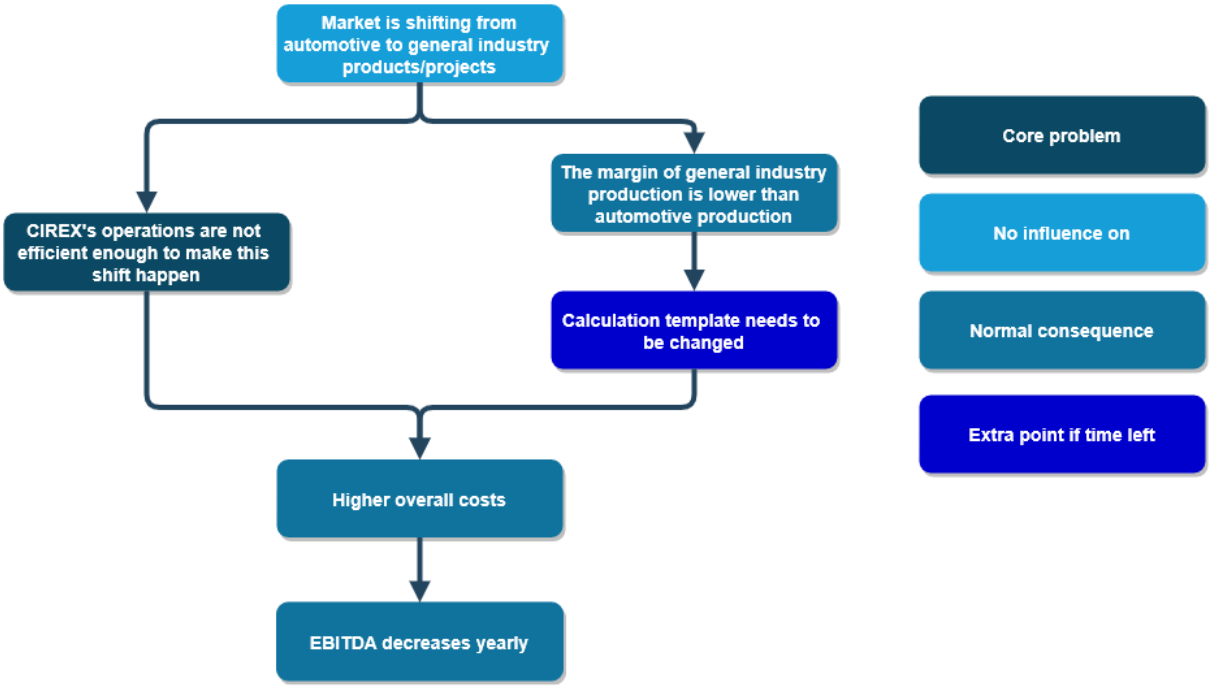

Figure 1. The problem cluster.

Often, the core problem is the problem at the origin, at the top of the cluster. In my case, this problem cannot be influenced because CIREX cannot influence market shifts. Then, two problems occur when this shift happens. The most valuable, important, and the biggest problem is that CIREX's operations are not efficient enough to make the shift from automotive to GI happen. The operations at the company must be more efficient to make more profit out of the market shift.

The market shifts result in more projects in the general industry. This brings a rise in the amount of work, it might be that the current employees and machinery cannot handle the market shift. This shift refers to the decline in the automotive market and a rise in general industry projects. The general plan of action is to go from department to department and see whether they are affected by more work. In the beginning, these problems per division were not clear. That is why I named the operations as one point to improve. When solving my main research question, this core problem is addressed adequately. The main research question reads as follows:

Which changes does CIREX need to make due to market shifts?

The extra problem is solved when the time is not limited. This extra problem comprises the calculation template. In this template, the costs for the customers of CIREX are calculated. In some cases, for general industry projects, they do not earn any profit for the work they did for a customer. Therefore, this calculation template must be changed to earn more profit.

Due to the market shifts, the cost/benefit analysis would change. CIREX needs to produce more low quantity batches. In this, the profit margin of low quantity needs to be adjusted, because they do not make a lot of profit at this moment from the general industry (GI). If they decide to accept more projects in the GI, the profit they make needs to be higher than they are currently making. I look at this problem if there is enough time left.

The operations involve most of the company, which results in the assumption of gaining more profit than the next point, the calculation template. That is why improving the operations have a priority before the calculation template.

Finally, the research questions are drawn up, based on the MPSM phases. These phases are explained in Section 1.3. After the question, I provide the chapter or section where the answer can be found. The plan of action for the questions in Phase 4 can be found in Appendix 3.

MPSM Phase 3 'Problem analysis':

- What is the current situation at CIREX? (2)
    - What information is needed per department to define a start level? (1.4)
    - Which categories in projects does CIREX have? (2.1.1)
    - What is the difference between automotive projects and general industry projects? (2.1.2)
    - What are the bottlenecks per department? (2.2 to 2.4)

MPSM Phase 4 'Generating and evaluation alternative solutions':

- Which theories in the literature can be used to make organisational changes? (SLR)
- Which theories in the literature are there to solve the bottlenecks found in the current situation? (SLR)

MPSM Phase 6 'Implementation':

- What changes does CIREX need to make? (3)
    - How can the solutions in literature help CIREX? (3)
    - How can the solutions be implemented in the departments? (3 to 4)

MPSM Phase 7 'Evaluation':

- What conclusions can be drawn? (5.1)
- What discussions occurred during my research? (5.2)
- What other recommendations can be given for CIREX? (5.3)

1.2 Company information

CIREX has experience with lost-wax casting, also called investment casting, since 1947. Since the beginning of 2019, CIREX belongs to Signicast. Nowadays, CIREX is one of the largest steel-casting companies in Europe that produces complex castings with extreme precision using the "lost-wax" method. Investment casting comes down to 4 steps. First, the product is designed and then injection moulded into a wax tree. The next step is that the wax tree is layered with a ceramic suspension. After this, the ceramic tree is baked at high temperatures to get the wax out. The last step includes casting the metal into the ceramic tree and cut and finish the products out of the trees. In Section 2.2.2, I give examples of the wax trees, which are finally processed to the finished products.

Next to the production steps, I made an overview of the relevant process steps that are important for this research. The overview is displayed in Figure 2.

The process starts when an order comes in. This can either be that the customer found CIREX, or CIREX found the customer. The order is reviewed by the sales department. They check, for example, whether the product suits for the production steps at CIREX. If the product can be made and everything is checked, kick-off is scheduled. In this kick-off, a selective group of people from each section is present to discuss the product and the customer. Then, the engineers make the product ready for production. Production & logistics finalise these steps and the product is planned in for production. Then, the production starts with wax injection moulding. Then, the other 3 steps mentioned above are finished and the product is shipped either to the customer or the plant in the Czech Republic.

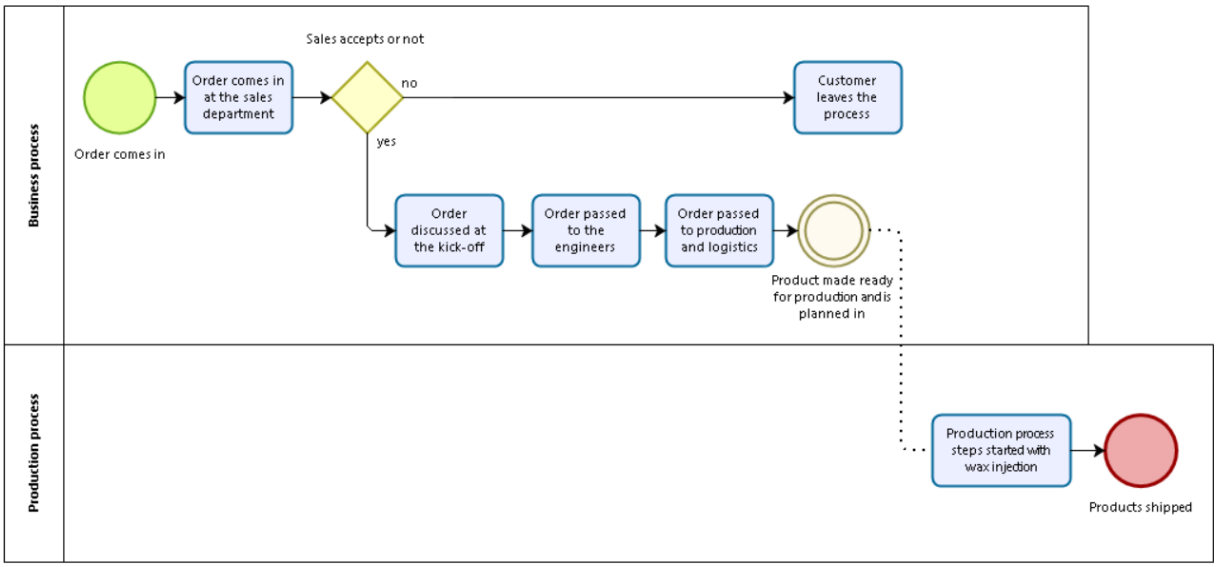

Figure 2. Relevant process steps.

CIREX (2019) stated regarding their investment casting method: "Thanks to this versatile method our engineers have considerable freedom in the product design and choice of materials. This means that in consultation with you we can produce optimum castings that meet your exact wishes and requirements."

What makes this method different than other casting methods is flexibility and quality. The production of complex shapes is easier than using another method. Next to that, the high quality guarantees high reliability of the casted products. In many industries, this reliability is needed to make sure bits of the product do not break so the safety can be guaranteed. Also, the unit costs decrease when producing larger batches. Once the injection mould has been created, wax patterns can be made quickly and in high quantities, as they require minimal time to cool and solidify (Reliance Foundry, 2020).

CIREX has three plants, one in the Netherlands, one in the Czech Republic and the last in Slovakia. The plants have different functions, either used as a foundry, or for finishing. CIREX's centre of knowledge and headquarter is located in Almelo. A team of specialised engineers are located here, along with product developers, metallurgical specialists, toolmakers, metalworkers, measurement technicians and X-ray technicians and other specialists.

Decreasing EBITDA

Due to the market shift mentioned in Section 1.1, the company will face some issues. Possible issues can be that engineers need more time to design more products. The set-up time of the machines for more products can add up to a total amount that some products cannot be produced anymore. In the department of sales, more customers need more attention, and so on.

If CIREX does not find a way to adapt to this market shift, they endure a yearly decrease in the EBITDA. The calculation of this value is for each corporation the same, which is why this value is so important. Companies can be compared with each other. This expression is used at CIREX to measure its operating performance. This is interesting for Signicast, the business that owns CIREX. The EBITDA is an easy way to see a company's performance without having to factor in financing decisions, accounting decisions or tax environments (Investing Answers, 2019).

Product characteristics

In this research, the different industries in which CIREX operates are discussed (3.1). Also in Section 3.1, the differences between those industries are exposed. For analysing the projects of both industries

(automotive and GI), the definitions of quantity and complexity are needed. At each company, the terms have different meanings. Therefore, those terms are briefly explained to which characteristics I think are appropriate.

Product description to calculate the quantity

The quantity means the number of products that are produced per project. These quantities are then divided into the number of trees. A tree is a pole with the products attached to it. These products are attached to branches. To make this more clear, I chose two figures to show this example. Figure 3 shows the trees with branches in the wax form at CIREX. Figure 4 shows the products attached to the tree. In the case of Figure 4, there is only one product attached to the branch. At the example of CIREX, there are two products on each branch. To this row of branches, the products can be attached on two sides. The number of rows can also differ. In the case of CIREX, the figure shows 5 columns of branches with products on both sides. On each branch, 4 products are attached. In the example of Figure 4, nine rows of branches are displayed. If this is also the case in Figure 3, the total number of products attached is 5 * 4 * 9 = 180 products.

Figure 3. Wax injection mould tree. (CIREX, 2019)

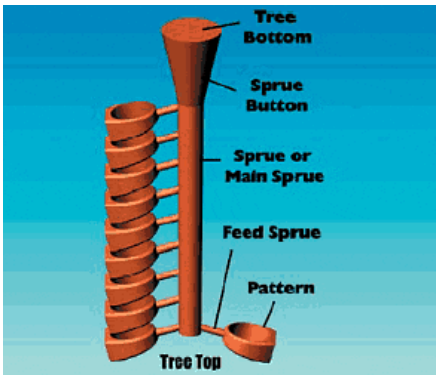

Figure 4. A tree with branches. (Eddie Bell, 2020)

The physical size of all of the products differ constantly at CIREX. That is because they have a huge variety of customers with specific products. When the products are smaller in size and thus also less in weight, more products can be attached to the tree. So because one product can be smaller than the other, the number of trees is more accurate when calculating.

Complexity

The complexity of a product consists of several steps that are taken to get a finished product. When a product is moulded, it needs steps to finish the product. CIREX (2019) states that the finishing steps may be milling or routing, or drilling and tapping threaded holes. The complexity is not only expressed in process steps but also the products can be very complex.

After the product is finished, it can be that it needs post-processing steps. This can be heat treatment, surface treatment, assembling and other techniques. All in all, each product is different and has a high variety of finishing steps that it can undergo. These steps contribute to the complexity of a product.

Organisational change

Due to the market shifts explained in Section 1.1, the organisation needs to change as well. This is because CIREX and I assume that a lot of changes result from the market shifts. Organisational change refers to the process of growth, decline and transformation within the organisation (I, 2019).

Due to the COVID-19 virus, the focus is on organisational changes within the company. There is no budget to buy more machines or hire more employees. Also, CIREX does not measure the hours of the workers and machines consequently. Therefore, solutions are found with the personnel and machines

that are there now. These solutions are in terms of efficiency and addressing the biggest changes due to market shifts.

1.3 Methodology

I like to have a structure that guides me through the steps I need to take for finishing this research. For defining a structural method, the MPSM approach is used as a basis to solve the problem statement. This method is invented by Heerkens & van Winden (2017).

Heerkens & van Winden (2017) state that each of the phases allows you to use different models, techniques and methods to your heart's content. That is why they say that this lends itself to methods used in project management, they have the same characteristics. Furthermore, every phase in the MPSM lends itself to the use of convenient tools and instruments from the various management theories. They conclude that this method is a general approach that allows enough room to use different, specific instruments as needed.

As quoted in the paragraph above, this method gives me a structure to hold on to while giving me the freedom to complete this thesis. This book, as well as the micro-lectures online, guide me through the process of solving the problems that occur at this company. To fully understand this method, each step is briefly explained, which is done in Table 2.

Step	**Activities**	**Result**
1. Defining the problem.	Drafting inventory of problems. Make a problem cluster. Select the core problem. Express the problem in variables.	The result is to identify the global problem. You get this by insight into the cluster of problems.
2. Formulating the problem-solving approach.	Draft a problem-solving approach. Use D3 (Do, Discover, Decide) to describe the activities and knowledge required, and choose from the various options available within your approach.	The outcome is a plan to solve the problem. This is done by outlining activities, established need for investigation and a plan of attack.
3. Analysing the problem.	Re-examine problem identification and problem cluster, and fill in missing details. Look for causes. Review why any earlier solutions have not worked. Use the research cycle to solve knowledge problems. Use a model to document relationships between problem and cause.	The definition and analysis of both problem and problem identification by reviewing logs detailing failures and researching relationships.
4. Formulating solutions.	Describe a solution. Establish a decision-making process. Draft list of criteria. Scale and weight criteria. Invent alternatives or use existing possibilities. Evaluate those alternatives.	A report on alternatives and their desirability with their corresponding criteria. Involve the stakeholders as well in this phase.
5. Choosing a solution.	Select one of the possible solutions.	The solution to the problem by reviewing the criteria and the opinion of stakeholders.
6. Implementing the solution.	Draft an implementation plan. Provide a brief and step-by-step description of activities.	A detailed plan for the company to change.

	A detailed approach to possible resistance.	
7. Evaluating the solution.	Convince participants of the need for evaluation. Evaluate all of the phases of the MPSM. Perform structured evaluation.	A comparison of the effected situation to the desired situation.

Table 2. Phases of the MPSM (Heerkens & van Winden, 2017).

1.4 Action plan

In this plan of action, the research questions are elaborated. Next to this, the research cycle is discussed and the research design is displayed.

Research questions

To solve the main research question, theoretical perspectives are chosen. In this matter, I mostly look at the financial perspective of the problem. In this case, it is all about making a profit. Besides, there are some organisational matters in terms of employees and machinery as well. These two theoretical perspectives are discussed where the finance is affected by the organisational changes. In the short term, this change may not be beneficial but compared to the long term the company has to change to maintain profitably.

To define the research questions and to make sure everything is included, I use several methods. I make use of the pyramid perspective (H. Heerkens, 2019). In this method, the previous question is needed to answer the next one. I choose this perspective because the questions need to be answered in sequence in my bachelor thesis as well. To begin with, for analysing the changes per department, I need to know what project changes are there. If I know that question, I can gather data for each division to solve their specific issues. In the MPSM, this pyramid perspective also comes back. Phases 3 and 4 are eventually needed to solve the questions of Phase 6.

Next to that, in this organisational matter, I use the Phase Approach. The unfreeze-change-freeze approach can be used in this case. This approach involves having a look at the issues at the company. Then, make changes to improve this and freeze it into a new situation. So both perspectives can be used in my case and I use them both. Heerkens (2015) made these methods.

With these perspectives and the research cycle described in Section 1.6, the research questions are drawn up. The pyramid perspective and the unfreeze-change-freeze approach help me when looking at the structure of the thesis. I need to define the current situation with the market shifts in mind. Then, the bottlenecks when accepting more projects needs to be defined. For solutions, a literature study is done and finally translated to the needs of the business. The current situation is unfrozen, adjusted with the literature solutions and then frozen into the new situation.

Research cycle

In this section, the general research cycle is stated. This research cycle helps when answering the research questions. The research cycle exists of seven steps, each with its characteristics. Per step, a general description is stated. The steps are in the right order of performing.

Step	**General description**
Research aim	The reason why I want to do solve the problem; this contributes to the action problem.
Problem statement	Knowledge problems are stated.
Research questions	I can split the knowledge problem into a research question if it is too broad.
Research design	How am I going to find out the answer to this problem? This can be a survey, observations, a literature study, some interviews and an analysis.
Operationalisation	State the variables/indicators of the knowledge problem/research questions.

Measuring	Start my research (design).
Analysing	Systemise, summarise, quote answers, make frequency distributions/tables.
Conclusions	The answer to my knowledge problem/research questions, a cost/benefit of my opinion.

Table 3. Steps of the research cycle (Heerkens & van Winden, 2017).

At every MPSM step except for the Solution Choice (Step 5), a research question can be generated. First, the step number is shown, then the question(s) to pay attention to. These questions helped me setting up the research questions. The research cycle is taken into account with each research question answered. Therefore, per the research question, the steps have been checked to make sure all of the points are there.

Step	**Questions to pay attention to**
1.	What problems occur? How bad is it?
2.	Which solution planning methods are there? Which people are the stakeholders?
3.	Why are the problems occurring? Which problems need to be solved, which have priority?
4.	Solutions for the problems tried elsewhere? In the literature?
6.	Possible implementation in a company, do people agree with it?
7.	How did the solution work?

Table 4. Set-up for research questions.

Research design

For each knowledge question, its research design is required. In the research design, a plan of action of gathering information is stated. Methods of gathering information can be an interview, an analysis, a survey and so on.

Most of the data gathering is done by interviewing. This is, in my opinion, the most effective way of data gathering because all of the employees together form the company. The workers possess all knowledge of the corporation, they know the ins and outs of CIREX. Since this research covers the whole corporation, each department is discussed. These divisions form the majority of the business. Some divisions are smaller, such as IT, administration and project engineering. These are the sections that are either too small to discuss or are not affected by this topic. The sections that are discussed are sales, engineering and production & logistics. In these departments, I either analyse the employees or the processes. The workers are analysed through interviewing. I state, with the help of interviews, which activities are affected the most. Because each staff member has different skills, the method of data gathering needs to be flexible.

Since this research is about the shift of the market focus of CIREX from automotive to general industry, only the people who are affected by this change are interviewed. These people are of the sections sales, engineering and production & logistics. When analysing each department, I start by interviewing the head of the division. They know most of the section and can tell me which employees are highly affected by the change. These interviews are taken into account when starting to identify the bottlenecks.

To get all information right, I interview the employees of the various departments. Various sections are chosen because the problem affects the whole company. The functions of the workers do not matter, I interview the personnel if I think his/her job is affected by my research topic. I think this is the right thing to do because a sales worker and the sales manager may have different views on the topics addressed. I discuss various topics with them, for example, which tasks they do and how many

hours these take. These questions come up when defining the current situation for each division. This makes the research complicated because each department has a unique environment.

I ask the interviewees questions at their desks. These interviews are deep, these are about why they make certain decisions. Also, aspects such as how many hours they are busy with a project, are reviewed. I interview all of the people that are directly involved in the issue with a maximum of 3 per department. Furthermore, a literature study is there to seek solutions to my main problem and the problems per division. I use a primary source as well, the calculation template. I use the literature study to search for solutions to the bottleneck of each division.

The methods of data processing and analyses are both quantitative and qualitative. For quantitative methods, I make use of analyses, graphs and tables to display data gained clearly. I also seek connections between certain topics, for example, the relationship between projects and profit.
For qualitative methods, interviews are held and written down. Next to that, explanations of the analyses, graphs, and tables are there. Furthermore, the research includes several documents, such as an analysis of the big differences between the markets in the automotive and the general industry and the effect on the departments of these differences. The research design is elaborated per research question is shown in Appendix 2.

I try to stick to the research design. However, when I visit each division, the plan can change because more knowledge is gathered when I am actually there. I am going to each section and I could get blown away with tons of information. I try to filter this information so the bottleneck can be identified after all. At the end of this research, knowledge about the whole company is gathered.

So, to check possible changes for the business due to the market shifts in advance, I made an overview of all of the big departments. I did this to define a start level. This also tackles the problem of overflowing with information, a direction can already be shaped. When interviewing, I used Table 5 to enlighten the interviewee about my thoughts. In this way, I have more control about the interview and the interviewee is better informed about my research.

Department	**Changes**	**Review**	**Solution**
Sales	More projects, more contact with the customers.	Analyse the employee portfolio and see which workers are affected.	See whether the employees can handle more products.
Engineering	More projects, more designing.	Analyse the workers' portfolio and see which employees are affected.	See whether the personnel can handle more products.
Production	More projects, changeover time in the wax department.	Analyse the wax injection machine, gather information about changeover time.	See whether the machines can handle more changeovers.
Logistics	More projects, more products so lead time can be higher, inventory costs, more outsourcing.	The whole process of affecting lead time, inventory and outsourcing.	Check whether there are problems with lead time, inventory and outsourcing when producing more products.

Table 5. Review of each department.

2. Current situation

To start with the plan of action, I review the current situation of the company. In this chapter, I describe the projects and the various departments. The divisions I review are sales, engineering and production & logistics. These are the biggest sections and therefore the majority of the corporation is analysed. For the projects, I compare the automotive market with the general industry to see how different they are in terms of profit. For the sales and engineering department, I review the employees to check whether their job is influenced by the change. For the production & logistics division, the flow of the processes is important. For each department, I identify the bottlenecks and I solve these appropriately according to the methods in online articles and books. These methods are based on lean principles. At the end of this chapter, the summary is placed to better follow the storyline.

2.1 Analysis projects

In the analysis of the projects, I discuss the different markets with their main differences. The automotive is analysed per category to see its specific turnover. In this way, together with the perspective of CIREX, the categories can be analysed more accurately. The perspective of CIREX is that the trucks, vans and motorbikes are not affected by the electrical motor change.

Next to the turnover, the number of projects in the category 'cars' is analysed. This is the category that is hit the most by the market shifts. This is because the combustion engines are replaced by electrical battery systems in the future.

2.1.1 Different markets

CIREX focuses on the market of the automotive industry and the general industry. The automotive exists of the categories cars, vans, trucks, and some products in motorcycles. Typical products are parts for the combustion engine or the gearbox. The general industry differs from tools, hoisting & transportation, industrial components, aviation and pumping & fluid technology to medical, petrochemical, and food & pharmaceutical (CIREX, 2019).

The general industry can be narrowed down to two main categories. On the one hand the rough general industry side and on the other hand the soft medicine side. Altogether, CIREX offers a wide range of products that differ in complexity. Also, the quantity for each customer differs. This variety in quantity and complexity of the products make the processes of CIREX complicated. For each product, different designs of the products, settings of the machines et cetera need to be adjusted.

In general, the automotive demands higher quantity production than the general industry. It also involves bigger products, in terms of volume.

2.1.2 Difference automotive and general industry

The difference between the automotive market and the general industry is the basis for the research. The outcome of this section is used for input in the analyses of the departments. The automotive and the general industry differ in added value. The added values are calculated in an Excel file that CIREX provided. In this file, the turnover and costs were given for the years 2018 and 2019. The added value was therefore easily calculated.

I filtered the projects and the ratio of the added value of the automotive divided by the general industry is calculated. The filter excluded one company that brings in a big project. This business is placed in the general industry but it delivers a profit that is equal to an automotive project. These kinds of projects are rare and therefore not valid to take into account because it is an outlier.

In 2018, the ratio of the number of projects in the automotive divided by the number of general industry projects was 33. In 2019, this ratio was 11. For calculating the average, the sum of these two

digits is divided by 2. This comes down to (33 + 11) / 2 = 22 general industry projects are equal to one automotive project. This means that CIREX has a lot more projects to accept if they want to maintain their EBITDA.

The turnover of the whole automotive is analysed to see whether trucks, cars and vans are influenced by this market shift. Trucks are at this moment not affected by the shift from combustion to electrical. This is because an electrical motor cannot bring up the power to make the truck move. For now, this is the case, but Tesla is already working on trucks that are electrically powered. However, for now, this category is removed from the analysis. The second graph shows the turnover of cars and vans. Vans can also be electrical powered so this is taken into account.

The graphs in Figure 5 and Figure 6 have the same boundaries. In this way, the graphs can be easily compared. Also, the decline from the year 2018 is clearly shown. On the y-axis, the turnover is not shown due to confidentiality. Next to that, the turnover numbers do not contribute any value to the core of the analysis.

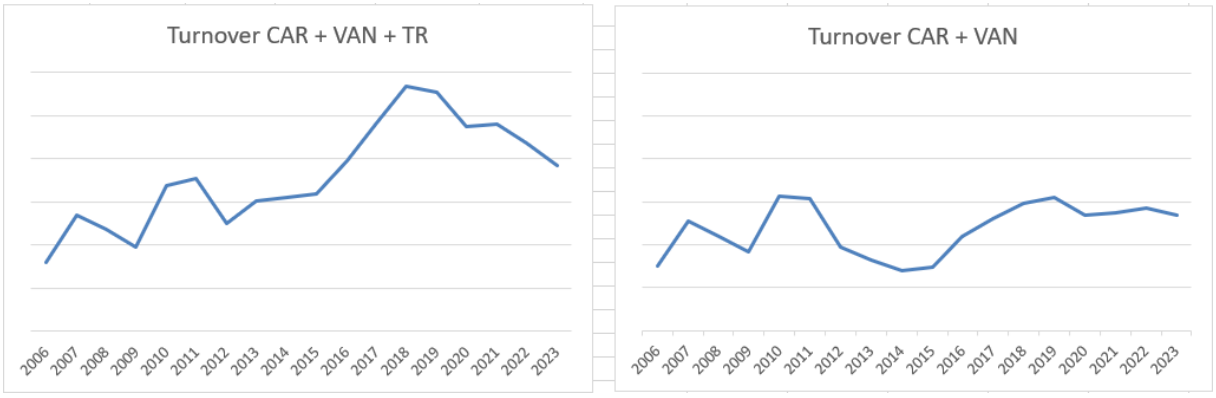

Figure 5. Turnover graphs for different categories in the automotive per year from 2006 to 2023.

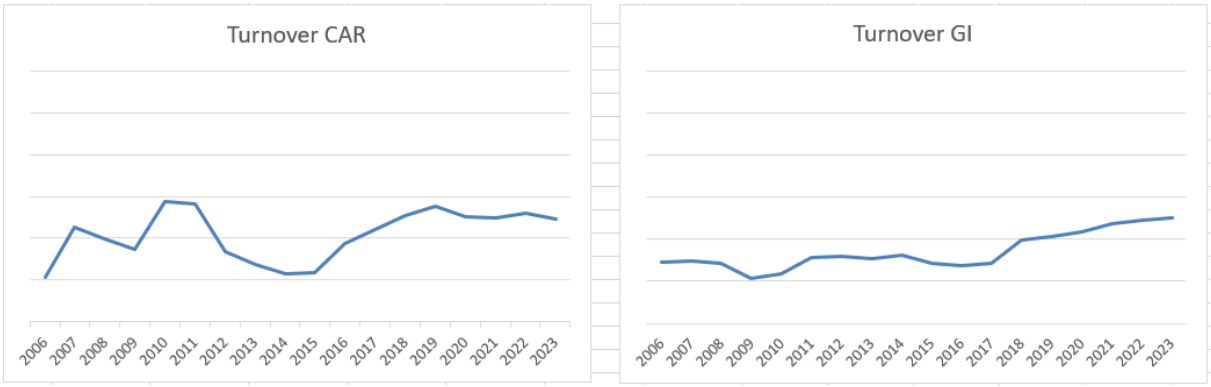

Figure 6. Turnover of the category car and GI per year from 2006 to 2023.

When we compare the graphs of cars and vans with only cars, there is no difference. Vans are not highly contributing to the turnover. This means that the turnover graphs between cars and vans can be seen as identical. Therefore, the trend of the category of cars is used and the vans are set aside.

In Figure 6, we see that the decline in the automotive is partly replaced by the turnover of the GI in the upcoming years. This graph of the GI is growing and must grow, to keep the EBITDA steady.

The turnover could be used to analyse the future situation. However, the fluctuation in the future of this turnover is not that high to see this change. Therefore, the number of projects is also calculated

to check if there is a different pattern. In Figure 7, a graph of the number of projects in the category car is shown.

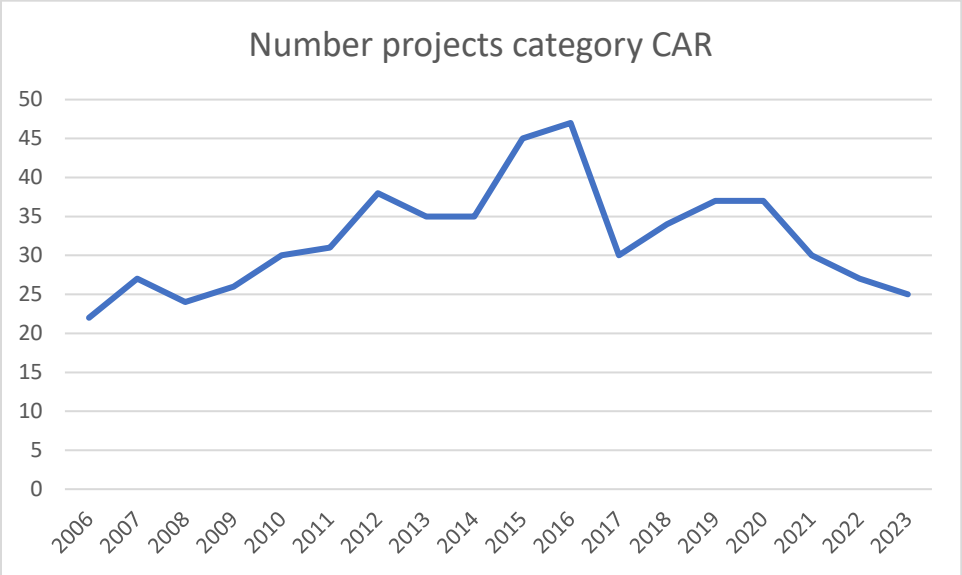

Figure 7. Graph of the number of projects in the automotive industry categorised in car parts only per year from 2006 to 2023.

Contrary to the turnover, the number of projects show a different pattern. The number of projects in the car category has risen steadily from 2006 until 2016. As of that year, the number of projects has been dropping almost every year. The decline of the automotive market needs to be replaced by the general industry. This is to keep up the turnover of the company and to realise the yearly growth of the EBITDA.

The exact numbers of projects per year can be found in Table 6. These numbers are the 'worst-case scenario' because the numbers of projects in Figure 7 are already accepted. An explanation of the worst-case scenario is stated in Section 3.5.

The numbers of projects of the upcoming years are compared with the number of projects this year, 2020. Then, the car projects that are not there, are replaced by general industry projects to keep the EBITDA steady. A question that can pop up is whether CIREX can get those clients into their portfolio. This is a topic for further research, discussed in Section 6.3.

In the end, the numbers of projects in the automotive are subtracted from the replaced projects and the total number is calculated. These projects are joining in the portfolio, next to the projects that are already there. This means that there is more work to do for some departments. The exact numbers of this replacement are stated in Table 6.

Year	**Number of projects**	**Project less**	**Projects replaced (project less * 22)**	**Total more projects compared to 2020**
2020	37	0	0	0
2021	30	7	154	147
2022	27	10	220	210
2023	25	12	264	252

Table 6. A forecast of the number of projects where some automotive projects are replaced by GI projects without big projects.

If the big projects of the general industry (GI) are counted in, the ratio would be 11 instead of 22. So this is the whole product portfolio that CIREX had in 2018 and 2019. This replacement is stated in Table 7. The second comparison besides the whole portfolio of GI projects is only big projects. This comparison is placed in Table 8. The ratio for these big projects compared with the automotive was 3.65.

Table 7 shows the number of projects replaced with the big projects counted in. This is done to show the contrast between only the low quantity projects and all of the projects in the general industry.

Year	**Number of projects**	**Project less**	**Projects replaced (project less * 11)**	**Total more projects compared to 2020**
2020	37	0	0	0
2021	30	7	77	70
2022	27	10	110	100
2023	25	12	132	120

Table 7. A forecast of the number of projects where some automotive projects are replaced by all of the GI projects.

The comparison made in Table 8 is there to see what influence each project has. This is done to check the contrast between the low quantity projects and the high quantity projects of the general industry. The difference between the small projects in Table 6 and the big projects in Table 8 is immense.

Year	**Number of projects**	**Project less**	**Projects replaced (project less * 3.65)**	**Total more projects compared to 2020**
2020	37	0	0	0
2021	30	7	26	19
2022	27	10	37	27
2023	25	12	44	32

Table 8. A forecast of the number of projects where some automotive projects are replaced by only the big GI projects.

2.2 Analysis of the sales department

So now with the analysis of the projects in mind, the divisions can be analysed. The first step in the product cycle of CIREX is that the project is brought in. This is done by the section of sales where the orders are processed and reviewed. If the number of projects increases, the division has more work to do. First, each person in the department is reviewed. Their functions are analysed to check if their job is affected by the number of projects. In Table 9, their names and corresponding functions are stated. Their names are abbreviated because of confidentiality.

Name	**Function**
H	Sales director, also processing customers from South-Europe.
B	Co-marketing and brand awareness of the company's website.
R	Account manager for high quantity projects, most in the GI (part-time).
O	Account manager, also the expert of technical aspects of the projects.
J	Account manager, for low quantity projects.
F	Account manager, for German automotive projects but also some general industry (GI) projects.
W	Account manager, for North-Europe automotive, more and more for GI.
M	Processing orders (part-time).
G	Processing orders from Germany.
A	Processing orders (part-time, leave of absence when I conducted interviews).

Table 9. Employees with their function of the sales department.

The functions that are mostly affected by the number of projects, in this case, are the employees that process orders and the employee that concerns the low quantity projects. Therefore, interviews with J, M and G are necessary. The other jobs are not highly affected by this change because most of them are active in the automotive market. They even get less work to do if they are only responsible for their specific market.

The jobs of M and G include processing orders, staying in contact with the customer, recording complaints, processing invoices and regulating the cancelled invoices. Also, mail and phone calls are handled by them. With the market shifts, more customers of the general industry need to come in. With this rise in the number of customers, the amount of work is higher for them. This is the case for each activity they do.

Processing orders are affected by the change because M and G need to process more orders of customers into the SAP system. More customers mean more contacts with customers, more complaints and more invoices.

To process an order, 5 minutes are taken into account, in general. G and M have to fill in and check the customer, article, price, conditions of delivery and payment terms. They also check whether they had trouble with the payment.

To process a new customer, 10 minutes are needed. The new customers are not familiar with the company. Therefore, they ask often whether the product is delivered on time with the guaranteed quality. CIREX plans a kick-off as well if the order is ready to produce. In this meeting, the new customers are discussed and the product as well. Altogether, these employees are busier when the business shifts to the new market.

Next to this, the account manager of low quantity production has a lot more work to do in the future. He is hired at the end of 2019 because CIREX already had the feeling that the demand for general industry projects was rising.

The job that J has, involves bringing in new customers and maintaining relationships with existing customers. This is typical for each account manager but he does this mainly for the small series production.

The process of bringing in new customers can take half a year up to a year. Some customers come back with a detailed report and the confirmation to produce and sometimes there are discussions about certain topics, such as the quality of the product. So the time that is spent on each customer differs a lot, from one phone call per month to a visit per week. And of course, a visit takes more time than a phone call.

Maintaining a relationship with a customer does not involve a lot of time. A few customers are sending in orders without contacting CIREX and some customers need more attention, for example, three calls a day. These customers that call a lot are dependent on the batch they get. They are small companies that cannot proceed further without the batch that CIREX produces for them. That is why they call a lot and ask whether they get their products on time.

At this moment in time, J has brought in 0 projects due to the COVID-19 virus and because he has been working here just a few months. The number of projects open and already brought in is 18. The majority of the customers do not need special attention and can be monitored in a reasonable timeframe.

Then, I have spoken with the managing director of the department. He says that all of the employees take over more and more projects outside the automotive industry. There is not a clear distribution of the small series of customers. It seems that J's function is taken over by the other account managers. J needs to be responsible for those projects but he is not assigned to all of them, although he has plenty of time.

2.3 Analysis of the engineering department

After the project is brought in by sales, the engineers are busy making the design, the mould and other specifications. The engineering department has the same structure as the sales division. The employees are responsible for all of the work delivered in the section. There are no machines available that take over the tasks of the engineers. Therefore, each employee is stated with their function. Again, due to confidentiality, the names are abbreviated.

Name	**Function**
A1	Technical director
F	MPE, the mechanical part
P	MPE, the material part
M1	MPE, the ceramic part
M2	AE/PD
R1	AE/PD
J	AE/PD
H	AE/PD
W	AE/PD
B1	Moulds engineer
R2	Measure engineer
M3	Quality manager
B2	Quality control
S	Quality control
N	Project engineering, mechanical
A2	Project engineering, electric

Table 10. Employees with their functions in the engineering department.

In the engineering department, all characteristics of the products are processed. The order is sent forward from Sales to Engineering and is reviewed by the application engineers (AE). The AEs first review the product before making a quote and designing the product. They receive a 2D or 3D drawing of the product and they adjust it to the production facilities at CIREX. When more projects arrive, the AEs are mostly affected by this change. They have to make a quotation for each incoming request. Besides, a design for the product must be made as well if this request is accepted by the customer.

Documentation is put down in the SAP system. This system has been recently bought to digitise all information in the same way in all of the plants. Information of all of the plants is provided in Section 1.1. If the project is approved by the customer, the production is started. In monitoring the production, all other jobs are involved. These jobs are not highly affected by the change when processing more projects as the application engineers are. They are measuring the quality and the production process. These tasks are not highly affected by the change. Therefore, these jobs are not discussed in my research.

Five application engineers review the projects. The projects are arbitrarily divided among the AEs. This is done by the technical manager. Of course, the amount of work between these engineers is proportionally divided. Next to this, the previous projects done by the Engineers are taken into account as well, when distributing the projects among the engineers. If the engineer has experience with a certain type of product or company, the product is given to that engineer.

When the project is a possible candidate, the application engineer takes several steps. Most of the time, a ‘B-quote’ is made where details are stated about the processes that this product contains. An ‘A-quote’ is more detailed and the ‘C-quote’ is the less detailed. CIREX also has a D quotation which is

called a development assignment. The sales department delivers the offer with a recommendation of one of the three types of quotations. A ‘D-quote’ is not used often.

When the product has been finally approved by the customer, it is produced. This involves a part of project planning by the engineers as well. Also, the products are monitored and reviewed by the customer to make any changes if they want to. Therefore, application engineers are also called Product Developers. If the product is not right it needs to be adjusted. The PDs are busy with developing the product to the next stage, also called product improvement.

To get more details about the job, I interviewed the engineer that takes most of the low quantity projects, M2. At this moment, M2 is busy with 20 projects. Yearly, about 10 projects are delivered. This number of difference between 20 now and 10 in a year is because most of the big projects of series production run between the 10 and 15 years. Most of the small projects are from the general industry, and the big projects indicated as the automotive branch. Of course, there are exceptions, as usually is the case in high product differentiation.

Before production, a series is produced before the actual batch. This is done to test the material and make sure that the specifications are good.

To review the engineering department, interviews are finished to gather information. I sat down with three of the five application engineers. They immediately said that a lot of time is spent on requests that come in. Most of these requests do not meet the customer’s desires so they are not produced. At first, the projects look interesting for the engineers so they proceed and follow the steps described earlier. Most of the time, CIREX is too expensive and the customers can produce their products cheaper somewhere else. This is because the lost-wax method is a relatively expensive way to produce metal. The quality of the product is the most reliable that is available on the steel production market. This way of producing attracts certain markets that are interested in CIREX. Next to this, a lot of companies that are not familiar with this method are asking whether they could produce their products at CIREX. These customers are time-consuming and are not beneficial to the result. Therefore, these customers can be seen as a waste of time. This waste of time is useless and must be reduced.

The department that accepts projects in the first place is sales. Most of the time, the details are sent by either mail or e-mail, which is checked by two employees. They filter out the projects that CIREX cannot make. Then, the project is sent forward to the worker that is responsible for that industry. In Table 10, the information about which employee is responsible for what can be found. After that, they analyse the customer with only two criteria. The first criterium is that the customer can deliver at least 25,000 euros in a year. The second one is that if this is not reachable, the customer could offer a strategic benefit. This involves potential growth within a few years because the company is big or has more products that might be produced at CIREX.

The strike rate that the corporation has is very low because most requests are accepted. The strike rate is the number of requests that are accepted divided by the total number of requests coming in. When these requests are accepted, a quotation must be made by the application engineers. When CIREX accepts more general industry projects, this number rises even faster. Therefore, the potential projects must be separated from the projects that are not beneficial.

If the requests are reviewed effectively, the other engineers would not have more work to do. The earlier the waste is eliminated, the less work the business has throughout the whole process.

2.4 Analysis of the production & logistics department

The last steps are the divisions of production & logistics. Since CIREX does not have a clear distribution between production & logistics, the two sections are analysed together. This is because they have a lot in common. For example, the flow of the production processes is a topic that is covered by both. Besides the production processes, CIREX has a shipping department. This department is the only pure logistic division that CIREX has. That is why I included this section in this research, it could be that this department is affected by market shifts as well.

The production & logistics department comprises a lot of activities. Together with the operations manager, we decided to take two aspects under investigation. First, the wax section is chosen as it is affected most. At the wax division, the set-up times are relatively large. If there are even more project changes, the wax department cannot handle these changes in the future. If CIREX wants to shift to the low order quantities, the set-up times must be reduced.

The second aspect is the overall process. There is not a specific production step that is affected by the change as the operations manager knows. Therefore, the aim is to bring down the total throughput time. This is the most general solution to provide when looking at the streamlined flow.

The steps between when the order comes in and when the product is on the wax press are reviewed. The steps of the processes are different for each product after the projects have been scheduled into the wax injection machines. If the whole process is reviewed, the research would be too broad. The production steps take up too much time to review. Therefore, the steps before and after production are reviewed. I begin with the steps before production. The process steps do differ in three ways. The three steps differ in the kind of project. These are that the project can be a new product, it can be a prototype production or a series production.

New project production

A new project is called when a new product comes in. The way of handling a new product does not differ for customers that are already known at CIREX. A new product is a new project and all dealt with in the same way. First, a mould number is registered in the SAP system when a deal is made by the account manager. Then, a kick-off is planned with many employees to discuss the customer and the product. Also, the lead time, mould arrival and many other steps are planned in this meeting. Then, the project is put in the SAP system. The engineers prepare the product for production. This includes designing the product, the mould and simulating the production processes and many steps after this.

The logistics manager gets a notification when the engineers are done and he sends the message forward to the logistics manager. The latter schedules the products for a prototype batch. This is done for the customer so they can test the products. If the customer is satisfied, the process for series production is enabled. The wax manager schedules the new projects into the wax department. Then, every week on Wednesday, the managers together with the administrator discuss the planning and make the schedule definitive. The managers are the operations manager, production manager, wax manager and the logistics manager. The administrator processes the information about the logistics and notes all of the changes.

Series production

After a new project has started and the customer is satisfied with the first batch, the series production is started. This series production is the production that runs for 5 to 20 years. The companies come in with well-planned contracts and they send their request for the number of products. This means that the only step CIREX has to do is to schedule the products. Also, the contract of the products is checked whether CIREX is on schedule. Besides, the administration checks whether the customer pays all of the

bills. The checking of the contracts does not take up a lot of time. Therefore, this process is not taken into account.

3D-printing prototype project
The customers are also coming in only for prototype production. This prototype production is handled as quickly as possible. An account manager and an engineer come together and discuss the potential of the project. Then, the project is designed for the 3D-printer. In the end, the design is printed and is put on a tree. Then, the tree follows the normal procedure of ceramic and finally casting. 3D-printing does not contribute highly to the profit of CIREX. They are also not specialised in this business. Therefore, this type of production is not taken into account. The method is built on fast throughput so this would be a waste of time if I did map this process.

Shipping department
After the products have been produced, they are ready to be shipped. This is the job that the shipping division is accountable for. In this section, possible issues can arise when operating more low quantity projects. It can be that it takes more time to organise the products in the right way, as well as finding a better to package the products for transport. However, CIREX tackles this already in a good way, they cluster a lot of different products. Also, the products that are being outsourced are well divided and clustered for each transport. The Shipping Manager says that it does not matter whether they ship one project or twenty projects. The projects are clustered in such a way that they can handle with operating more projects. So, this future problem that can arise in the shipping department is already tackled.

Next to this, an application engineer discusses with a sales employee about the packaging format. Finally, the AE decides what kind of packaging the products get. So this way of designing the package is already customised. So there would not be any adjustments for the shipping department when distributing more low quantity projects.

2.5 Validity

When calculating the number of projects (3.1), the worst-case scenario is applied. This means that if no automotive projects are accepted anymore, the numbers of Table 6 are valid.

The number of projects from 2021 to 2023 will probably be higher because there will be more customers that are interested in products that CIREX can make. This forecast can change per year because a more accurate view can be stated. Next to this, automotive projects are not all big projects. Some of them can also be compared to a general industry project. Therefore, the biggest outliers are erased from calculating the average. The 'typical' automotive and general industry projects are used to calculate the ratio of the automotive divided by the general industry. This ratio comes down to 20. There is one outlier removed from the year 2019 of the automotive industry. In the general industry, the big projects of a certain company are not included in the process, because such a project appears once in a decade.

Next to this, if we compare the turnover with the number of projects in the category of cars, the outcome is controversial. In 2016, the number of projects in the car branch was at his highest. However, when this year is compared with the turnover, it is at its lowest point. This comes down to a lower amount of profit per project. So in 2016, many small projects had been accepted compared to other years. In 2019-2020, these small projects have diminished because the number of projects was lower, but the profit rose immensely. Therefore, there are relatively big projects in the portfolio of CIREX. This contributes to the validity of the numbers shown in Table 6.

Altogether, with these uncertainties, the numbers in Table 6 are interpreted as an indication and not as a factual calculation. Therefore, Table 7 is used as a better indication of the company because every project is included. Table 8 is there to see the contradiction to the low quantity projects in Table 6. All these tables are used as an indication for the future. It shows how important the different types of projects are.

2.6 Summary

In this conclusion, the summaries of the projects and departments are stated. I did this to make the structure of my research clearer. The departments will experience more work due to a different focus on the markets facilitated by CIREX.

Projects

CIREX caters various markets at the same time, the automotive and the general industry. The difference between these markets is the amount of quantity production. In the automotive, in general, a high quantity of products is demanded. For the general industry (GI), this is characterised with low quantity production. Therefore, the profit (added value) of a project in the GI is lower than an automotive project. This comes down to 22 projects in the GI are equal to 1 automotive project. We also see that, from now on, the turnover of automotive declines. This has partly to do with the fact that the graphs are a forecast. With the analysis in turnover, nothing can be said about the number of projects. Therefore, the number of projects in the category 'cars' are calculated. From the year 2016, the number of projects in the 'cars' category declines, in general. With the comparison between projects of the different markets and this decline in projects, I made a forecast about how many projects of the GI needs to be there to get the same profit. If the GI projects are all low quantity projects, this comes down to a compensation of 147, 210 and 252 more GI projects in the upcoming years (2021-2023).

Sales department

The functions that are affected by the market shift of less automotive and more general industry projects are the employees that process orders and the account manager of low quantity production.

The latter will have more work because general industry projects are typically low quantity products. With the rise in general industry, he will experience more work. The employees that process orders pass through more customers because, for 1 automotive project, 22 general industry (GI) projects are needed to keep the same EBITDA. When taking Table 6 into account, 252 more projects are needed.

Both of them can handle more work than they have now. The account manager did not bring in any projects and the number of projects that he maintains is 18. This is not a high number, especially not when these projects are relatively small. Compared to other account managers of the automotive and considering the ratio of 1 automotive is equal to 22 GI, he is responsible for almost one automotive project.

When I interviewed the 2 workers that process orders, one employee was absent. The two employees that were present could handle more work. 2 out of these 3 workers work part-time. When more work comes and they cannot process it, they can work whole weeks to get the work done.

Engineering department

The function that is most affected by more general industry projects is the application engineer. He is the first person that receives the order after the sales department is finished. The application engineers make a quotation for the customer and estimate the costs of the processes. The application engineers experience wasted time when making these quotations. A lot of customers want to have a quotation but indicate, later on, that the deal will be cancelled. When more customers come in, this number of requests will grow.

Production & logistics department

The wax section and a part of all of the processes are reviewed. The wax division is the only department in production that has high changeover times. With more general industry projects, this time adds up to a high amount. Next to that, the start of the whole process until production is reviewed as well. This is done to see where CIREX's bottlenecks are. The two main production types are researched, the new project production and series production. The shipping department is not affected because they tackled the problem in advance.

3. Future situation

In this chapter, the current situation of Chapter 2 is taken into account to define the future situation. The bottlenecks are identified in the current situation and are in this chapter dealt with. That means that the impact of the market shifts is measured and described for the department of sales, engineering and production & logistics. The solutions to the bottlenecks found in the current situation are given with the help of the systematic literature review that is stated in Appendix 3. This review only includes a plan of action so it is not necessary to read that to understand this chapter. For each department, the current situations with their problems are stated with the appropriate solution to solve their specific issue. Again, a summary is placed at the end of the chapter to better follow the storyline.

3.1 Results for the sales department

In the department of Sales, 3 out of the 9 employees are affected by the change of more projects. When conducting the interviews, I together with these 3 sales employees noticed that they all could handle more work.

The account manager (J) says that he puts in more time on bringing in a customer than maintaining a relationship with a regular customer. This is because he does not serve a lot of customers at this moment. The number of projects can easily be larger and he would not have a problem when dealing with the increase in projects. Therefore, if the number of projects with low quantity increases, he can handle this change. Also, when the number of projects rises, he does not need to spend time searching for customers but can put his time into maintaining a good relationship. Besides, many sales colleagues can take over these projects as well because they could have less work. The fact that often other employees are taken over more projects outside the automotive is in my opinion, a good solution for the short term but in the long term, you need specialised staff that can handle the low quantity projects. Also, worker J can handle more work so he should be assigned to all of these low quantity projects outside the automotive industry.

The process step of booking in orders does not take a lot of time. Only setting up a new customer takes more time, which they can manage in time. They use the argument that they could work more days because two employees work part-time, or they can save time by easily classify the projects. Next to this, a colleague returned at the beginning of June that was absent.

Altogether, they can manage more projects so there is not any change in this department. In my point of view, the personnel is efficient and know how to deal with these changes. Hiring more employees does not benefit the company both in short term and long term. Nevertheless, if the corporation wants to make a change, I recommend retaining the employees they already have instead of recruiting. The benefits of this recommendation are found in Figure 8. Now, due to the COVID-19 virus, CIREX observes a lower demand. Therefore, they made drastic measures and fired J because the amount of work at this moment is too little.

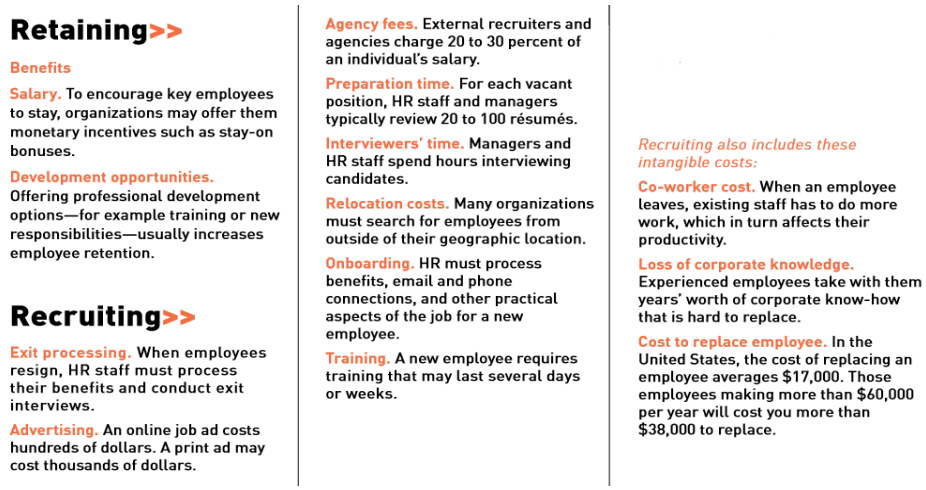

Figure 8. The benefits of retaining instead of recruiting (T + D, 2007).

3.2 Results for the engineering department

The problem in the engineering department is that a lot of requests of products do not get to the series production. The solution that can be provided, is to make a project portfolio scorecard. In this way of making a project portfolio, the beneficial projects are separated from the poor ones. In this project portfolio, a set of criteria is drawn up. The requests are rated and provided with a recommendation of the type of quotation to the engineers. They can add up their criteria and give a final score to the project. If this score does not reach a certain level, the project is rejected. Of course, the engineers and sales employees can take a risk when accepting the project. The list of criteria only indicates the potential of the projects. In this way, the projects can be evaluated easier and the project portfolio selection can be updated to prevent time waste.

Archer & Ghasemzadeh (1999) state that project portfolio selection and management of selected projects are essential for companies. They say that this is because activities, such as process new system development in production and information systems, and research & development for new product development carried out in a large number of industries, require project management approaches. Next to that, they say that project portfolio selection is to create a portfolio from the proposed projects to meet the objectives determined in a way to address all dimensions of the organisational strategy, considering the interactions between projects, resource needs of the projects, and shared resources among projects without exceeding the available resources and violating other constraints.

Most of the methods in literature are complex and industry-specific. A lot of these methods are built on schedule based problems. Examples are Song et al. (2019), Ma et al. (2020) Yu et al. (2012) and so on. The trade-offs are made by calculations on a computer, which is not possible at CIREX due to the diversity of the projects and the simplicity of the trade-off. At CIREX, the department of sales has to make the trade-off when accepting a project. This trade-off is now between a beneficial part and a strategic part. The beneficial part means that one project brings in 25,000 euros per year. The strategic side is that the customer has, for instance, more products that they can produce at CIREX. These are the only two criteria that they work with, far too less and vague, in my opinion. The benefit of this portfolio is that the sales employees can base their opinion not only on a guess but control the process of rating customers with the criteria in the portfolio.

The portfolio is drawn up together with the engineers because they have the most knowledge, in my opinion, about these projects. Afterwards, the portfolio is checked with the sales department. The

portfolio exists of two parts, one part that the sales department rates and one that the engineers rates. The sales factors are about the potential of the project. The engineering factors are about the profit side of the project. At CIREX, the profit weighs more than the fundamental potential of such a project. Therefore, engineering factors weigh more comparatively than sales factors.

To rate a customer, I made a formula. This formula for calculating the final score of a request is defined as follows. These formulas below refer to the project portfolio scorecard of Table 11.

$Z = 0.6\ X_1 + 0.4\ X_2$

$X_1 = S_1 + S_2 + S_3 + S_4$

$X_2 = E_1 + E_2$

Z is the overall score, calculated by the sales and engineering scores.

X_1 is the sales score, S_1, S_2, S_3 and S_4 are the criteria that the sales department can rate.

X_2 is the engineering score, E_1 and E_2 are the criteria that the engineering department can rate.

The sales score is there to advise the engineers about which type of quotation they need to make for the customer. This advice is based on a certain grade. This advice is as follows:

- Advice for the type of quotation:
    - $X_1 <= 5$ is not accepted or perhaps a D quotation.
    - $5 < X_1 <= 7$ will be a C-type quotation.
    - $7 < X_1 <= 9$ is the B quotation.
    - $X_1 > 9$ refers to the A-type quotation.
- An overall score where the minimum is Z = 6 to be interesting enough for CIREX.

Sales Scores	**1**	**1.5**	**2**	**2.5**
S_1 Growth potential	The customer comes in with one request but cannot offer CIREX a potential for more products.	The customer has now one part requested and can deliver a potential of 1-3 products for CIREX.	The customer comes in with one product and can deliver CIREX a potential of 4-7 products.	The customer comes in with one product and has a potential of 8+ product to produce at CIREX.
S_2 Known customer	The customer is new to the company.	The customer is known to the business although it has not ordered any projects, or the customer has a lot of requirements.	The customer is known to the company and ordered up to 3 projects and has almost none requirements.	The customer is known to the corporation and ordered above the 3 projects and has almost none requirements.
S_3 Duration project start series	The duration of the expected lifetime of parts lasts for less than 5 years.	The duration of the expected lifetime of parts lasts for more than 5 years but less than 10 years.	The duration of the expected lifetime of parts lasts for more than 10 years but less than 15 years.	The duration of the expected lifetime of parts lasts for more than 15 years.
S_4 Lost-wax method	The products cannot be made with the lost-wax method or are not beneficial to do it this way.	The products can be produced in this way, but it is doubtful.	The products can be produced with the lost-wax method and the customer is convinced it must be with this method.	The products can only be made or are most beneficial when produced by the lost-wax method.
Sales scores $X_1 = S_1 + S_2 + S_3 + S_4$				
Engineering Scores	**2**	**3**	**4**	**5**
E_1 Out-sourced	The ratio of outsourcing costs divided by casting & finishing costs is more than 1.	The ratio of outsourcing costs divided by casting & finishing costs is between 1 and 0.6.	The ratio of outsourcing costs divided by casting & finishing costs is between 0.6 and 0.1.	The ratio of outsourcing costs divided by casting & finishing costs is less than 0.1.
E_2 Gross margin	The yearly gross margin of this project is less than €3000.	The yearly gross margin of this project is between €3000 and €10000.	The yearly gross margin of this project is between €10000 and €30000.	The yearly gross margin of this project is more than €30000.
Engineering scores $X_2 = E_1 + E_2$				
Final score $Z = 0.6 * X_1 + 0.4 * X_2$				

Table 11. The project portfolio scorecard.

For defining the start level of the criteria list not only the input of the engineers is taken into account. I also analysed 20 projects where the calculation template was recently filled in. I started by looking at the number of products with the corresponding profit. Then, with the help of the interviews held with the engineers, the other criteria have been made up. The information of the interviews can be found in Section 2.3, the analysis of the engineering department. To give more details per criterium, I discuss why they are important for the selection.

Growth potential
The growth potential matters because if the customer has a lot of products that CIREX can make, they can come to CIREX to produce them. In this way, CIREX gets a client that comes in with more than one project, which contributes to the profit.

Known customer
If the customer is known, CIREX knows how to deal with that customer. The engineers know which tolerances the product must have and the sales can see whether they paid in time. CIREX can review how a customer acts. Also, if the customer brings in a lot of requirements, they are analysed poorly. This criterium is judged by the account manager with their experiences about the customer.

Duration project start series
Next to this, the duration of a project matters. There is a difference between the amount of money when the project is there for five years or twenty years. The profit from five years to twenty is 4 times as high. In the calculation template, the profit is calculated per year. That is why this is crucial for determining the type of quotation.

Lost-wax method
Many projects are rejected because CIREX is too expensive. With this criterium, many customers that in the end find CIREX too expensive are filtered out. Most products that are beneficial to be produced by this method are accepted. The engineers have more knowledge about lost-wax casting than sales and sales is now rating this score. This is done to include this criterium before advising of the type of quotation. If the engineers disagree with the score that sales gave, they can change it.

Outsourced
CIREX gets its profit out of the products that are produced insourced. That means that most of the finishing steps are outsourced. Also, more checking needs to be done when outsourcing. That is why this is such an important factor. The ratio in the scorecard is calculated by $\frac{Amount\ outsourced}{Amount\ casting+finishing}$. Outsourcing can be heat treatment, surface treatment, assembling and other techniques. Casting costs are the costs made by producing the products. These are making wax moulds, making the ceramic layer and melting steel in it. The finishing costs are steps after the product is made. These steps are drilling and cutting to crack the product of the tree. Also, blasting and sanding can be included in the finishing steps.

Gross margin
In the end, the profit matters. This is calculated in the calculation template by the number of products multiplied with the profit per product. This profit is based on yearly production. Finally, the profit advice is passed to the sales department and they provide the final ‘gross margin’. Therefore, the employees in the sales division can change the score if they want to.

We also see with the criterium that they now have, 25,000 euros of revenue to be accepted that the requests most of the time do not get to this amount. Therefore, each request must have a ‘strategic advantage’. This can also not be the case, so the protocol that sales pick its customers is not valid for most of the cases. That is why this scorecard is even more important.

3.3 Results for the production & logistics department

To provide solutions for reducing the set-up time, Slack et al. (2016) come in handy. They state that there are four main aspects of reducing changeover times.

- Measure and analyse changeover activities.
- Separate external and internal activities.
- Convert internal to external activities.
- Practise changeover routines.

The first three points were already mentioned by Kruijswijk (2019). He did this research about the production department roughly a year ago. Nevertheless, CIREX did not implement these recommendations. Therefore, I strongly recommend them to look into the advice that this student provided. If the points are implemented in the manufacturing area, the fourth bullet point comes naturally. In Appendix 4, the importance of these points regarding the low quantity batches is stated.

I analysed the whole flow of the process before the wax product is made in the wax injection machines. This is done to identify the bottleneck. For solving the bottleneck in this department, the lean methodology is used. This is an outstanding method to improve efficiency. Lean comprises a lot of different methods to identify bottlenecks and to address them appropriately.

Slack et al. (2016) state that synchronisation means that the flow of items (materials, information or customers) that constitute services and products always deliver exactly what customers want (perfect quality), in exact quantities (neither too much nor too little), exactly when needed (not too early or too late), and exactly where required (not to the wrong location). Furthermore, they say that lean synchronisation is to do all this at the lowest possible cost. Next to this, it results in items flowing rapidly and smoothly through processes, operations and supply networks.

A method of lean synchronisation used in this research is the value stream map. Slack et al. (2016) state that the value stream map is 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. So this is the ideal method to map a part of all of the process steps and see their added value.

The average hours of each step are stated and finally mapped into a value stream map. These value stream maps are stated in Appendix 1. In total, I made two stream maps, because they refer to two different processes. The two processes are now shortly described with added information than in Section 2.4 can be found.

Since CIREX has a complex structure, I made up a general process flow. This complexity comprises a variety of products and the products' needs. This flow is followed by each new project coming to the company. In this flow, the process starts with the order request. Then, a kick-off is planned with a handful of people and each department is represented. After that, the engineers make the design of the product. Finally, the project is scheduled by the logistics manager and then discussed with the managers and administrator. Finally, the first batch is arranged for the wax injection moulding. This batch can be the final series production or a prototype batch of 25 pieces, it does not matter for the flow.

Next to this type of production, I analysed the series production. This series production is the production that is produced each year with, more or less, the same number. This type of production comes after the new project production. The series is produced to the demand of the customer. The customer wants a total number of products, either each year or each month. This information is

provided to the wax manager and he schedules the wax department. Again, the managers together with the administrator discuss this schedule and the final schedule is drawn up.

The steps of the series production are also found in the new project production, these are the first and the last three steps. The first step is that an order comes in. The last three milestones are the date of scheduling the products, the scheduled date of production, and the date of the actual production on the wax injection machines. The difference between a new project and the series production is that the series production produces the actual product and the new project production can be seen as the prototype product.

Calculations

Now, the steps are known, so the way of calculating the values in the value stream map can be discussed. For calculating the time of each step, queries of data of the SAP system are fetched. In these queries, the dates of each step are displayed. The difference in net working days between each date is calculated. The negative differences are erased because these are not valid. The negative difference is only valid for the difference between the planned wax production and real wax production. This is because the real wax production can be scheduled a few weeks earlier than planned. This situation can occur because, for instance, the production has little work to do or the company wants the products as soon as possible. The other processes are built upon each other. You cannot begin with the next step if the current step is not processed yet. Therefore, there cannot be any negative numbers at the other steps.

Besides, I identified and erased the outliers of the queries. There were a lot of outliers due to not accurately processing of the data into the SAP system. This is because they just started to use the SAP system. The outliers are identified with the 1.5xIQR rule. This rule is commonly used to identify any outliers.

In the value stream itself, the hours busy with the work can differ hugely due to project complexity. This difference carries on in the number of people needed for kick-off and in the engineering department.

Since only the actual steps that happen are recorded in SAP, not all information is provided. The big steps are measured but not the small steps between the working hours. Also, the SAP system does not always provide reliable data. That is why, where necessary, data is calculated manually. This is done for the steps before the scheduling happens. In most cases, the data of the previous years is taken, where 2019 can be seen as the average production year. This is taken into account when I calculated the date differences.

Value stream map

The importance of a value stream map comes in when comparing the waiting times. The waiting time is the time between the processes where people are working. This waiting time is time that nothing is done so this can be seen as waste. The lean method dictates that waste must be reduced or eliminated (Slack et al., 2016).

The value stream map of the new project production is disclosed in Figure 9 and the series production in Figure 10. In most processing steps, more people work together to deliver a concept. This is stated underneath the process step. The process step is the step coloured in the orange, in the middle of the value stream map. Above the process step in the map, either the department or the people that are responsible for this step are stated. Below the process step, the amount of time of the process steps is mentioned. Then, at the bottom of the map, the abbreviations are listed with their meaning.

For the planning, the wax manager schedules the wax department. However, process managers have a weekly meeting. This half-hour cannot be divided into one project because at least 50 projects are discussed. That is why this amount of time is so low per project, which is the reason that this weekly meeting does not contribute to the total throughput time per project.

Planned wax is the step between the planning of the wax division and the actual production. In this step, nothing happens, only the interim step is shown to display the different waiting times. The step of the wax production itself is not taken into account, because this is not interesting for this research.

New project production
The first waiting time is the time between that the order comes in and the kick-off is finished. For the kick-off, a few things need to be prepared. This waiting time almost costs one week. In this week, the people prepare their work for the kick-off.

Between kick-off and engineering, no waiting time is there, because the engineers can start their work immediately after kick-off. Besides, the engineers are always busy with the product, their work is throughout the whole process. The next waiting time occurs because making the mould is outsourced and this takes a bit more than six weeks, on average. This waiting time is outsourced and therefore a fixed amount that cannot be changed.

Furthermore, the waiting time between the engineers and planning is slightly over one week, on average. The waiting can partly be explained by the weekly meeting. The logistics manager and the wax manager wait sometimes for the weekly meeting on Wednesday to schedule the products.

Finally, the waiting time for production is there because CIREX schedules the wax department equally per day. Therefore, products have to wait some time to be made. The time between the planned production and the actual production is partly there because of the weekly meeting. In this meeting, the final schedule is made.

All of these waiting times can be lowered a bit, to bring down the total throughput time a lot. I see that the last waiting times, the time that an order is scheduled until it is on the wax division, are the longest. The sum of these waiting times is equal to 6.9 days. The slightest change in the waiting times has an immense effect on the total throughput time. Often, the logistics manager and wax manager wait for the mould to come in. If this mould is brought in, the production can be started. If this total of 6.9 days can be brought down to 5 days, then, per project, 1.9 days are saved. The other waiting time, between order and kick-off, can also be lowered down. The value is now 4.26 days, that can be brought down to 3 days. These reductions result in a decline in the total throughput time of 28.32%. The total amount of hours saved is: 3.16 * 252 * 8 = 6,370.56 hours per year.

Series production
For the series production, there are three waiting times. The first waiting time is the time between an order comes in and the project is planned for the wax department. The second waiting time is the time between the moment the project is scheduled and the planned date of wax production. The last waiting time is between the planned date of production and the actual date of production.

The time between order and scheduling is one week of work. The second waiting time is almost three weeks of work. The last waiting time is negative, -1.87. The latter can also be expected because the waiting time from the scheduling until the planned production is very high.

The last waiting times, the time between the scheduling and the actual production, is the longest waiting times. When we subtract that negative number of the almost three weeks, the net working days are 12.92 days. This number of days can be brought down to 5 days, the same as the new project

production. Also, the time between order and scheduling can be reduced from 5 to 3 days. This saves 55.43% of the total throughput time. The total amount of hours saved is: 9.95 * 252 * 8 = 20,059.20 hours per year.

Cross-case analysis

If we compare the new project and the series production, the two differ hugely in the number of days. The value-added time at the series production equals almost 0%. At the new project production, this is more than 10%. The difference can be logically explained. In the new project production, a lot of work is done by employees and in the series production that is not the case. In the series production, not a lot of time is needed for the workers, but the value-added time compared to the total throughput time is almost zero. Due to this, the most time can be won at the series production.

We also see that at both production types, the waiting times after the scheduling is the highest. The same process is done so this means that the waiting times can be the same. Therefore, I both recommend to bring them down to 5 days. Next to this, at the new project production, the time between order and kick-off can be reduced to three days. The same three days are achievable at the series production, where this time corresponds to the time between an order coming in and the scheduling of the products.

We can compare the production types easily because the process of scheduling to production is the same. The other waiting times cannot be compared because other operations take place. In Table 12, the waiting times are compared to the two production types.

W_1 is the time from the order until the next process. Because the next process is different in both product types, we define it as the 'next step'. W_2 corresponds to the waiting time between scheduling and planned production in days. W_3 represents the waiting time between planned production and actual production in days. After that, W_t means that total waiting time of the processes now, same as $W_1 + W_2 + W_3$. Then, $W_{optimal}$ is the time that the total waiting time that W_1, W_2 and W_3 need to be. After that, the total saved time is displayed. Finally, the total throughput time saving is stated.

Type of production	**W_1 (days)**	**W_2 (days)**	**W_3 (days)**	**W_t (days)**	**$W_{optimal}$ (days)**	**Total saved time (days)**	**TTT saving (%)**
New project	4.26	5.26	1.64	11.16	8.00	3.16	28.32
Series	5.03	14.79	-1.87	17.95	8.00	9.95	55.43

Table 12. Cross-case analysis value stream maps.

On top of these waiting times, the production takes up the most time. This comes down to a minimum of 8 weeks. This means that the total throughput time of the whole process is longer than four months for a new project. Especially with CIREX that uses the MRP system, the process before production needs to be very short. MRP is based on the push system that produces products to put it in inventory. The long amount of waiting time together with the MRP system makes it hard for a new customer to get their products fast. To be attractive for new customers, this total throughput time must be reduced or CIREX may consider switching to JIT. This method is based on the pull system that produces products only when needed to.

3.4 Summary

The departments experience more work due to the decline in the automotive projects and rise in general industry (GI) projects. These GI projects are smaller batches and 22 projects are needed to get the same profit as 1 automotive project. For some jobs at the departments, the work will be 22 times as high as well. This means that the workflow needs to be more efficient if CIREX does not want to hire more employees.

Sales department

The sales department does not experience any trouble when having more work to do. For the sales department, the focus is on retaining workers instead of recruiting them.

Engineering department

The engineers are busy with non-beneficial requests. They spend their time in making a comprehensive quotation for the customer. CIREX can offer 4 types of quotations, the one more detailed than the other. But after all, the customer goes away so this time is lost. An order comes in at the sales division, they check whether the customer is interested enough to make products for. The first criterium, now, is that CIREX earns 25,000 euros or more from the customer. The second and last criterium is that the customer offers a strategic benefit. This can be, for instance, that the customer can offer more products. In practice, very few companies are above the 25,000 euros threshold. This means that a lot of companies offer a strategic benefit. Due to the complaints of the engineers, this is not the way to proceed in the future. Especially not when more projects are coming in and the majority of the projects is accepted. Therefore, I made a project portfolio scorecard where, with the aid of several criteria, a customer is rated. This rating determines which type of quotation the customer gets and a final rating to ensure the final decision of accepting the customer or not. This scorecard has criteria such as the potential of the customer, how long a project will last if the customer is known and if the lost wax method is the most beneficial way to produce the product. With these criteria, the type of quotation is decided. After that, the engineers rate the profit and outsourcing steps. With these six criteria, the final score is drawn up and the sales and engineering departments decide whether to accept the customer or not. The implementation of this scorecard (see Chapter 4) reduces the average time per request with 4 hours.

Production & logistics department

For the wax department, I recommend implementing the SMED method. Besides, the total waiting time of both production types can be brought down to 8 days. I can say this with the insight in the processes of CIREX with help of the value stream maps. For the new project production, this reduces the waiting time by 6,370.56 hours per year. At the series production, the total waiting time is dropped by 20,059.20 hours per year.

4. Implementation

In the sales and the engineering departments, the project portfolio scorecard can be implemented directly. This is the only solution that can be implemented because the other solutions are either about analysing the current situation. I graded the projects first with the help of the project portfolio scorecard. After that, 10 projects are evaluated with two engineers with the aid of the scorecard.

Engineering

Firstly, to analyse the criteria project portfolio, I picked out 10 projects. These projects or requests have been processed less than three months ago, so they are up-to-date.

The criteria of the project portfolio are filled in and the scores are then stated in the corresponding columns, Sales and Engineering. The criteria of the project portfolio can be found in Table 13. The total grade is used to check whether CIREX even wants to accept the project or not. The threshold is a minimum of 6. The last column is about quotations. The rate of the sales department represents the first letter. After this first letter, with the help of the project portfolio scorecard, I can estimate the new type of quotation.

Project	**Grade Sales**					**Grade Engineering**			**Total grade (Z) 0.6 X_1 + 0.4 X_2**	**Quotation (now, after)**
	S_1	**S_2**	**S_3**	**S_4**	**X_1**	**E_1**	**E_2**	**X_2**		
Automotive	2.5	1.5	2	2	8	4	3	7	7.6	B, B
GI	1.5	1	2	2	6.5	4	5	9	7.5	B, C
Automotive	2	2	2	2	8	3	5	8	8	B, B
Motor	2.5	2	1	2	7.5	5	1	6	6.9	B, B
Motor	2.5	2	1	2	7.5	5	1	6	6.9	B, B
GI	1.5	1.5	2	2	7	4	5	9	7.8	B, C
GI	2	2	2	1.5	7.5	5	4	9	8.1	B, B
GI	2	2	1.5	2	7.5	1	1	2	5.3	B, B
GI	2	2	1.5	2	7.5	4	1	5	6.5	B, B
GI	2	1.5	1.5	2	7	5	1	6	6	B, C
Average	1.9	1.8	1.7	2.0	7.2	4	2.7	6.7	6.9	3/10

Table 13. Projects rated by the project portfolio by W.H.A. Smits.

The calculation is as follows, the meanings of these scores are stated in Section 3.2.

$Z = 0.6\ X_1 + 0.4\ X_2$

$X_1 = S_1 + S_2 + S_3 + S_4$

$X_2 = E_1 + E_2$

Z is the overall score, calculated by the sales and engineering scores.

X_1 is the sales score, S_1, S_2, S_3 and S_4 are the criteria that the sales department can rate.

X_2 is the engineering score, E_1 and E_2 are the criteria that the engineering department can rate.

The sales score is there to advise the engineers about which type of quotation they need to make for the customer. This advice is based on a certain grade. This advice is as follows:

- Advice for the type of quotation:
  - X_1 <= 5 is not accepted or perhaps a D quotation.

- $5 < X_1 <= 7$ will be a C-type.
- $7 < X_1 <= 9$ is the B quotation.
- $X_1 > 9$ refers to the A-type.

- An overall score where the minimum is Z = 6 to be interesting enough for CIREX.

Then, together with the engineers, I analysed 10 other projects to get their view on the project portfolio list. They could come up with any project, also with requests that have not been accepted yet. They can fill in the project portfolio scorecard and take that into account when making quotations in the future.

Project	**Grade Sales**					**Grade Engineering**			**Total grade (Z) 0.6 X_1 + 0.4 X_2**	**Quotation (now, after)**
	S_1	**S_2**	**S_3**	**S_4**	**X_1**	**E_1**	**E_2**	**X_2**		
GI	2.5	1.5	1.5	2.5	8	3	2	5	6.8	B, B
Automotive	1.5	1	1.5	2.5	8	2	5	7	6.7	B, C
Automotive	2.5	2.5	1.5	1	7.5	4	4	8	7.7	B, B
Automotive	1	1	1.5	2	5.5	1	1	2	4.1	B, C
GI	1	1	1.5	1	4.5	5	1	6	5.1	C, delete
GI	1.5	1.5	1.5	1.25	5.75	5	3	8	6.7	B, C
Automotive	2	1	2	2.5	7.5	4	5	9	8.1	B, B
GI	1.5	1	1.5	1	5	1	3	4	4.6	B, delete
GI	1.5	1	1.5	2	6	4	5	9	7.2	C, C
GI	1.5	1	1.5	1.5	5.5	3	4	7	6.1	C, C
Average	1.7	1.3	1.6	1.7	6.3	3.2	3.3	6.5	6.3	5/10

Table 14. Projects rated by the project portfolio by two engineers. (M2 and J)

The time being busy when making a quotation differs for the type of quotation. For type C, between 5 minutes and 2 hours are considered. With this C-type quotation, the engineer is estimating the costs on his own without discussing the product with others. For simple calculations, the average of one hour is chosen. All of the quotations at CIREX have the same variations in time. This means that every quotation can be seen as the average values. For type B, this time is between 8 to 16 hours. The average is 12 hours. This involves meetings with other engineers. They discuss the quality, the moulds and other engineering topics. The time busy exists of all of the manhours summed up. For type A, the amount of time compared to type B is doubled, 24 on average is spent on the quotation. An 'A quotation' involves a meeting with the customer. The time is between 16 and 32 hours.

Concluding, the time differences between the various quotations are immense. Especially the difference between the C and the B type. This difference is 11 hours, on average. Therefore, the decision taken by the sales employee on the type of quotation is huge.

In 50% of the quotations, the advice of the type of quotation is not valid. In the six out of twenty rated projects, the B quotation could also be a C quotation. In the other two cases that the quotation is not the right type to advise, they could even be deleted. The time that is spent on a B quotation is eleven times more than the C quotation. Due to this difference and the number of 'wrong' indicated type of quotation, a lot of time could be saved there.

For these twenty projects, rated by the project criteria, there are eight wrongly classified projects. When the average is taken, the saved time is 79 hours. This number divided by the number of projects reviewed comes down to almost 4 hours per project request.

5. Conclusion, discussion and recommendations & further research

5.1 Conclusion

When the demand of the automotive market drops, CIREX must compensate with projects in the general industry (GI). In the upcoming 3 years, the drop in automotive projects is respectively 7, 10 and 12. The number of replaced projects by the GI varies in quantity and complexity. In the project portfolio that CIREX has, 22 typical low quantity projects of the general industry are equal to 1 automotive project, compared in added value. With the portfolio of the GI that CIREX now has, this ratio of the profit of the automotive per project divided by the profit of the general industry per project is 11. When only big projects of the GI are counted in, the number is 3.65. In the worst-case scenario, in three years, CIREX has to compensate for the loss in automotive with 252 low quantity projects to maintain the same revenue.

The sales section can handle the change, the focus is on retaining instead of recruiting. In the engineering division, together with the sales department, a project portfolio scorecard is implemented. This scorecard has criteria such as the potential of the customer, how long a project will last if the customer is known and if the lost wax method is the most beneficial way to produce the product. With these criteria, the type of quotation is decided. After that, the engineers rate the profit and outsourcing steps. This scorecard with these criteria denies non-beneficial requests from being processed. This implementation saves, on average, 4 hours per request. Compared to the worst-case scenario, the scorecard saves 1,008 hours per year. These hours were, unlike now, lost to extra work for the engineer.

For the series production, when the prototype production is approved, the compensation of 252 general industry projects is enabled as well. With the recommendations I gave, the total throughput time (TTT) is 55.43% less, which is more than 20,000 hours yearly that is otherwise spend on waiting time. For the analysis of the new project production, 28.32% of the total throughput time can be saved. Compared to the 252 projects, this saved time is 6,370.56 hours, which are now lost to waiting time.

The hours that are saved are based on the year 2023. After 2023, the assumption is that automotive projects keep dropping. Therefore, even more time can be saved when implementing the scorecard and recommendations. For other new projects than the general industry, the recommendations can be applied as well.

The total throughput time of the whole process is minimal for 4 months. The high amount of waiting time together with the use of the MRP system makes it difficult for new customers to get their products fast. Therefore, CIREX must apply the changes to save time and it should consider switching to JIT production.

5.2 Discussion

First, my research was very broad because it involved the whole company. That is why it needed to be limited. I limit the research until the results of the department production & logistics. What I could do, if I had more time, is the implementation of the change in the production & logistics division. This could not be done, but I estimated the waiting time until the point that I thought was reachable for the business.

Furthermore, the corporation has a very complex structure. My research intended to display the amount of work that is done by employees and machines in the current situation. Then, this would be compared with the future situation and the time is measured how busy the personnel and machines are with their work. Since CIREX does not keep track of the hours of the workers, and the projects vary a lot, this was impossible. Also, the SAP system has just been installed and may therefore not be

reliable. The data that the SAP system provides are not accurate. This is because the data are filled in by employees, on another day than they should. Parts of the data of the new project production are also saved on another file, 'the project planning'. This data are accurate, but you must calculate the differences manually. This is what I did.

Finally, this research used average values to make calculations. For example, the value stream map shows the average time of the engineer while working. However, in reality, this varies a lot due to the project's complexity. It is hard to measure the time that engineers are busy with a certain task because these tasks differ immensely. They could not provide this information, so another way of improvement is chosen. When these calculations are rounded to an average, the reader should take into account that these values are not the representation of reality, but the best possible representation within the boundaries of the research.

5.3 Recommendations & further research

The recommendations include the conclusion of Section 5.1. These are to implement the project portfolio scorecard and to bring down the waiting times before production.

The recommendations start with feedback about the projects. After that, I discuss the extra point of the problem cluster, the calculation template. Furthermore, I have recommendations about the sales department. Then, I discuss the research that can be explored in the future. These are about the project portfolio scorecard and the limitation in the division of production & logistics.

Recommendations

Project

Probably, the number of projects stated in Table 6 cannot be achieved. If a lot of these small projects are accepted, the company would not benefit anymore. When Table 8 is reviewed, the change can be made easily. The focus here is on big projects in the general industry, which is the focus that CIREX must have. Therefore, I recommend looking into other industries that rely on the quality of the product and do not care if this costs more money. These industries can be government-supported companies, such as the defence sector or the port of Rotterdam.

In the future, if CIREX can link time attendance to their workers. Also, they can measure the maximum of how many projects they can have. Also, how many workers of the crucial personnel (mentioned in the current situation) are needed in that situation.

The turnover of the trucks is also really high (Figure 5). In recent years, this has been the majority of income for the business. In the coming years, this income drops. This is probably because companies need to renew their contracts. However, the focus must be on big projects, the number of small projects would otherwise be too large.

Calculation template

The calculation template covers expenses on a scale for the number of trees. They do this because then they achieve economies of scale and bring down the unexpected costs per product. For lower amounts, this benefit stops at 50 trees. I recommend looking into this because the costs of these low quantity projects are not covered all of the time. Several steps can be taken to tackle this loss. Also, a combination of the following steps can be implemented.

- Make two more scales below the 50 trees to cover.
- A minimum number of products/trees may be defined.
- A minimum amount of money is enabled to cover these costs.
- The time of the engineer may be connected to the hourly rate.

All of these options can be implemented in the existing calculation template. The boundaries of the options can be calculated with typical projects already accepted based on the calculation template.

Sales

To come back at the point made in the project section about looking into other industries. I saw that the sales workers do not seek actively for customers in new industries. That is why the sales personnel need to take more time to look into these sectors, in my opinion. Especially in this time of low demand, this needs to be done to maintain profitably.

Further research

Engineering

The project portfolio can also be used to search for new customers. The criteria are used to seek for unique industries that can add value to CIREX.

Production & logistics

With the results of the value stream maps, the bottlenecks have been identified. I did not have the time to check whether these savings in waiting time can be achieved. However, in my opinion, nothing happens during these waiting times and therefore these days can be lowered down to the amount I recommended. Next to this, the research of Kruijswijk (2019) is important to be implemented.

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Appendices

Appendix 1 | Value stream maps

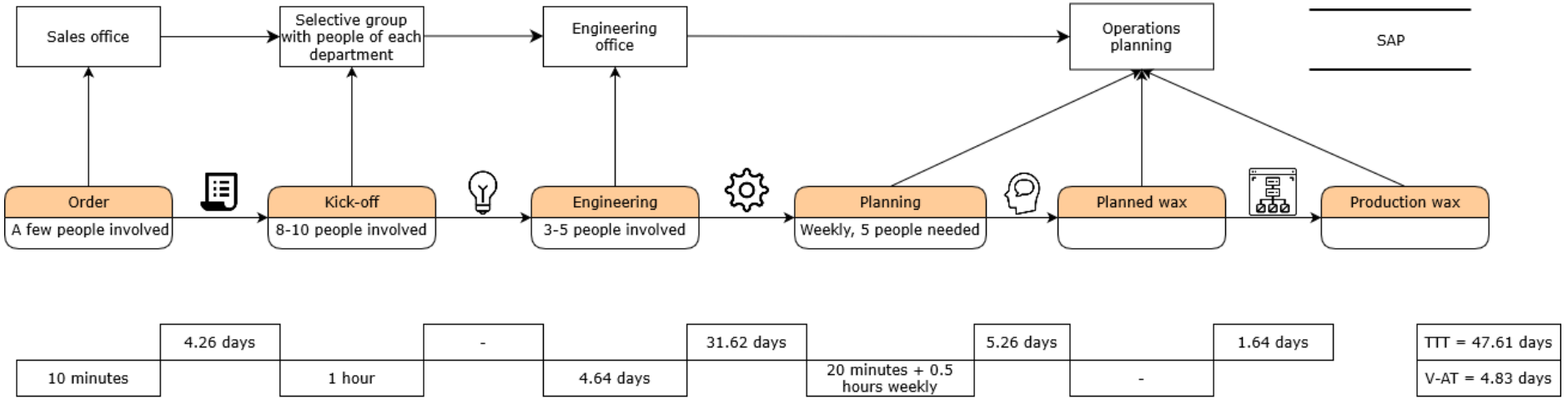

Figure 9. Value stream map new project production.

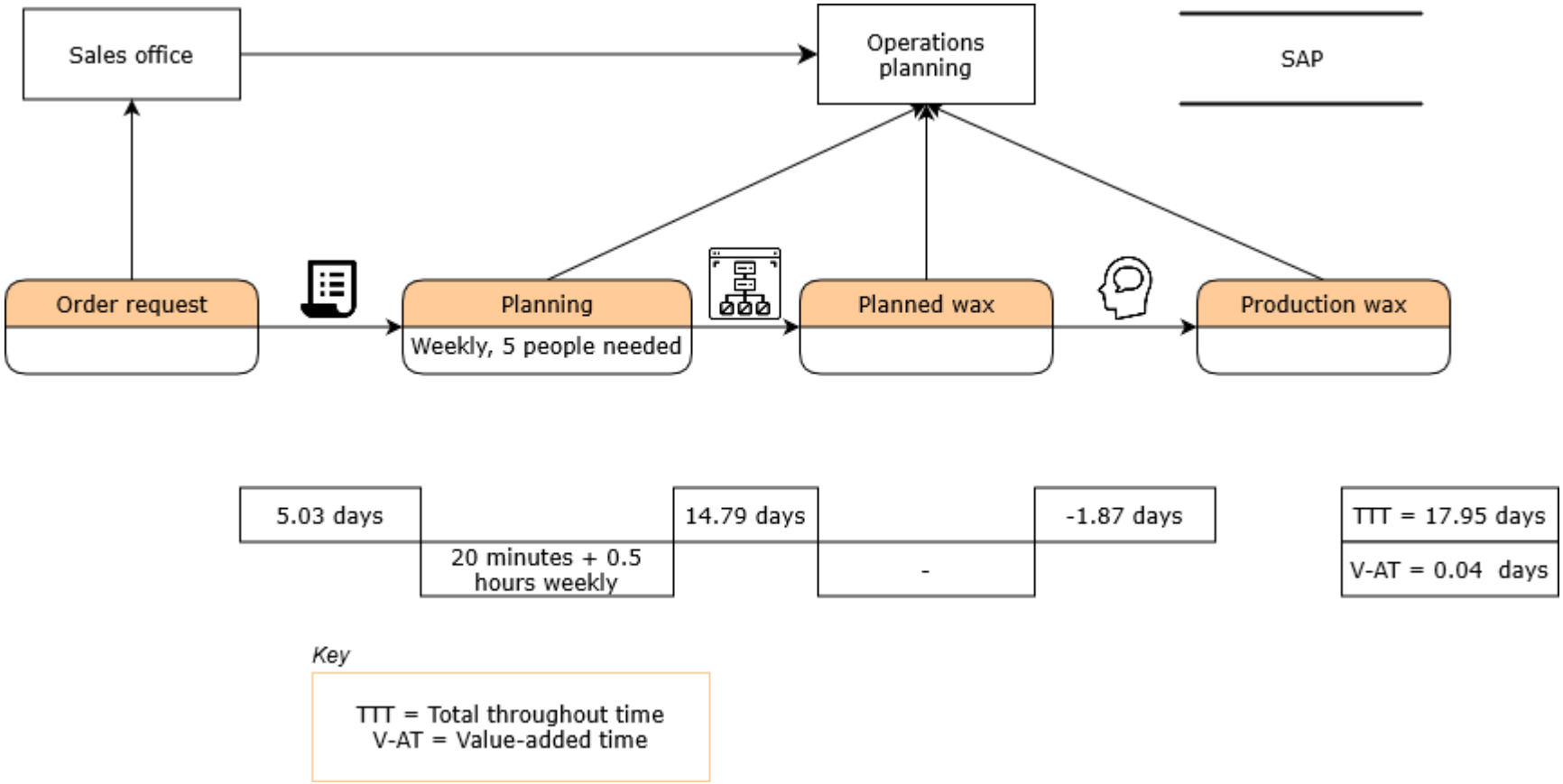

Figure 10. Value stream map series production.

Appendix 2 | Research design

Research question	**Type of research design**	**Research objects**	**Subjects or people of interest**	**Data collection techniques**	**Data analysis method**
How does the current situation look at CIREX?	Experimental (observation of employees and machines)	Corporate data and management	Selection of employees and machines, calculation and financial models	*Qualitative:* In-depth interviews, analysis of primary data *Quantitative:* Consequences of the changes per department	Analysis, interview transcripts
Which theories in the literature can be used to make organisational changes?	Descriptive (case study)	Literature	Scientific articles and books	*Qualitative:* Analysis of secondary sources	Summary – what can CIREX and I consider as possible options seen to the past?
What changes does CIREX need to make?	Correlational (causal-predictive)	Corporate data and management	Selection of employees and machines	*Qualitative & Quantitative:* primary and secondary data, interviews	Analysis, summary, implementation plan
What is the added value of those changes at CIREX?	Descriptive (describing situation)	Corporate data and management	All stakeholders	*Qualitative:* The financial expectation of these changes	Figures and charts, interview transcripts

Table 15. The research design in a scheme (Question Pro, 2020).

Appendix 3 | Systematic literature review

The literature study is used as a tool to search for methods that I can use to solve the bottlenecks. First, organisational changes made by companies are searched for. Unfortunately, these search terms did not hit any useful articles because the search was too broad and not specific. The topic that I research is too broad and cannot be generalised. Therefore, with the help of the bottleneck per department, articles are searched for that specifically solve that problem. With this, more accurate sources are found and can be useful to solve knowledge problems.

Definition of knowledge problems

The first search is about CIREX shifting to the market of the general industry. With this change, they produce batches with lower quantity but the same total number of products is produced. This can only be done when more projects are accepted. The knowledge problem here is that they do not know what impact it has on the foundry. Therefore, I search in the literature for solutions to this specific problem.

For sales, no extra personnel is needed. That is why the search addressed the benefits of retaining staff than recruit others. The knowledge problem is that the benefits of retaining staff rather than recruiting are not clear.

For engineering, the bottleneck is that a lot of time is spent on requests of companies. That is why being more efficient when rating these requests matters. When to accept a certain project and when not to. So the knowledge problem is: which methods are there to filter out non-beneficial projects?

For production, the first approach was to reduce the changeover times in the wax department. The results were the same as another student at CIREX already found out. After this, a book instead of online sources is used to solve the bottleneck.

Criteria

The inclusion and exclusion criteria are taken into account for each search. The criteria are made up of the first search term but can also be used for all of the searches to narrow down the number of searches.

Inclusion criteria

The prospective subjects must have the following characteristics:

- The subject has to be about the industry of moulding, preferably in the lost-wax.
- It has to contain the topic of low quantity production.
- An organisational matter due to market shift.

If the list is too big then:

- To keep the articles up to date, it must be published in the last 10 years.
- Due to the COVID-19 virus, it has to be an online article.
- The articles have to be either a PDF or full text.

For overall inclusion criteria, I am satisfied with 10-30 search results.

Exclusion criteria

Characteristics that disqualify the prospective subjects:

- The subject is only about tooling techniques and not about the impact on the company
- The subject is only about organisational change as a result of other factors than market shift
- The article cannot be found in English nor Dutch.

Search strategy

The best way of finding literature sources is to follow a search strategy. Noort (2020) made a scheme in which a search strategy is chosen (Figure 11). The figure includes two-axis, broad versus specific and qualitative against quantitative. A broad match type reaches the largest audience. Several cross types of words are searched for. In a specific match type, the exact words that you type in are looking for. I like the broad search type because this industry that CIREX is in, is relatively small. Quantitative data is data that can be measured, counted and expressed in numbers. Qualitative data is conceptual and descriptive. In the first search, of organisational change, the descriptive explanations are the most important. An organisational issue is a problem that is built on experiences and exploratory views because each company is different. With these characteristics, I come down to PICo or P(E)O which are based on experiences and exploratory views. A quantitative analysis is interesting as well, this comes down to PICO. The difference is the 'O', the outcome. I think the outcome, which is in this study the yearly profit, is not interesting enough to be included in the search. The yearly profit is already included in the EBITDA. Therefore, PICo is the ideal search strategy to use while finishing the literature study.

For analysing the departments, PICO is chosen. That is because the solutions are all about effectiveness. The solutions for each division are compared to each other as well. These are characteristics of PICO, the focus is on effectiveness and outcomes.

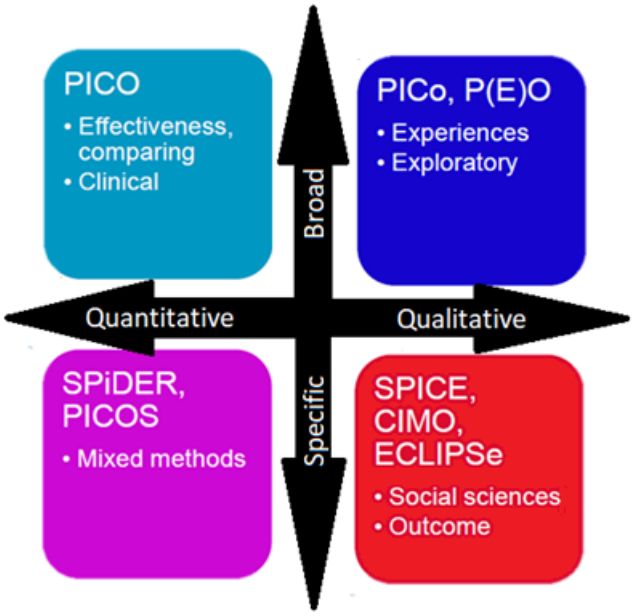

Figure 11. A scheme with characteristics of research methods to choose a search strategy.

With PICO, there are facts and evidence needed to substantiate a method in the literature. Therefore, PICO can be seen as an evidence-based model. NYU libraries (2020) state that Evidence-based models use a process for framing a question, locating, assessing, evaluating, and repeating as needed.

Furthermore, they say that the PICO elements include Problem/Patient/Population, Intervention/Indicator, Comparison, Outcome, and (optional) Time element or Type of Study.

On the next page, the search strategies are shown for each category. The first is about the general organisation changes. The last four are about solving the bottlenecks for that specific section.

PICo	Constructs	Related terms	Broader terms	Narrower terms
Problem	Organisational change	Management change	Change, company	Staff and employee change
Interest/intervention	EBITDA decline	Turnover decline	Profit decline	Product value decline
Context/comparison	Market shift	Project portfolio change	Shift	Product change
	Lost-wax casting	Investment casting	Moulding	Wax-injection moulding

Table 16. The search strategy PICo elaborated on the organisational issue.

PICO	Constructs	Related terms	Broader terms	Narrower terms
Problem	Retaining employees	Keep personnel		
Interest/intervention	Efficiency		When	
Context/comparison	Recruiting workers	Hire employees		
Outcome	Fewer costs			

Table 17. The search strategy PICO elaborated for the sales department.

PICO	Constructs	Related terms	Broader terms	Narrower terms
Problem	Requests			
Interest/intervention	Criteria	Portfolio		
Context/comparison	Projects	Stages		Products
Outcome	Framework			

Table 18. The search strategy PICO elaborated for the engineering department.

PICO	Constructs	Related terms	Broader terms	Narrower terms
Problem	Unnecessary			
Interest/intervention	Production Management		Manufacturing	
Context/comparison	Guidelines			
Outcome	Reduction			

Table 19. The search strategy PICO elaborated for the production & logistics department.

Database

Due to the learning process with the previous systematic literature study in the project plan, I use the database of EBSCO (EBSCO Host, 2020). This database can be accessed with the permission of the university. This permission is provided to you when you study at the university. In this, the Business Source Elite is chosen as a database of EBSCO.

Protocol

In this chapter, a table with information about the searches in the literature is stated. It includes the search string, the number of articles found and the number of articles used in the thesis. Next to this, if the number of articles found exceeded the 30 articles, the criteria are applied. Not all of the searches are included but the most important searches are in it. The list would be three pages long if all of the searches were included.

Search String	Number of articles found	Number of articles after criteria, criteria	Number of articles used
Organisational			
Organisational change AND Market shift	15		0
Organisational change AND Market shift AND industrial	5		0
Sales			
Recruiting AND retaining AND costs AND efficiency	10		0
When to hire more employees	29		1
Engineering			
Engineering AND product requests	52	28, after 2000, full text	0
Framework project portfolio	26		0
Criteria project portfolio	22		1
Production & Logistics			
Guidelines production management	31	16, after 2000, English	1
Total number of selected articles			3

Table 20. The number of articles found and used per search string.

Final articles with the main findings

Title	Author(s)	Year	Keywords	Main findings
Recruiting Vs. Retaining?	Magazine T+D	2007	When to hire more employees	The benefits of retaining instead of recruiting.
A two-stage fuzzy approach for Industry 4.0 project portfolio selection within criteria and project interdependencies context.	Demircan Keskin, Fatma.	2020	Criteria project portfolio	A project portfolio with criteria can be a solution to get the number of requests down for the Engineers.
Escape from the unnecessary-some guidelines for production management.	Segerstedt, Anders	2010	Guidelines production management	To identify bottlenecks for the departments.

Table 21. Main findings per article.

Appendix 4 | Relationship between set-up time and order quantity

The first solution to the production department is related to the set-up time, also known as the changeover time. In the literature, I found that set-up time affects the order quantity and vice versa.

Segerstedt (2010) states that you must reduce set-up times to reduce the order quantities. Next to this, he says that long set up times warrant large order quantities. Despite large order quantities, a great share of the time at a work centre is spent on set-ups instead of production. Furthermore, large order quantities lead to:

- Long operation times.
- Prolonged adaptation to changing demand.
- Large quantities of work-in-process (establishing a proper utilization of equipment requires a large number of different orders to guarantee work-tasks within every part of the production facility).
- Long throughput time for the production due to time spent in queues waiting for set-ups and operation of other items.

Shingo (1981, 1985) says that the best way to shorten the set-up times is to use the SMED method. This is the method that Kruijswijk (2019) used at CIREX, in an earlier assignment at the business. Segerstedt (2010) recommends to start to shorten the set-up times on existing equipment; do not wait until new investments are introduced. However, they state that, when investments are made, the possible alternatives should be thoroughly analysed concerning their different set-up times. They elaborate on the topic that when the set-up times are shortened, the order sizes can be reduced without a reduction in capacity in the production facility. Then he explains that smaller order quantities present a smoother workload, which in turn leads to reduced investments in work-in-process, which positively influences throughput-time, flexibility and utilization of equipment and personnel. The final statement is that smaller order quantities present less investment in inventory.

With the help of the article by Segerstedt, I conclude that the set-up time and the order quantity are closely correlated. Many companies want to achieve lower set-up time by lower the order quantity. For CIREX it is the other way around, they want to bring down the order quantity. That is why they need to lower the set-up time. They want to lower the order quantity due to the market shifts, stated in Section 1.1. More low quantity projects will be produced so the set-up time reduction is momentous.

Appendix 5 | Personal improvement

I write this reflection on my professional functioning to effectively learn from my decisions. I reflect on various assessment criteria provided by the University of Twente. Next to this, I compare my skills to the characteristics of a self-driven learner.

Clarity and justification

I tried to set the basis for the research as early as possible. I did this to clarify my final research questions as early and as accurate as possible. Because the direction changes constantly, the research questions need to be adjusted as well. With the change of the research questions, the research design changes as well. This has a massive impact on the research, but it is necessary to succeed.

I involved many employees and asked about their opinion about my research to identify the problems the employees encountered. Only listening to one person, my supervisor at the hosting company, would not bring me to the point where I am now. The plan of action was adjusted to most of the ideas of the majority of the employees. I did this because the research also involved the whole company. Coming up with the research questions took me more time than I thought. In the first weeks, I got flooded with many ideas of the employees to tackle this issue that the company faced. Therefore, I was relieved that the Operations Manager helped me setting up the basis of the research.

Theoretical framework

In my research, I do not have a specific theoretical framework as the work was mostly practical. I used the literature to get ideas about solutions to the bottlenecks I came across. In this, I used the framework provided by a teacher at the University of Twente. This also involves a structured plan of action on how to find good sources. I also made up a list with criteria, one was that an article could not be older than 10 years. With this, I can only analyse the latest literature, which makes the research up-to-date.

Chosen methods

Most of the data I collected was through interviewing. I believe that all employees form the company and therefore know all the ins and outs of the business. This data gathering method was effective as I found all of the bottlenecks that CIREX faced. Next to this, I analysed a lot of Excel sheets with figures of 2018 and 2019. Furthermore, the profit of 2006-2023 is analysed to see what the future brings for CIREX. Lastly, I described the value stream maps for two different kinds of production types. All of these data are bundled to one storyline.

Design validation

The analysis of the projects in my research is valid and of high value to CIREX. I created a separate section about validity because CIREX has a lot of constraints. They have a complex organisation regarding the process steps and the functions of every employee. I expressed my solutions in terms of hours to show the value of the implementation of my recommendations to CIREX. I discussed a lot with the stakeholders of the company to keep them satisfied and to change the direction when needed. I tried to understand the cultural aspects of the organisation by talking to most of the workers there. In this way, I tried to comprehend their methods of working.

Structure and style

The structure and style of my research are my weak points. I make a lot of spelling mistakes but I acknowledge them. I learn a lot of these mistakes and try to prevent them the next time. My first supervisor, Joosten, pushed me each time to keep improving the presentation of my research and the right use of spelling, for which I am really glad he did.

Presentation
As my colloquium is the 21st of August, and this needs to be handed in before that date, I cannot tell about how my oral presentation went. What I can tell is that I learnt a lot of presentation skills in the three years of my Bachelor. Also, the interviews I held in my research contribute to this communicating skill. Only the lack of not speaking English for a while in school is a negative point in these last months of writing my bachelor thesis.

Professional Skills
I like to reach out for others to hear their opinion about my research. Therefore, each time, I took the initiative to meet or to discuss my research with my supervisors, buddy and family. I used this feedback to strengthen my research to get the highest grade possible. I also realised that I needed to get into action every time, to get a task done. Nobody was concerned about me, that is sometimes how this business life works. This contributes to the development of my skills.

Self-driven learner
In terms of self-motivation, self-management and self-monitoring, I state here what I learnt in the time of finishing my research. Before that is done, a common understanding of those terms is needed. Firstly, I introduce the topic and then give an example of how I improved this skill.

Self-management stands for the management of the context, including the social setting, resources and actions. When making decisions independently, you can explore alternatives and make the right choices. You can plan and manage workload and time effectively and efficiently.
The example that matches with this topic is that I am all on my own when I finished the bachelor thesis. Of course, I got help from my supervisors but most work is coming from myself. I need to make decisions by myself and do research on all the alternatives when doing this. For instance, when creating the research questions portfolio this is needed. What questions do I need and what do I exclude or combine with another question. I learnt a lot when doing these tasks and in the end, I am managing myself even better.

Self-motivation drives the decision to participate and the will to see a task through to the end so that goals are achieved. Hereby you need to take responsibility and plan your learning outcomes and activities.
The example that fits with this subject is to critically reflect on me and admit when I am wrong. In the beginning, this was an easy task to do because I just began. But when I was a few weeks in, the problem cluster kept changing. This annoyed me but I kept improving this cluster again and again. After my final version of the bachelor thesis, I completely changed the problem cluster. This is a huge learning process and highly contributes to self-motivation.

Self-monitoring is the process whereby the learner monitors, evaluates and regulates their cognitive learning strategies. You can reflect on your thinking and actions and see whether you failed or did well. Also, the decisions that could be improved can be taken into account.
This reflection of the 3M's contributes to my self-knowledge and evaluate which things I learnt this module. Besides, the skill developments of Module 11 and 12 helped as well to my self-knowledge and the improvement of this skill. I have an open mind when it comes to learning so each moment is cherished.

Concluding, the basis for my research is the most important aspect. This involves a process of mistake after mistake and learning of this. To get to know the company and its employees is crucial for solving the problem statement. In this situation, I need to stand open for all input and take all possibilities into account. If I do this, all alternatives are taken into account and finally directed into one direction.