Improving the throughput time of the service department at AKOR BV

Bachelor thesis

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Preface

This research is the result of my bachelor thesis that I have conducted at AKOR BV. This thesis is the final assignment of my study Industrial Engineering and Management at the University of Twente. The focus of this thesis is improving the throughput time of the service department at AKOR BV, which is done by analysing the current processes and designing new processes for the sub-departments of the service department and by creating standard operating procedures to implement the new processes.

I would like to thank all the people that have assisted me during my research. At first, I would like to thank my supervisors at AKOR BV, Frank Baan and Martin van Gent, for their guidance, useful feedback and for their time spent helping me. I would also like to thank all the other colleagues at AKOR for creating a pleasant working atmosphere and for having the time to chat, laugh and drink coffee.

Next to that, I want to thank my first supervisor at the University of Twente, Marco Schutten, for all the help and useful feedback during my bachelor thesis. Marco made time for all my questions and he gave very insightful advice and feedback, from which I learned a lot. I would like to thank my second supervisor at the University of Twente as well, Eduardo Lalla-Ruiz, for all the useful help and feedback he has given me and for his time spent being my supervisor.

I would also like to thank my fellow student, Wim Klaassen, who helped me by giving feedback on my thesis. And lastly, I would like to thank my parents and my girlfriend, for always supporting me during this research. They were very thoughtful, and they were always there for me during my research.

Summary

Introduction

AKOR BV is a Dutch construction company located in Rijssen. AKOR is specialised in contracting projects in the field of residential, commercial, retail, and service & maintenance. The latter is the scope of this research. The service department of AKOR is facing a problem, the throughput time of their process is too high. So, this research will focus on "improving the throughput time of the service process at AKOR BV".

The service department is divided into two sub-departments, the housing sub-department and the retail sub-department. To improve the throughput time of the service process, it is necessary to improve the throughput times of both sub-departments. To do this, new processes are designed, and standard operating procedures are used to implement these new processes.

Current situation

To find out where the problem lies, flowcharts of both sub-departments are made, and a data analysis is conducted. The flowcharts show that the current processes are very complicated and that the processes of both sub-departments are not similar to each other. The administration from the retail sub-department is still being done using paper time sheets and paper invoices. The data analysis proved that the throughput times of the sub-departments are higher than expected, the stakeholders estimated these throughput times to be respectively 8 and 11 days for the housing and retail sub-department, whilst the actual throughput times were respectively 30.65 and 51.32 days for the housing and retail sub-department.

Methodologies and tools

To find a solution to the problem faced during this research, a literature research is conducted to find a methodology and corresponding tool(s) that will help create a solution. The methodologies discussed are Optimized Production Technology (OPT), Theory of Constraints (TOC), the Drum-Buffer-Rope principle (DBR) and Lean. Information about these methodologies is collected using literature to select the best-suited methodology. The methodology chosen is Lean. The Lean tools that were considered for creating a solution are: Standard Operating Procedure (SOP), 5S, Pareto analysis, Value Stream Mapping (VSM), process mapping and Kaizen. Two of these tools were chosen using the weighted scoring method, namely SOP and process mapping.

Solution

The solution includes the new processes that are created using process mapping and by eliminating all wasteful events in the current processes. These new processes are explained, and they should be implemented using the SOPs created for both processes. These SOPs will guide the employees in following the new processes. The results of implementing this solution is estimated, the estimated throughput times are 2-12 days and 6-16 days for respectively the housing and retail sub-department.

Conclusions and recommendations

The goal of this research is to lower the throughput times to 5 and 8 days for respectively the housing and retail sub-department. These values lie in the range of the estimated throughput times of the new processes. However, due to the limited time, it was not possible to test or implement the solution to obtain the definite throughput times.

Recommendations are made for AKOR, these recommendations involve inventory management, data analysis, the arrival of orders, and elaboration on how AKOR should continue this research.

Table of contents

Definitions

In this report, some terms are used that need further explanation to avoid misunderstandings. The definitions of these terms are listed below.

Throughput time	The throughput time is the time spent between the start of a process, and the end of a process. In this case, the throughput time is the time between the arrival of an order and the sending of the invoice to the client.
ERP system	An ERP-system (enterprise resource planning system) is an information-based software system that manages and integrates parts of a business.
Work-In-Progress	The term Work-In-Progress (WIP) is used in this research to describe the jobs that are already finished by the carpenters but from which the invoice is not yet sent out.
Housing association	A housing association rents out houses and apartments to people. They also build and manage houses, by hiring construction companies like AKOR.
Order	An order is a detailed description of the job that is requested by a client. The order is updated throughout the process with administrative details and details needed to execute the job. These details are used to create an invoice to send out to the client.
Waste	Waste is seen in this research as time spent without adding value to the process.

1 Introduction

This chapter serves as an introduction to this research. It introduces the company and it gives insight to how this research is conducted and why. This chapter also introduces the problem faced during this research and the deliverables of this research. This chapter has the following structure:

- Section 1.1 introduces the company.
- Section 1.2 gives the motivation for this research.
- Section 1.3 gives a description of this research.
- Section 1.4 gives the identification of the problem faced during this research.
- Section 1.5 gives the design of this research, including the research questions answered during this research.
- Section 1.6 describes the deliverables of this research.

1.1 Introduction to the company

AKOR BV is a Dutch construction company located in Rijssen that operates mainly in the Netherlands. However, they also operate in Germany, France, Belgium and Austria. AKOR is specialised in contracting projects in the field of residential, commercial, retail, and service & maintenance.

1.2 Motivation for research

AKOR has a lot of different projects, which are run by different departments. One of these departments is the service department. AKOR discovered that this department was not operating as effectively as it could, since the throughput time of a job is high. That is why the goal of this research is to improve this throughput time.

1.3 Research description

This research is conducted in the service department. This department consists of two sub-departments: housing and retail. Housing covers repairs and maintenance to houses from the housing associations that AKOR acquired as clients and to houses from private individuals. Retail consists for about 90% of repairs and renovations to stores from company X[1]. This is a big company, for whom AKOR built many stores. The other 10% covers the repairs and renovations of other buildings that AKOR built in the past, except for houses (which are covered by housing).

However, the processes of these sub-departments are not functioning well enough, since the throughput time of the jobs are too high. That is why research should be done to find a solution for lowering the throughput time of the service process.

[1] The actual name of the company is not given due to confidentiality

1.4 Problem identification

The main problem AKOR is facing in the service department is the high throughput time. So, the action problem (Heerkens & Van Winden, 2012) in this research is:

"The average throughput time of the service maintenance process at AKOR is too high."

The causes of this problem and especially the core problem must be found to solve this problem. This is done by creating a problem cluster which shows the causes between the action problem and the potential core problems, Figure 1 presents the problem cluster. (Heerkens & Van Winden, 2012)

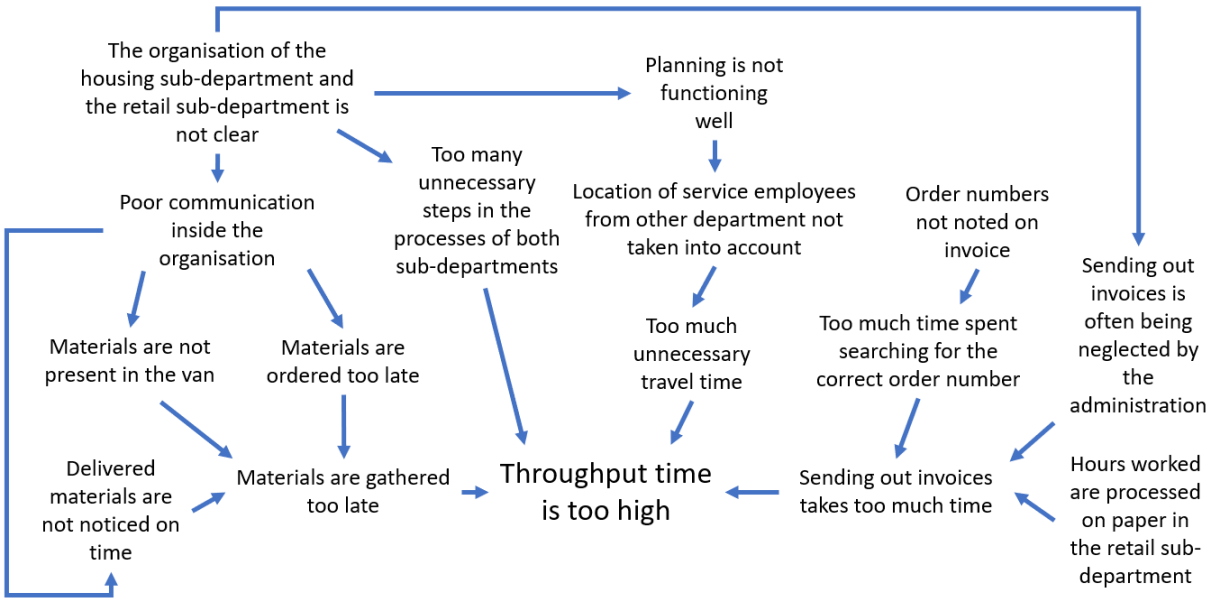

Figure 1 | Problem cluster

Since it is not possible to solve all potential core problems in the timeframe of this research, a core problem (Heerkens & Van Winden, 2012) is determined in consultation with the stakeholders at AKOR BV. This core problem is:

"The organisation of the housing sub-department and the retail sub-department is not clear"

The organisation of both sub-departments must be made clear to improve the throughput times of these sub-departments, since a smoothly flowing organisation helps get rid of wasted time and confusion, which improves the throughput time. This can be done by looking critically at the current processes of both sub-departments to determine the time-wasting factors in the organisation.

The stakeholders at AKOR already made an estimation of the current throughput time, which is 8 and 11 days for respectively the housing sub-department and the retail sub-department. This estimation is determined via a meeting with all the stakeholders of the service department. The stakeholders determined how much time each part of the process took by discussing this with each other. These values are estimations, so more research is needed to determine the definite values.

1.5 Problem-solving approach and research design

This section contains the research questions needed to solve the problem faced in this research and the reason behind these research questions. The research questions are divided into four parts: the current situation, the literature research, the conclusions of the literature research and the solution. These are also the titles of the chapters which answer the corresponding research questions.

1.5.1 Current situation

This part answers a research question which is supported by four sub-questions. Chapter 2 provides answers to these questions.

1 What is the current situation?

a. Who are the stakeholders?
b. How are the current processes of the housing and retail sub-departments designed?
c. What was the average throughput time per sub-department per year since 2015?
d. What/which part(s) of the processes from both sub-departments cost(s) the most time?

The sub-questions in this part give a clear overview of the current situation. First, the stakeholders are determined and listed to clarify who is affected by this research. The current processes of the housing and retail sub-department are designed using flowcharts, to make sure that the current processes are clear. Then, a data analysis is conducted to find out more about the current throughput times and about which parts cause the most waste.

1.5.2 Literature research

This part answers two research questions, both with 2 sub-questions. These questions are answered by conducting a literature research in Chapter 3.

2 What optimisation methodology is the best choice for AKOR and this research?

a. Which methodologies are suited for AKOR?
b. What are the strengths and weaknesses of these methodologies?

This research question consists of finding suitable methodologies for implementing at AKOR and of figuring out the strengths and weaknesses of these methodologies. This information helps choosing the correct methodology in Chapter 4.

3 Which tools can be used for creating a solution?

a. Which tools are suited for AKOR and this research?
b. What are the strengths and weaknesses of these tools?

This research question consists of finding suitable tools for implementing at AKOR. These tools will be derived from the methodology chosen in Chapter 4. To make sure the right tool is chosen for this research, two sub-questions are answered. These sub-question help finding suitable tools and determining their strengths and weaknesses.

1.5.3 Analysis of methodologies and tools

This part answers two research questions, the first does not have sub-questions, the second has two sub-questions. These research questions are answered in Chapter 4. Both research questions are answered using information obtained in Chapter 3.

4 Which methodology suits AKOR and this research the best?

Answering this research question will give the right methodology to follow during this research. The methodology will provide the tools from which the most suitable is chosen.

5 Which tool(s) will be used for creating a solution?

a. How will the tools be assessed?
b. Which tool(s) score(s) the highest after assessment?

Answering this research question will deliver the right tool(s) for creating a solution. These tools are assessed using assessment criteria and a scoring system. The tool(s) that is the most suited will be used in creating a solution.

1.5.4 Solution

This part answers two research questions, both research questions do not have any sub-questions. The research questions belonging to this part are answered in Chapter 5.

6 How can the selected tool(s) be used to create a solution?

The answer to this research question consists of a solution that will improve the throughput time using the tool(s) selected in Chapter 4. An implementation plan for the created solution will be delivered as well in Chapter 5.

7 What are the expected results of implementing the solution?

Solving this research question will provide estimated results of the solution. No exact results can be determined since there is too little time during this research to conduct experiments or to implement the solution.

2 Current situation

This chapter describes the current situation of the service department at AKOR. The following research question is answered: “What is the current situation”. Section 2.1 gives an overview of the stakeholders of this research. Section 2.2 gives the flowcharts of the current processes from both sub-departments of the service department; these flowcharts are explained as well. Section 2.3 provides a data analysis of the current process, which consists of an analysis of the throughput times and of the separate parts of the current process.

2.1 Stakeholders

The stakeholders of this research are all the people that are directly influenced or have a direct influence on the service process. They are listed below:

General:

- Assistant director of AKOR BV
- Controller

Retail:

- Project manager/work planner
- Work planner
- Carpenter (x3)

Housing:

- Work planner
- Carpenter (x2)

Administration:

- Accountants/administrators (x4)

The retail sub-department consists of three carpenters, a work planner and a project manager. The project manager plans jobs as well, but he also keeps an overview and handles issues when they occur. However, formally, there is no project manager in the housing sub-department. This is the case because the work planner of the housing sub-department acts as a project manager. Besides the work planner, there are two carpenters as well in the housing sub-department. So, there are five carpenters active in the service department, but these are divided into the two sub-departments (housing and retail).

The administration consists of four accountants/administrators. They do not only cover the administration of the service department, but also all the other departments in AKOR. However, they are considered stakeholders, since they are responsible for multiple steps in the service process.

2.2 Current processes of the housing and retail sub-departments

This chapter describes the current situation at AKOR. Recall that the service department consists of two sub-departments: housing and retail. Both sub-departments have their own process in which a work order goes from the beginning where it is received to the end where the invoice is sent out. Section 2.2.1 describes the process of the housing sub-department and Section 2.2.2 describes the process of the retail sub-department. Appendices 1 and 2 provide the complete flowcharts of the processes.

The flowcharts of the processes are explained in parts to ensure that they are well-understood. An explanation about the events in the process is provided per part of the flowcharts.

As can be seen in this chapter and in Appendices 1 and 2, there are multiple colours and shapes in the flowchart. The different colours in the flowchart depict the different functions in the process and the different shapes denote whether the event is a starting/ending event, a decision or a regular event. Tables 1 and 2 provide the legends to clarify this.

Colours	Function
	Administration
	Service planner
	Carpenter

Table 1 | Legend functions

Shapes	Type of event
Rounded rectangle	Start/end point
Rhombus	Decision
Rectangle	Regular event

Table 2 | Legend shapes

2.2.1 Housing

The people responsible for a job flowing through the process of the housing sub-department are the work planner, the administrator(s) and the carpenter(s).

Part 1 of the housing sub-department process

The process starts with a job coming in at the administration (via mail, call, post, etc.) which is then booked in the ERP-system of AKOR (Vakware[2]) noting all the details obtained from the client of the job (information of client, description of job, address, contact details of client). Then this job is sent to the work planner, who rates the priority of the job. The priorities are rated according to the agreements with the housing association from which the clients rent their house. These priorities are often rated in consideration with the client or housing association and vary between an emergency (the job must be finished within 4 hours) and a regular job (the job must be finished within 15 days). After the priority is known, the planner calls the client to make an appointment. If the client is reached an appointment will be made and the appointment will be noted in the calendar of Outlook. This calendar is used for planning the jobs, the service carpenters also have access to view this calendar. The planner then creates a work order in Vakware containing the job description and details of who will execute the job and when. The first part of the flowchart is presented in Figure 2.

[2] Vakware is the name of the ERP system currently in use by AKOR, for further information check: https://www.admicom.nl/bouwsoftware

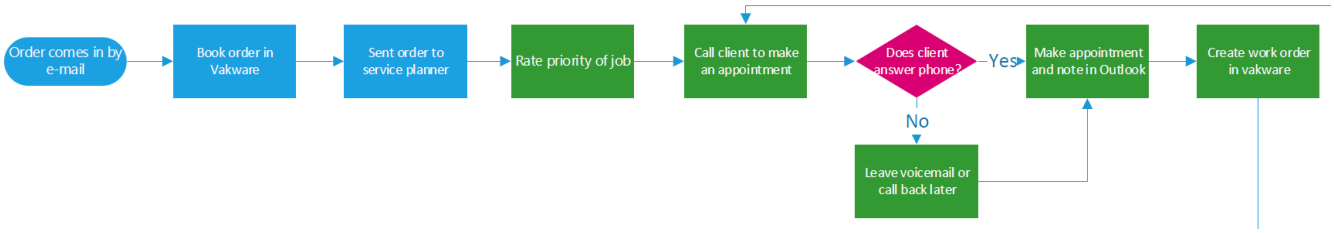

Figure 2 | Part 1 of flowchart (housing sub-department)

Part 2 of the housing sub-department process

After the planner has created a work order in Vakware, the housing association is notified that an appointment is made. This is done because the housing association wants to be updated on the jobs that are being executed on their houses. After this, the carpenter gets a notification once the appointment is planned by the planner. Then, on the planned date and time, the carpenter travels to the appointment address. Here the carpenter checks whether the client is home; if not, a new appointment is made. If the client is home, pictures of the situation/problem are taken to determine the needed materials and these pictures are sent to the work planner via WhatsApp since there is no application or platform linked to the ERP system where these pictures can be shared yet. The work planner then sends these pictures to his or her own e-mail and places it in Vakware to link these to the work order, along with more details about the job (more in-depth description of problem, needed materials, estimation of time needed for execution of job). The second part of the flowchart is presented in Figure 3.

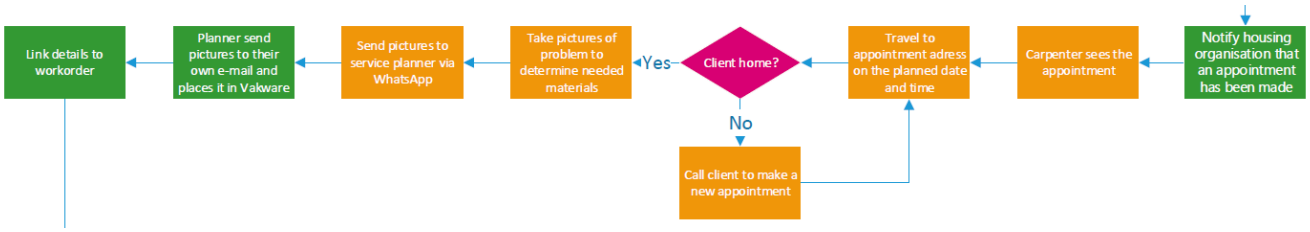

Figure 3 | Part 2 of flowchart (housing sub-department)

Part 3 of the housing sub-department process

After updating the work order, the materials needed for the job are ordered by the work planner. An expected delivery date is given to the work planner if the required materials are in stock at the supplier. However, if the required materials are not in stock, the supplier gives an indication of arrival.

So, the work planner must check whether the ordered materials have arrived by going to the shop floor (materials delivered to AKOR always arrive here) to check the inventory. When the arrival date is known, the work planner can check on the right day but when only an arrival week is known, a work planner may have to check on multiple occasions, which is not ideal.

The service carpenter is given a notification when the work planner sees that the materials are delivered. The carpenter then retrieves these materials and places them in his van. When this is done, an appointment for executing the job is made with the client by the work planner or the carpenter (the carpenter plans jobs with well-known clients if the jobs only need less than about an hour). When it is time for the appointment, the carpenter travels to the client, where he executes

the job if the client is home; if not, the carpenter calls the client to direct the client to the planner or to plan the job (when the job requires less than an hour of work).

After the job is done, the carpenter cleans up and takes pictures of the finished work and sends these pictures to the planner. The carpenter then finds the client and let him or her check the finished work. The third part of the flowchart is presented in Figure 4.

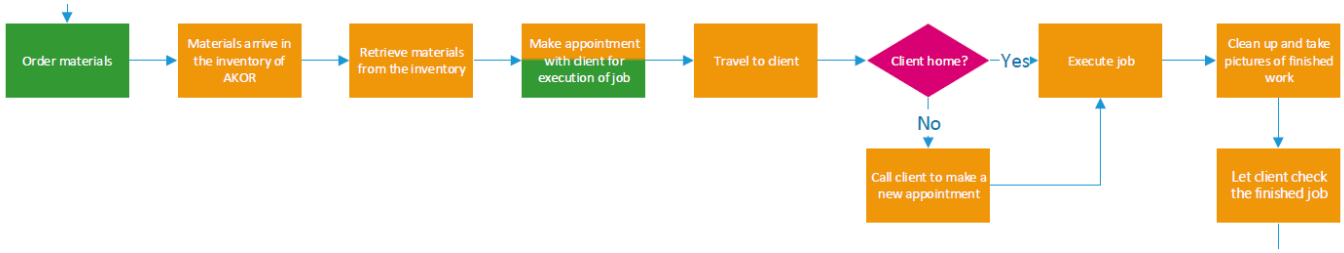

Figure 4 | Part 3 of flowchart (housing sub-department)

Part 4 of the housing sub-department process

After the client has checked the job, he or she approves or not. If the client approves, he or she signs via an application on the tablet of the carpenter. If the client does not approve the client and the carpenter(s) discuss whether it is possible to repair the job immediately. If an immediate repair is not possible, another appointment must be made; in this situation the process starts again with the planner making an appointment with the client (the job is planned by the carpenter if the job requires less than an hour of work). If the job is repaired immediately, the client signs via an application on the tablet of the carpenter. Then, the carpenter fills out the details of the job, the used materials and the hours worked on the work order, and mails this to the work planner. After this, the job of the carpenter is done. The fourth part of the flowchart is presented in Figure 5.

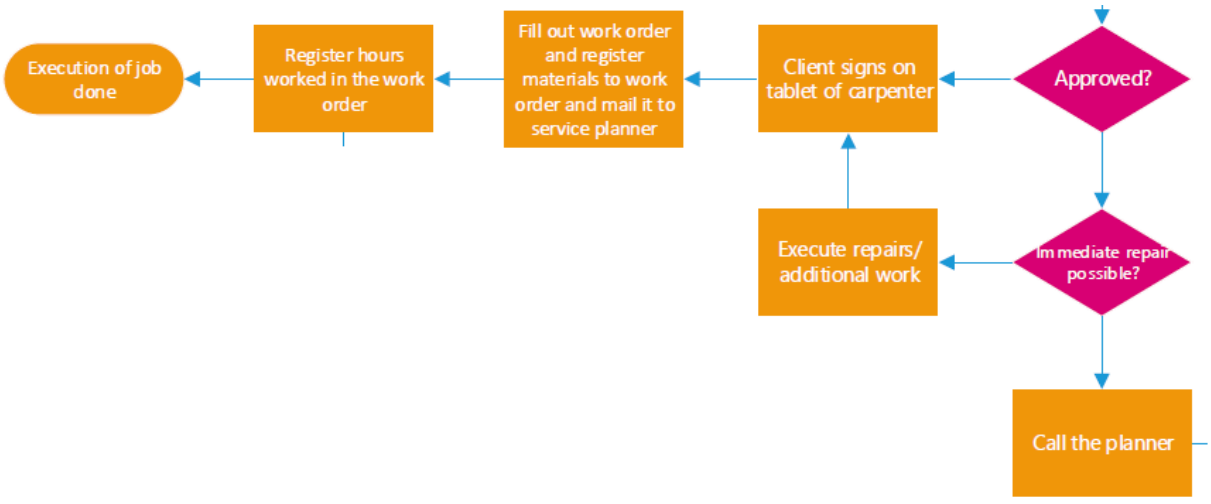

Figure 5 | Part 4 of flowchart (housing sub-department)

Part 5 of the housing sub-department process

After the carpenters' job is done, a notification of the finished work order is sent to the work planner. The work planner then registers the hours worked of the carpenter and the used materials into Vakware and the work planner registers the completed order. Then the work planner checks whether

the hours worked, and the materials are registered accordingly and edits them if this is not the case. This is done to avoid mistakes in the invoice, since mistakes in the hours worked or the materials can lead to the client paying too much or too little. If everything is approved and the hours worked, and the used materials are booked, an invoice can be made to send to the client (all the details of the job should be present before an invoice can be made). The fifth part of the flowchart is presented in Figure 6.

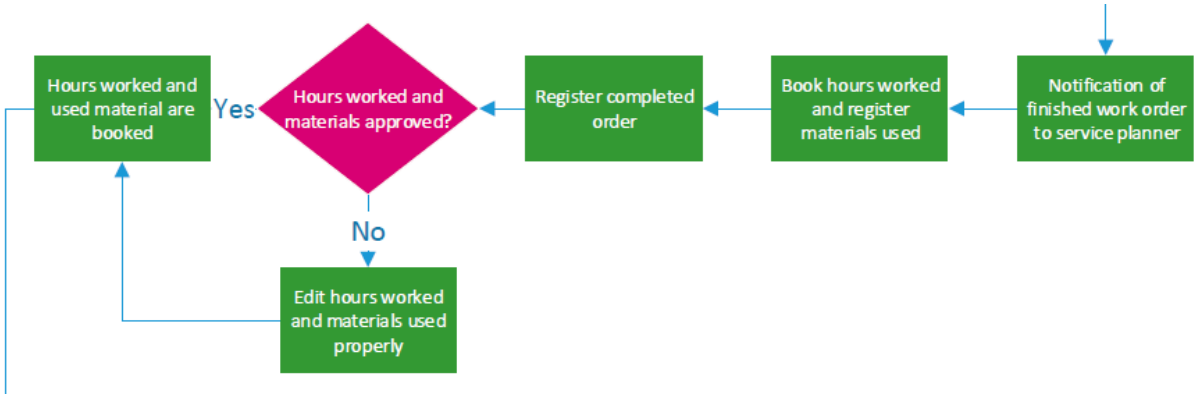

Figure 6 | Part 5 of flowchart (housing sub-department)

Part 6 of the housing sub-department process

After the hours worked and the used materials are booked, an invoice is made. To make this invoice, all the prices of the materials should be known, if they are not known already the prices should be looked up, then they must be noted on the invoice. Administration will look at the details of the job and the money spent on the job and create a test invoice. This test invoice is sent to the work planner who checks it and edits it if needed, then this invoice is created as a definitive invoice and it is sent to administration. Administration prints out the invoice and sends the invoice to the client via e-mail, which marks the end of the process. The sixth part of the flowchart is presented in Figure 7.

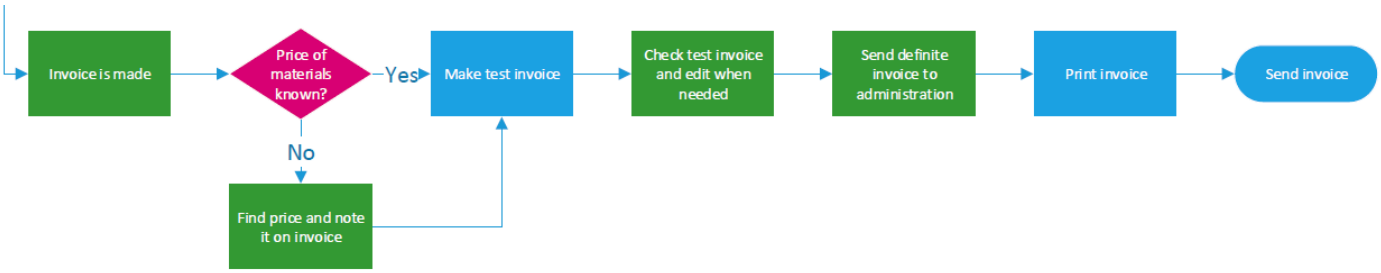

Figure 7 | Part 6 of flowchart (housing sub-department)

2.2.2 Retail

The activities in the process of the retail sub-department are covered by the administration, two work planners and three carpenters (the number of carpenters per job is dependent on the size and nature of the job).

Part 1 of the retail sub-department process

The process of the retail sub-department starts with a notification from the client via e-mail, this e-mail contains details about the job and the priority level of the job. The priority levels are rated from the highest priority (1) to the lowest priority (4), where priority levels 1 and 2 are very rare and they require service in respectively 2 and 24 hours. Priority level 3 occurs rarely as well but more often than priority levels 1 and 2; priority level 3 means that action within 5 days is needed. Priority level 4 is most common. Level 4 indicates that the job should be executed within 30 days (so the work planner can plan the job between the moment the job came in and 30 days later). The needed response times and frequencies of the priority levels are presented in Table 3.

Priority levels	Response time	Frequency
1	2 hours	0.1%
2	24 hours	1.9%
3	5 days	6.0%
4	30 days	92.0%

Table 3 | Priority levels for jobs of retail sub-department

The job is then booked in Vakware by the administration. The order number that the client has sent is added to the job in Vakware as well, this order number is needed for the administration of the job for both parties. Then the order is printed and the job is registered on the progress report. After this the work planner calls/mails the client for more details on the job. The first part of the flowchart is presented in Figure 8.

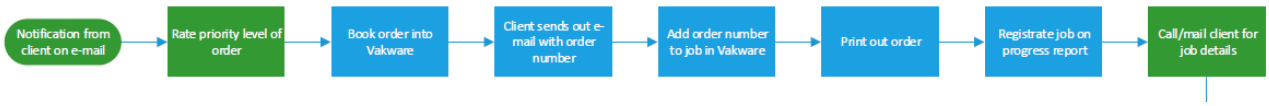

Figure 8 | Part 1 of flowchart (retail sub-department)

Part 2 of the retail sub-department process

After having received more details of the job, the definite priority is established. Since the priority is given by the client, it may happen that the priority level is not correctly rated. For instance, when the hinges of a door squeak, it is not necessary to give the job a priority level lower than 4. In about 10% of the cases, the priority level is wrongly determined by the client. When this happens, the work planner establishes the right priority level.

Then, the work planner and the carpenter(s) check whether all the materials needed for the job are present. If this is not the case, an order for these materials is placed via e-mail and a notification is sent to the client. If all the needed materials are present in the inventory at AKOR or in the van, the carpenter is contacted by the work planner and the job is planned in Excel.

When the time of the planned job has come, the carpenter(s) will gather all the materials and load them in the van. The job will then be explained further to the carpenter(s) and small materials

needed are picked up (nails, screws, bolts, etc.). The second part of the flowchart is presented in Figure 9.

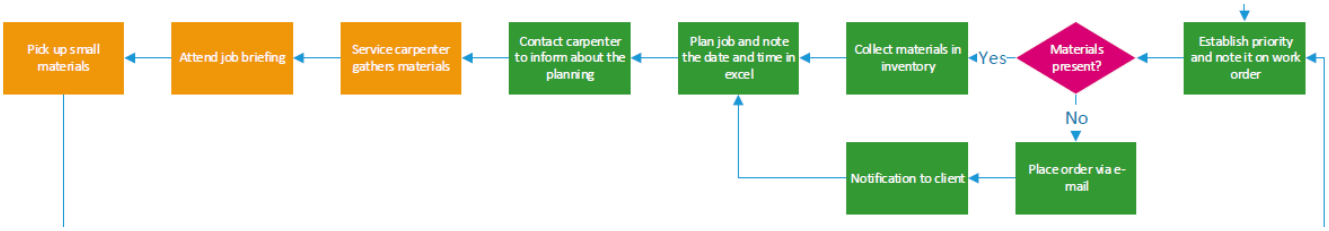

Figure 9 | Part 2 of flowchart (retail sub-department)

Part 3 of the retail sub-department process

After this, the carpenter(s) log in for the job at the customer service desk at the client via an application linked to the client. Then they get a briefing from the client about the job and they take pictures of the situation. If that is done the job is executed, after this they will fill out the work order and write down the details of the job and they update the job details in the application linked to the client. They then take pictures of the finished work and they sent these to the planner. The third part of the flowchart is presented in Figure 10.

Figure 10 | Part 3 of flowchart (retail sub-department)

Part 4 of the retail sub-department process

After having updated the application linked to the client, the carpenter(s) find(s) the client and show(s) the results of the job. The client then checks the executed job and approves or not. If not, the client and the carpenter(s) discuss whether it is possible to repair the job immediately. If an immediate repair is not possible, the application linked to the client is updated and another appointment must be made; in this situation the process starts again with establishing the priority.

If the finished job is approved or if an immediate repair is possible and executed, then the client will sign the work order on paper. Then the carpenter(s) will go back to the customer service desk and log out. The hours worked are then filled out on a paper timesheet and delivered together with the work order at the office of AKOR. This marks the end of the execution of the job by the carpenter(s). The fourth part of the flowchart is presented in Figure 11.

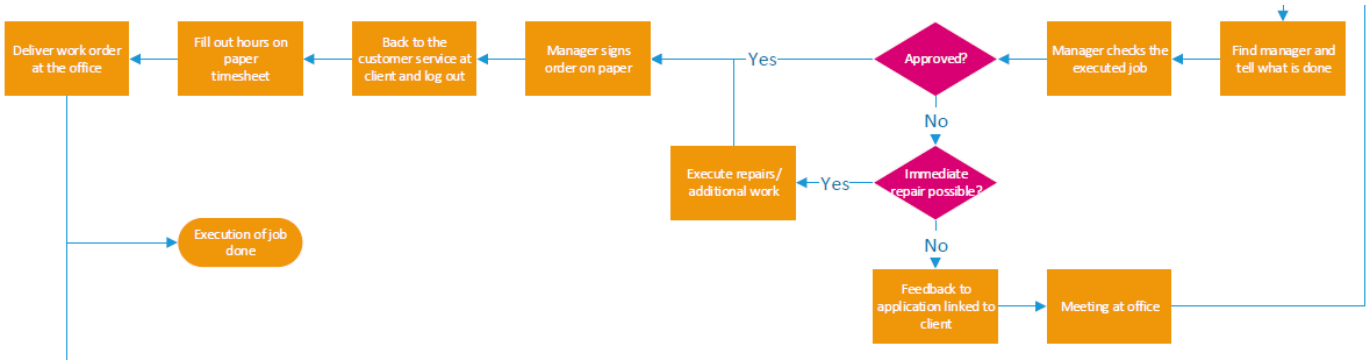

Figure 11 | Part 4 of flowchart (retail sub-department)

Part 5 of the retail sub-department process

Then, the work planner will register the executed job in the progress report and the work planner notifies the client via e-mail. The administration then books the used materials on the work order and the administration registers the used materials per order number. After this are the hours worked registered. The work orders are sent back to the work planner after the administration is done. The work planner creates input for the invoice by using the work order and progress report, this input is sent to the administration, who makes a test invoice. The test invoice is checked by the work planner and edited if needed and then sent back to the administration who sends it out to the client. The fifth part of the flowchart is presented in Figure 12.

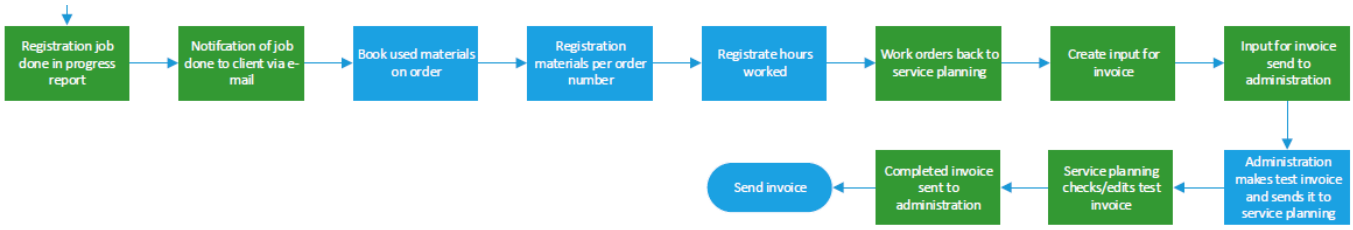

Figure 12 | Part 5 of flowchart (retail sub-department)

2.2.3 Calculation

The flowcharts described in Sections 2.2.1 and 2.2.2 are flowcharts of the processes when no calculation on forehand is needed. However, there are times in both sub-departments where the client requests a calculation before the execution of a job. In this case the work planner on the job must calculate a price before the work is done by looking at the cost of the needed materials and he needs to make an estimation of the time spent working by the work planner self and the carpenter(s). The work planner must visit the client for an inspection to determine the costs and to make an estimation of the amount of time needed. After this is done, the calculated price of the job is sent to the client, so the client can accept or refuse this price before any work is done. The planners must calculate the price of the job when the job has a turnover of more than €1000.-. These jobs happen more often at the retail sub-department than at the housing sub-department, respectively 32% and 5%.

2.3 Analysis of current throughput time

This section answers the following research questions: “What was the average throughput time per sub-department per year since 2014?” and “What/which part(s) of the processes from both sub-departments cost(s) the most time?”. The average throughput times per sub-department will be determined and information will be given on what parts of the processes cause the high throughput time. This analysis is done to determine the throughput times with certainty, since AKOR has estimated the throughput times.

2.3.1 Explanation throughput time

Since the throughput times of the processes of both sub-departments are determined in this chapter, it is necessary to first explain how throughput time is defined in this research. The throughput time is the time that has passed between the moment a job order comes in and the moment the invoice is sent to the client. The time it takes for the client to pay the invoice is not taken into consideration, since AKOR already made agreements with the big clients about the timeframe in which the payment must occur. These agreements are reviewed every year and the clients are expected to follow these agreements. These agreements will not be reconsidered during this research since changing these agreements can lead to disapproval of the clients and to change those agreements, meetings should be held with the clients to determine the best timeframe and to come to an agreement. This would all take too much time, so this research will focus on the process from the arrival of a job to the sending out of an invoice.

There are a few key moments in the processes that are taken into consideration during this analysis. These moments are respectively: Arrival of job order; job execution started; job execution finished; all details booked; and invoice sent. The time it takes between these moments is measured during the analysis.

Furthermore, there are four types of processes considered. Both the housing- and retail sub-department have two different processes: calculated and non-calculated. Calculated jobs are jobs that have a turnover of more than €1000.-. These calculated jobs require an extra step in the process, namely calculation. Calculation consists of calculating the price of a job before executing the job, the price will be sent to the client. More information about calculation can be found in Section 2.2.3.

2.3.2 Average throughput times per sub-department since 2015

The current throughput times are determined to find out more about the current situation of the service department of AKOR. These throughput times are found by using the current ERP system of AKOR (Vakware) in this ERP system all the important dates can be found of all jobs that are done since 2007. These dates can be used to determine the average throughput time per sub-department per year by subtracting the start- and end dates from each job and by then subtracting the weekends and holidays since work is only done during working days.

Only jobs from 2015 to the present are taken into consideration since the big clients that are currently responsible for about 90% of all jobs are all acquired since 2015.

Housing	2015	2016	2017	2018
Average throughput time (in days)	35.09	31.61	30.87	30.65
Number of jobs	425	406	524	657
Average turnover				
Average profit				
Total profit				

Table 4 | Data analysis of housing sub-department

Retail	2015	2016	2017	2018
Average throughput time (in days)	65.28	58.06	59.21	51.32
Number of jobs	509	497	541	473
Average turnover				
Average profit				
Total profit				

Table 5 | Data analysis of retail sub-department

Tables 4 and 5 show the average throughput times of the housing and retail sub-departments, these are respectively 30.65 days and 51.32 days during the last year. These values conflict with the estimations of AKOR, these were respectively 8 and 11 days, which indicates that the main problem they are facing in the service department is bigger than originally thought. Furthermore, the throughput time is higher for the retail sub-department than for the housing sub-department. The reason for this is that retail jobs usually take more time to execute, these jobs are executed at larger buildings and the jobs are often located further away than housing jobs. The average turnover, average profit and total profit per year are not given due to confidentiality.

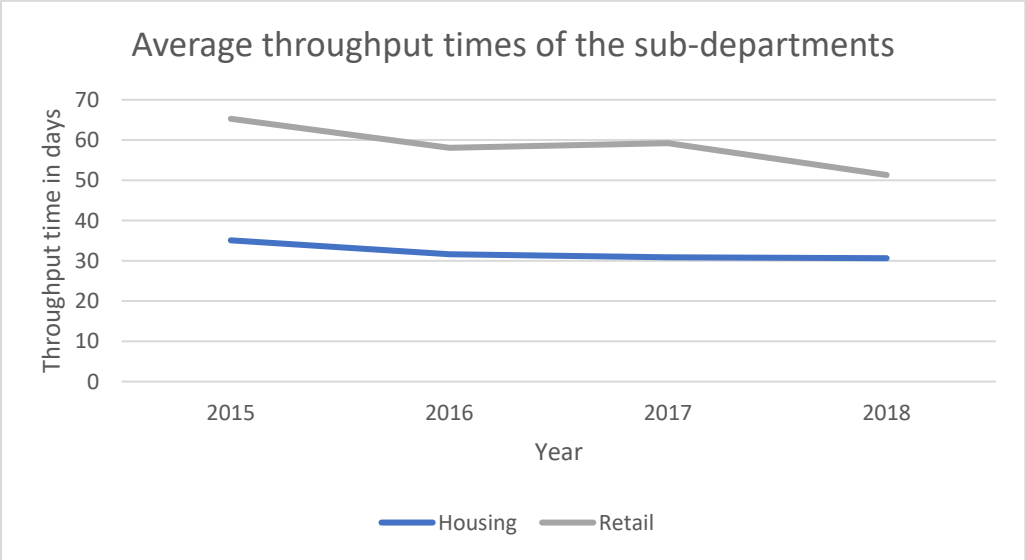

Figure 13 | Course of average throughput times from 2015 to 2018

Figure 13 shows that the average throughput time of the housing sub-department is stagnating. Which means that change is needed to make sure improvement occurs. The throughput time of the retail sub-department is dropping since 2015, from 65.28 days to 51.32 days, which is a big

improvement. However, 51.32 days is still too much. So, the throughput times of both sub-departments are still too high, which means improvement of the process is needed.

2.3.3 Further analysis of throughput time

To find out what the most time-consuming part is of the processes of both sub-departments, another analysis is made. As previously mentioned there are two processes per sub-department: “with calculation” and “without calculation”. Calculation is done when a client requests it, or when there is a large job with a turnover of more than €1000. To find all the jobs that were calculated, a filter is placed on the database for jobs that required more than €1000. This is the mandate for calculation of jobs from both sub-departments.

Calculation refers to the act of calculating prices for clients as explained in Section 2.2.3.

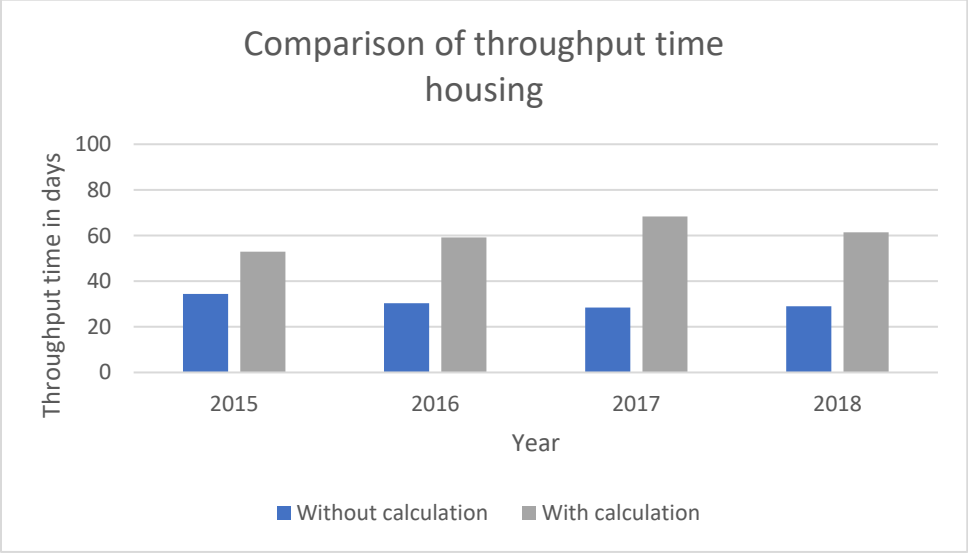

Figure 14 | Comparison between throughput times of both processes from the housing sub-department

Figure 14 shows that there is a big difference between calculated jobs and non-calculated jobs in terms of throughput time for the housing sub-department. The throughput time is much lower for non-calculated jobs (29.03 in 2018) than for calculated jobs (61.39 in 2018). This is caused by the fact that calculated jobs often take more time and since the calculation itself costs time because a visit to the client is required and because calculating the prices takes time.

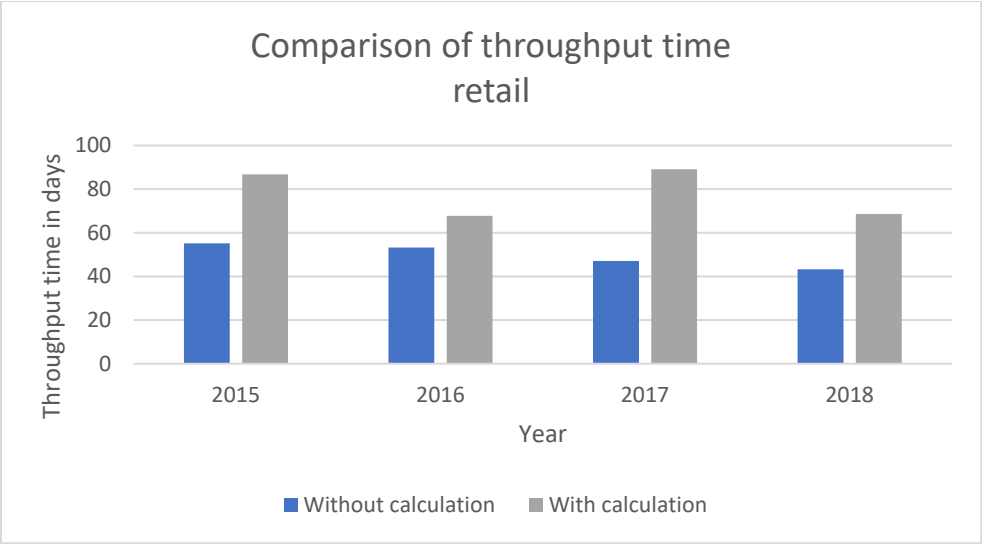

Figure 15 | Comparison between throughput times of both processes from the retail sub-department

The retail sub-department also has a higher throughput time for calculated jobs (68.68 in 2018) than for non-calculated jobs (43.26 in 2018), as can be seen in Figure 15. The higher throughput time of both sub-departments after calculation is caused by the extra time spent in the calculation process just as is the case with the housing sub-department. The larger size of the calculated jobs causes the throughput time to be higher. This is because jobs with a turnover higher than €1000 often require more hours of work than jobs with less turnover.

To make sure the organisation of the sub-departments will be improved and to lower the throughput time, it is necessary to find out which part(s) of the processes takes the longest. By finding these parts it becomes easier to improve the throughput time by solving problems in the parts of the processes that are most in need of improvement.

To do this, another look at the data is needed. 18 finished jobs per sub-department are investigated further to determine how long each part of the process takes. These 18 jobs consist of 9 calculated jobs and 9 non-calculated jobs. To make sure that there are no extreme values, only regular jobs with common job descriptions are used. This is done to make sure that the conclusion derived from this data is reliable, since extreme values that are rare do not give a good representation of the reality. And to make sure the results are not coincidental, no extreme jobs (jobs that take much longer or much shorter than the average) or emergency jobs are chosen.

All selected jobs started in 2018 to ensure the jobs are relevant. Jobs handled before 2018 may have been handled in a manner that is not used anymore.

Figures 16, 17, 18 and 19 all show the throughput times per job, each coloured part shows a different part of the respective process. The blue part depicts the time it takes from the moment an order comes in to the moment a job is technically started (technically started means when the carpenter starts working on the job or when a work planner starts calculating a job). The orange part shows the time between the start of a job to the moment the job is technically finished by a carpenter. The grey part depicts the time it takes for all the details of the job to be booked after technically finishing the job. These details are: description of the job including pictures; hours worked; materials used; hours travelled; and all contact details of both the client and AKOR. The yellow part shows the time it takes

from the moment all details needed are booked to the moment the invoice is sent to the client. When a part is absent in the figure, it means that that part took less than a day, this is not shown in the figures since the throughput time is measured in full days.

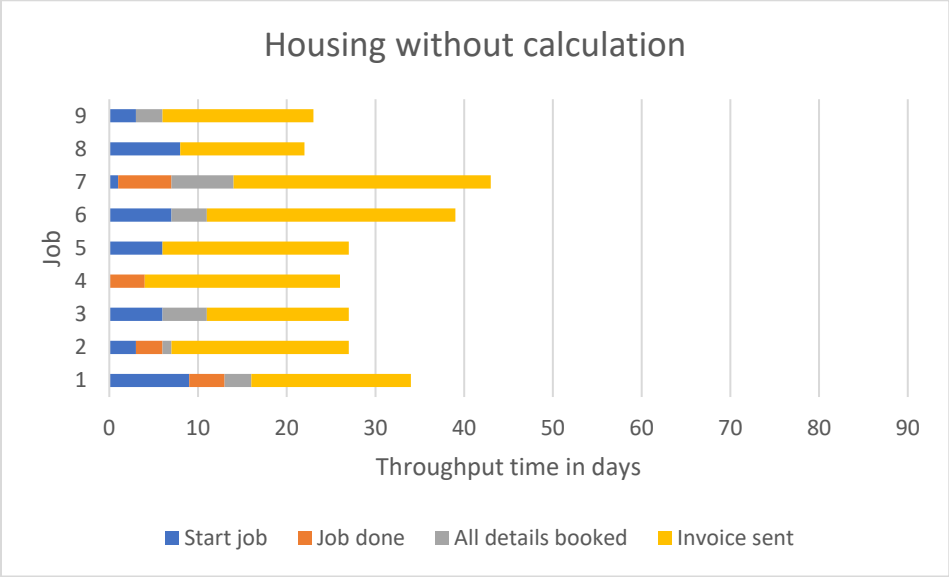

Figure 16 | Breakdown of jobs of housing sub-department without calculation

As can be seen in Figure 16, the time it takes between having booked all the details and having sent the invoice takes the longest. The time it takes to send an invoice is the most time-consuming part in each job, which indicates that this part of the process causes a big part of the throughput time.

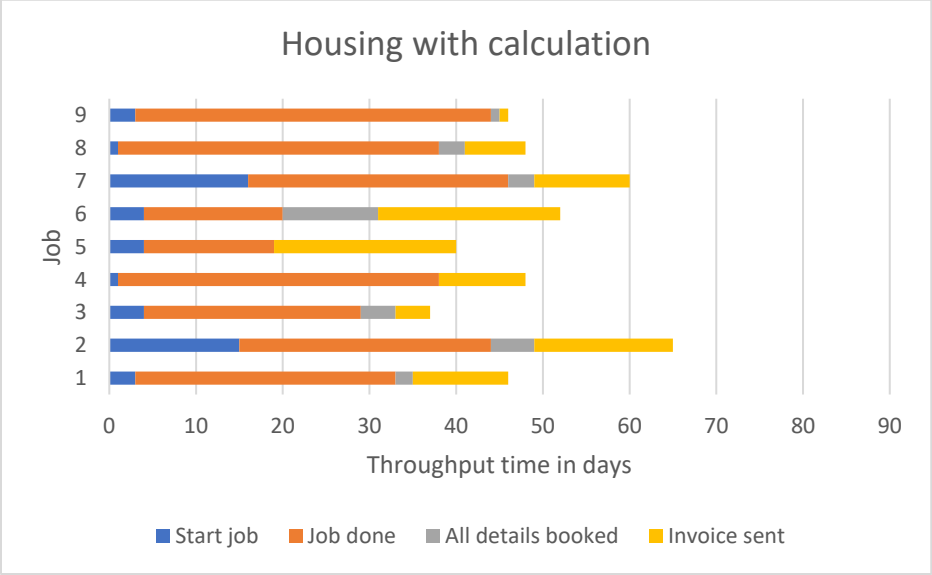

Figure 17 | Breakdown of jobs of housing sub-department wit calculation

A different trend occurs at the calculated jobs from the sub-department housing, as can be seen in Figure 17. When calculation occurs, it takes a longer time for the job to be technically finished. This is expected, since jobs that require calculation have more turnover. And if the turnover is higher, then the hours worked are higher as well. Sending the invoices still forms a problem, but not in every job

and the time spent sending invoices is not the largest part of the throughput time in this process, in contrary to non-calculated housing jobs.

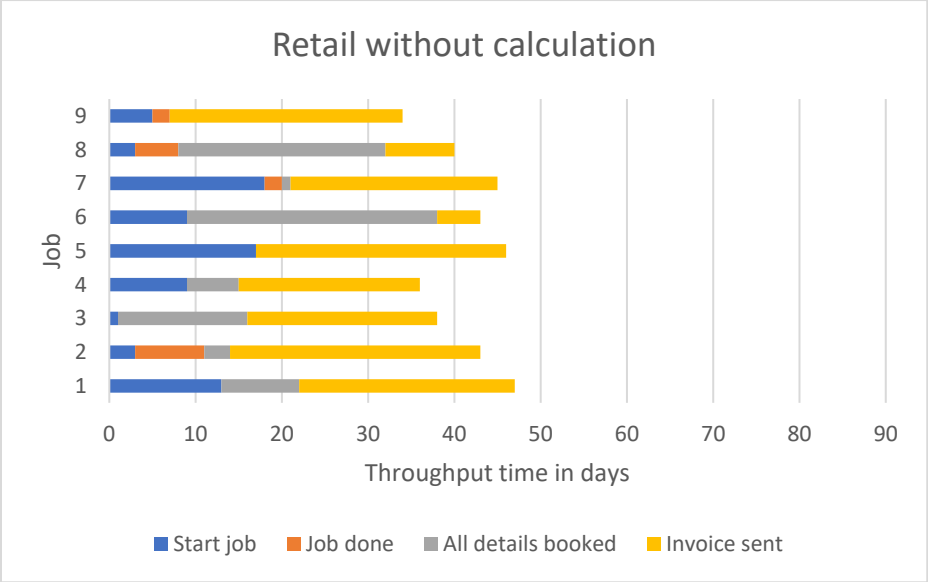

Figure 18 | Breakdown of jobs of retail sub-department without calculation

The time it takes to send an invoice is the most time-consuming part of the process in seven of the nine jobs selected, as can be seen in Figure 18. This indicates that this part of the process causes the most throughput time. However, other parts of the process also cause a lot of throughput time, especially technically starting the job and booking all the details.

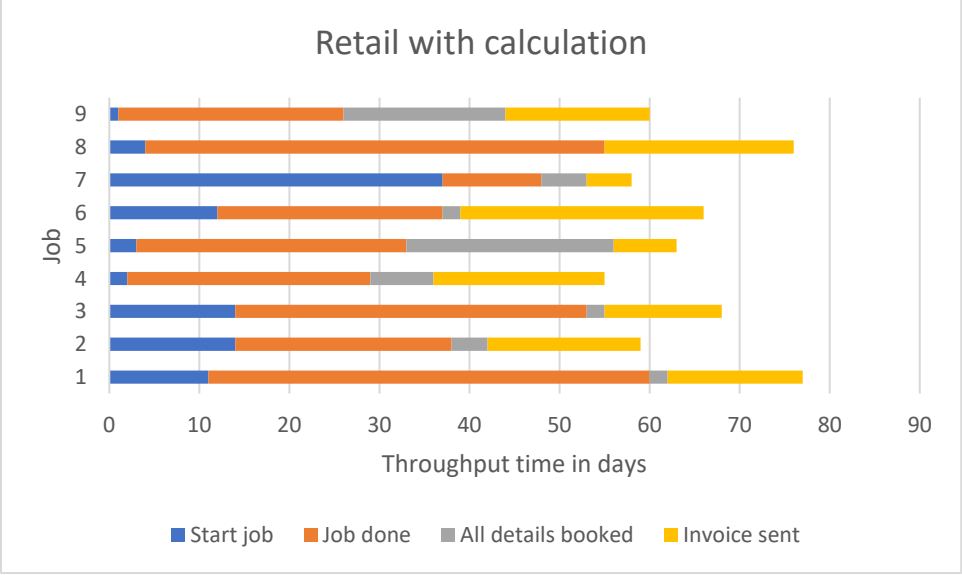

Figure 19 | Breakdown of jobs of retail sub-department with calculation

Figure 19 shows that the execution of the job takes the most time in seven of nine jobs, which means that this is the main cause of the high throughput time in this process. A similarity can be seen between the processes of calculated jobs of both sub-departments, since the execution of the job takes the most time in both these processes. The reason for this is that multiple visits are needed for executing a calculated job and more hours of work are needed.

However, it also takes longer than 10 days to technically start a job in this process, which is a long time to do nothing, and the time spent sending invoices is high as well as in all the other processes.

2.3.4 Conclusions

The throughput times of both sub-departments are very high, which indicates that improvement is needed. The throughput time of calculated jobs were for both the housing- and retail sub-department higher than the non-calculated jobs, which is due to the larger amount of time that is needed to execute a calculated job.

The parts of the processes that cause the most throughput time are: job execution for calculated jobs, technically starting the job for the retail sub-department, and especially sending out invoices for all processes.

The execution of the job is in 14 of the 18 calculated jobs the most time-consuming part of the respective processes. The time spent idle in the execution due to other appointments or multiple visits is the main cause of the high throughput time, since the visits to the client are spread over too many days. This time spent idle is considered as waste, since no work on the job is done during that time. According to the Lean philosophy, waste must be eliminated. Sometimes, this waste is inevitable due to a full schedule of the carpenter or the client.

Technically starting the job takes more than 10 days in 8 of 18 jobs from the retail sub-department, which is very wasteful. This is due to the agreed terms with company X, who are responsible for 90% of the jobs from the retail sub-department. These terms state that for a regular (non-emergency) job a response is needed within 30 days. So, when looking at these terms, 10 days is agreeable. However, for the throughput time to be lowered, the technical start of a job should be much earlier. Since every day that goes by without executing the job can be considered as waste. So, AKOR should strive to lower the days it takes to technically start a job.

Sending out invoices is the most time-consuming part of the respective process in 19 of all 36 selected jobs. It is a very time-consuming part of every researched process. This is, however, not needed. Since all details needed to send out an invoice are already booked, there is nothing to wait for with booking. The reason it takes so long now, according to the stakeholders, is that invoices are being printed and they all end up in a pile. And only when there is spare time or during a session once per month, invoices are being sent out. This means that these invoices are just lying around for the remainder of time, which is very wasteful, and this causes a large part of the high throughput time.

The reason why the invoices should go out as fast as possible is that the money to be collected by sending out the invoices is collected much later than is needed. So, by leaving the invoices on a pile, the amount of work-in-progress (WIP) adds up. If the invoices are being processed faster, the WIP is going to be lower, which gives AKOR the opportunity to use the money that is collected faster for other purposes. So, the working capital of AKOR will increase.

Goal values

The goal of this research is mainly to bring more structure and flow in the organisation. This way, the throughput time can be reduced, the efficiency can be improved and the working capital of AKOR will increase. To make this goal measurable, the desired throughput time is determined by the stakeholders at AKOR. This throughput time is 5 days for the housing sub-department and 8 days for the retail sub-department. This throughput time is based on a regular job where no calculation is needed. It may take more time if calculation is required for a job. However, due to the unpredictability of the number of visits and hours it takes to technically complete a calculated job, there is no goal value made for the calculated jobs.

This is a very ambitious goal, since, according to the data analysis, the throughput times of non-calculated jobs of the housing- and retail sub-department were respectively 29.03 days and 43.26 days in 2018. However, the goal is attainable, since the main cause of the high throughput times are the days that a job spends being idle. Ideally, technically starting the job can be done within a day and technically finishing non-calculated jobs can be done in the first visit in about 95% of the jobs. Only when the jobs require unusual materials that are not present in the inventory or the van, the job cannot be done on the first visit.

To book all details into the ERP system should not have to take long, since the cost of all regularly used materials are known and the hours worked are registered online by the carpenters of the housing sub-department. However, the hours worked are still registered on paper by the carpenters from the retail sub-department. All the other details, such as contact information and pictures, are also available from the moment the job is technically started, so booking all details needed should not take multiple days. The only reason for waiting to book all details is if not already known materials or materials from an unknown supplier are used to execute a job. Then, it is necessary to wait for the invoice from the supplier. However, according to the stakeholders at AKOR, this only happens in about 5% of all jobs.

Sending the invoices should not cause any idle time in theory, since all details that are needed for the invoice are already known and booked in the system. So, the only action that must be performed is checking the booked details and sending out the invoice to the client, which should not take a lot of time.

In conclusion, the goal values of respectively 5 and 8 days for the housing- and retail sub-department are attainable. However, it may take some time for the solution to be implemented and for the results to show.

3 Literature research

This chapter answers several research questions using literature. Section 3.1 answers the research question: “Which methodologies are suited for the research and what are the strengths and weaknesses of these methodologies?”. This research question helps choosing the right optimisation methodology. Section 3.2 provides additional information about the chosen methodology. In Section 3.3, an answer is given to the following questions: “Which Lean tools are suited for the research?” and “Which assessment criteria will be used in choosing the right Lean tool(s) for creating possible solutions?”. Based on the answers to the last two research questions, the best-suited Lean tool is chosen in Chapter 4.

3.1 Optimisation methodologies

This section provides information about the methodologies considered for implementing at AKOR, and it gives the strengths and weaknesses of these methodologies as well. The following methodologies are discussed: Optimized Production Technology, Theory of Constraints, Drum-Buffer-Rope Principle and Lean.

3.1.1 Optimized Production Technology (OPT)

OPT helps to schedule production systems to the pace dictated by bottlenecks. If the rate of activity in any part of the system exceeds the bottleneck, then items are being produced that cannot be used. If the rate of working falls below the pace of the bottleneck, then the entire system is under-utilized. (Slack, Brandon-Jones & Johnston, 2013)

OPT helps organisations reach their goal, which is “to make more money now as well as in the future”. This goal consists of three aspects:

1. Throughput: the rate at which the system generates money through sales.
2. Inventory: All the money that the system has invested in purchasing things that it intends to sell.
3. Operating expense: All the money the system spends to turn inventory into throughput.

So, the goal is to reduce operating expense and reduce inventory whilst simultaneously increasing the throughput. OPT helps reaching this goal by utilizing the bottlenecks to determine the throughput of a production process. (Goldratt & Cox, 2004)

Strengths and weaknesses

OPT reduces inventory by restricting it to certain strategic locations as determined by the bottlenecks in the process. The advantage of having little inventory is that no unnecessary costs must be made in terms of an abundance in raw materials. OPT ensures that facilities are only used when they contribute directly towards throughput, which means that the facilities are not always used to their full capacity. Although this may feel wasteful, it is not. Since always using facilities to their full capacity leads to unnecessary stock, OPT regards always letting the facilities work to their full capacity when this is not contributing to a direct throughput as a waste of time. (Ashcroft, 1989)

Another strength of OPT is that it ensures a smooth flow in the process. OPT does this by making sure the bottleneck is used to determine the input for the process, this input will never be more than the bottleneck can handle. Meaning that the bottleneck will never overflow and that the process runs smoothly. (Ashcroft, 1989)

However, OPT does have weaknesses. The first being that OPT relies on a stationary bottleneck, while bottlenecks often shift. This means that OPT may not rely on the correct facility to determine the flow of the process, which may lead to an overflow of materials at the actual bottleneck.

Also, OPT is not widely applicable, since processes that can be optimised using OPT need multiple machines and resources and they need a uniform process (i.e. production process) since a process with too many (unpredictable) variables will not have a stationary bottleneck. This means that there are many companies in different fields that do not satisfy the requirements of OPT.

3.1.2 Theory of Constraints (TOC)

TOC has been developed to focus attention on the capacity constraints or bottleneck parts of the operation. TOC follows five steps to improve the bottleneck.

1. *Identify the system constraint* – the part of a system that constitutes its weakest link.
2. *Decide how to exploit the constraint* – obtain as much capability as possible from the constraint, preferably without expensive changes.
3. *Subordinate everything to the constraint* – the non-constraint elements of the process adjusted to a level so that the constraint can operate at maximum effectiveness. If the constraint is eliminated, go to step 5.
4. *Elevate the constraint* – 'elevating' the constraint means eliminating it. This step is only considered if steps 2 and 3 have not been successful and major changes to the system are considered at this step.
5. *Start again from step 1*

These steps show the continuous improvement that TOC suggests. (Slack, Brandon-Jones & Johnston, 2013) This continuous improvement does not have an end, since after eliminating the bottleneck, a new part of the system becomes the bottleneck.

Strengths and weaknesses

Mabin & Balderstone (2003) conclude in their analysis and discussion of TOC that organisations applying TOC gained considerable improvements in important performance measures such as lead time, cycle-time, and revenue, indicating that TOC did provide a substantial source of competitive advantage for these organisations. This makes TOC a great methodology to implement, however, TOC does have weaknesses.

The first weakness lies in the fact that, like OPT, TOC uses bottlenecks as the drive of the process. So, TOC shares a weakness with OPT, namely that many companies in different fields cannot apply this methodology to their company, since there are too many different variables which are not the same during every run of the process. The variables in the process cause the bottleneck to be different every time. That makes it less appropriate for TOC to be implemented at such companies, since TOC focuses on a stationary bottleneck, such as OPT.

Another weakness of TOC is that it treats many items, such as production technology, capacity, constrained resources, product mix, demand, and prices, as fixed and inflexible. Although these items may be fixed in the short run, TOC fails to recognize the fact that in the long run each of these items is flexible. (Yayha-Zadeh, 1999)

3.1.3 Drum-Buffer-Rope methodology (DBR)

The drum-buffer-rope methodology is derived from TOC and OPT. It was originally described by Eli Goldratt. This methodology helps to decide where in the process control should occur. Goldratt & Cox (2004) say that the bottleneck in the process should be the control point of the whole process. The bottleneck is therefore called the *drum* because it sets the 'beat' for the rest of the process to follow. Because the bottleneck has the lowest productivity of all facilities, it should be working constantly. Therefore, it is sensible to keep a *buffer* of inventory in front of it to make sure that it always has something to work on. And because the bottleneck constrains the output of the whole process, any time lost at the bottleneck will affect the output from the whole process. Therefore, some form of communication is needed between the bottleneck and the input of the process to make sure that facilities before the bottleneck do not overproduce. This is called the *rope*. Figure 20 shows an example of how this methodology works. (Slack, Brandon-Jones & Johnston, 2013)

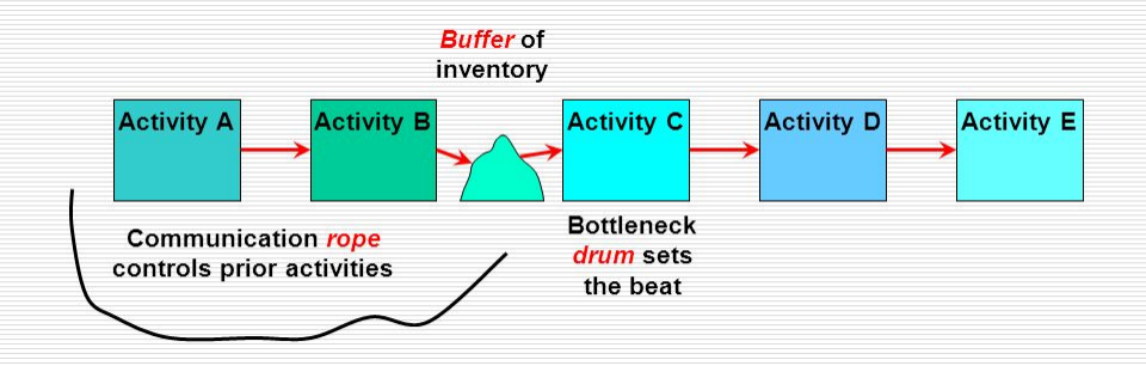

Figure 20 | Example of Drum-Buffer-Rope methodology

Strengths and weaknesses

The Drum-Buffer-Rope methodology derives from TOC and OPT, which means it shares a big part of their strengths and weaknesses. The main advantage of the DBR methodology is that it ensures a smooth flow in the process and it prevents overloading of the system. However, like OPT, it does not take shifting bottlenecks into account, which means that the DBR methodology often yields short-term success.

3.1.4 Lean

According to Slack, Brandon-Jones & Johnston (2013), Lean is not just a straight-forward methodology or tool, it is seen as three things in one: a philosophy, a method of planning and control with useful prescriptions of how to manage day-to-day operations, and a set of improvement tools.

- Lean is a philosophy:
  Lean is a coherent set of principles that are founded on smoothing flow through processes by doing all the simple things well, on gradually improving them, on meeting customer needs exactly and on squeezing out waste every step of the way. The elimination of waste is central in the Lean philosophy. (Slack, Brandon-Jones, & Johnston, 2013) Lean is not just a tool or just a one-time application, it is a philosophy which will help improve an organisation by eliminating waste and simplifying processes.
- Lean is a method of planning and controlling operations:
  Lean helps creating a smooth flow in the organisation by simplification of processes and by eliminating waste, but also by using planning and controlling tools. Uncoordinated flow

causes unpredictability, and unpredictability causes waste. Lean planning and control can help get rid of that waste by creating an organized flow. (Slack, Brandon-Jones, & Johnston, 2013)

- Lean is a set of improvement tools:
  The Lean philosophy is a set of improvement tools as well, there are many techniques which could be termed 'Lean techniques'. (Slack, Brandon-Jones, & Johnston, 2013) These tools are very useful in making sure the Lean philosophy is executed correctly. The tools are often combined when installing a Lean philosophy, since there are different tools available for different problems.

Strengths and weaknesses

An important advantage of Lean is that it is very customizable due to all the different tools it provides. This means that this methodology is applicable in a wide variety of fields and Lean provides tools for all parts of the processes of those companies. However, due to this variety it can be hard to determine what tool is the best for the respective problem a company is facing.

The core of Lean lies in eliminating waste, which is very useful since this minimizes inventory, minimizes throughput times and eliminates useless activities in every process. This reduces cost within the operation and it ensures that work within the operation is done efficiently.

Another weakness of Lean is that it often takes quite some time to implement, since many companies have employees that need to work according to the Lean methodology, which will take training and time.

Another great advantage is the improvement culture Lean installs. This improvement culture will lead managers and employees to continuously eliminate wasteful activities in processes. This culture is part of the Lean philosophy and it activates everybody in the company to keep identifying opportunities to eliminate waste.

3.2 Extra information about Lean

As can be seen in Chapter 4, Lean is chosen as the methodology to be used in creating solutions for this research. To get to know more about this methodology, further research is done in this section.

Besides the three aspects of Lean described in Section 3.1.4, there are also five essential steps in the Lean philosophy:

1. Identify which features create value:
   This step involves the determination of which features create value in the product or service, which is needed for determining which features are wasteful. (Nave, 2002)
2. Identify the sequence of activities called the value stream:
   This step is about identifying which activities create value. The entire sequence of activities is called the value stream. A determination must be made whether an activity that does not contribute value to the product or service is necessary. If it is not necessary, the activity is labelled as wasteful and it may be eliminated in step 3. However, if an activity is needed as a prerequisite to another value-added activity or if it is an essential part of the business, it should not be eliminated. (Nave, 2002)

3. Make the activities flow:
   The third step is improving flow, which aim is having a process with only value-adding activities that are unencumbered by waste. This can be achieved by eliminating the wasteful activities, that way a smooth and swift flowing process can be created. (Broft, 2017)
4. Let the customer pull the product or the service through the process:
   The fourth step is allowing the customer to pull. This means making sure that the materials or the service is only moved when the customer wants it. This improves customer satisfaction and it declines the change of inventory building up at a station/activity. (Slack, Brandon-Jones, & Johnston, 2013)
5. Perfect the product:
   The fifth step is perfecting the product. Perfecting the product means to improve continuously by keep striving for perfection, although perfection may not be possible in every case. It also means seeing failure as a possibility to improve. Lean installs an improvement culture, in which everyone from the organisation plays a part. (Dombrowski & Mielke, 2014)

These steps are executed differently for each situation, since there are a lot of tools that can be used and since Lean is applicable in many different situations. (Nave, 2002)

Causes of waste
According to Slack, Brandon-Jones, & Johnston (2013), there are 3 sources of waste, namely: muda, mura and muri, these are Japanese words conveying three causes of waste that should be reduced or eliminated. Muda contains activities that are wasteful because they do not add value to the operation or customer. Mura contains activities that are not consistent and that are not dependable, this is wasteful since this leads to different results while the activity stays the same. Muri contains activities that are wasteful because the requirements are unreasonable, which leads to a poor outcome.

These three causes are related. When a process is inconsistent (mura), it can lead to the overburdening of equipment and people (muri) which, in turn, will cause all kinds of non-value-adding activities (muda). (Slack, Brandon-Jones & Johnston, 2013)

3.3 Tools

Section 3.3 gives an overview of the tools that are suitable for the service department of AKOR and this research. The tools are chosen by searching in the literature and by discarding Lean tools that are not suitable with AKOR and this research. To make sure the tools are suitable to the research, it is important that the tool is linked to process optimization and not just optimization of one part of the process (such as Just-In-Time, since it focuses attention to inventory management). To make sure the tools are suitable with the service department of AKOR, every tool that is not compatible with the relative short jobs of the service department is discarded. This is since the jobs are not executed on the same location every time, unlike big construction projects. So, the Lean tools must be able to be implemented in short jobs. This means Lean tools such as the Last Planner System and Concurrent Engineering will not be effective.

A description of each suitable tool is given, as well as the strengths and weaknesses of each tool. These strengths and weaknesses are taken into consideration when selecting the tool that will be used for further research.

3.3.1 Standard Operating Procedure (SOP)

A Standard Operating Procedure (SOP) is a set of step-by-step instructions which describe a process. SOPs are written so that every user can clearly understand the steps of the respective process. (Wangskarn, Siritantitam, Meesri & Chiravirakul, 2016) SOPs help an organisation to create structure in their process and SOPs ensure that mistakes made by employees are kept to a minimum.

SOPs are often used to give instructions for every step in a progress, which may restrict creativity, since there is little room for experimentation. However, this can be avoided by leaving parts of the process to be variable and other parts fixed. Since the SOPs are created and not given, it is easy to implement some flexibility in some parts while keeping strict instructions for other parts. This creates the desired effect of uniformity and minimized mistakes, without losing creativity in the process.

SOPs are useful for companies that are growing, since SOPs can be used by new employees to understand the process and the job. This saves time in training and educating new employees.

SOPs are useful for implementing Lean elements in the process, it can be used to describe the process as it is, but it can also be used to describe the process after eliminating wasteful elements or after redesigning a process to minimize waste. However, another Lean tool is needed for identifying and eliminating the waste.

3.3.2 5S

5S is an originally Japanese tool which intends to organize, clean, standardize and maintain the discipline at the workplace in pursuit of sustainable improvements in the productivity, efficiency, cost optimization and reduction of waste in an organisation. This is maintained by following 5 steps, which are depicted in an overview in Table 6. (Randhawa & Ahuja, 2015)

Japanese (5S)	English (5S)	Meaning
Seiri	Sort	Discard unnecessary items from the workplace
Seiton	Set	Arrange necessary items in good order for quick retrieval and storage
Seiso	Shine	Keep the workshop swept and clean
Seiketsu	Standardize	Maintain a high standard of cleanliness and workplace organisation
Shitsuke	Sustain	Make a habit of maintaining established procedures

Table 6 | Overview of steps from 5S

5S is a philosophy for systematically achieving overall organisation cleanliness and standardization at the workplace. This is achieved by following the 5 steps given in Table 6. (Randhawa & Ahuja, 2015)

5S is very useful for creating a clean and standardized workplace, but it can only work if there is enough commitment and interest in the implementation of 5S. It often happens that some employees are not committed enough, which causes 5S to fail. This can be fixed by making commitment a requirement, but that can lead to dissatisfaction at the employees.

If there is enough dedication to 5S, it can help with creating a clean and lean workplace and this leads to better performances and shorter throughput times.

3.3.3 Pareto analysis

The Pareto analysis, also referred to as the 80-20-rule, says that 80% of tasks can be completed in 20% of the available time. The remaining 20% of tasks will take up 80% of the available time. This

principle is used to sort tasks into two parts. According to this form of Pareto analysis it is recommended that tasks that fall into the first category be assigned a higher priority. (Kaur, Aulakh & Cheema, 2011)

The 80-20-rule can also be applied to increase productivity; it is assumed that 80% of the productivity can be achieved by doing 20% of the tasks. If productivity is the aim of time management, then these tasks should be prioritized higher. (Kaur, Aulakh & Cheema, 2011)

The Pareto analysis can be used in optimisation as well. In this case, the 80-20-rule dictates that 20% of the problems produce 80% of the disruption. (Slack, Brandon-Jones, & Johnston, 2013) So, by creating a Pareto diagram, the problem(s) that occur the most should become visible. The most occurring problem(s) that together form 80% of all disruption should be solved first. This ensures that the company solves their problems in an efficient way.

There are, however, some disadvantages when using the Pareto analysis. Since Pareto analysis focuses on the problems that occurred in the past, it can happen that the past information used is no longer relevant. This can lead to solving the wrong problems.

Pareto diagrams show solely qualitative data, namely the frequency of certain problems occurring. This may lead to a wrong interpretation of what really is the problem with the largest impact, since some problems occur less but cost the most money or cost the most time lost. This can be fixed by altering the Pareto diagram in such a way it measures money or time as the factor to measure the biggest problem instead of frequency. However, this will cost more time and more data will be needed.

3.3.4 Value Stream Mapping (VSM)

The main objective of VSM is to visually show how the process works. VSM also helps to visualise the flows of materials and resources in the process. (Orihuela, Orihuela & Pacheco, 2015) VSM is a three-step tool: first a current state is depicted, then a future state is made to identify the causes of waste and the unnecessary steps in the process, and finally, the improvements needed for the future state are carried out. (Rahani & Al-Ashraf, 2012)

Figure 21 shows an example of a value stream map. A value stream is a collection of all actions that are required to bring a product through the main flows, starting with raw material and ending with the customer. The goal of VSM is to identify all types of waste in the value stream and to eliminate these. (Sunk, Kuhlang, Edtmayr & Sihn, 2016)

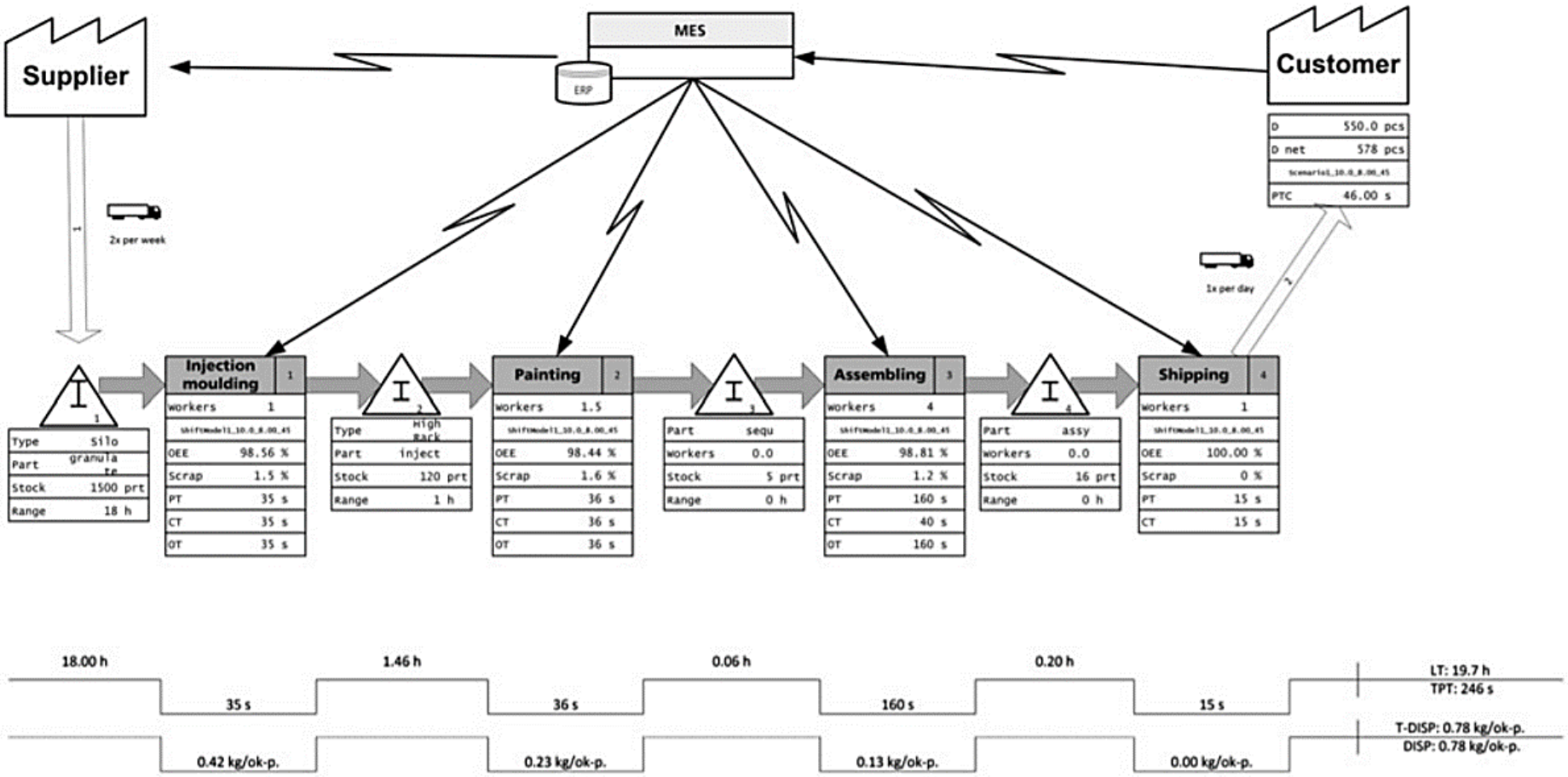

Figure 21 | Example of VSM (Sunk, Kuhlang, Edtmayr & Sihn, 2016)

VSM is very helpful for determining where waste occurs, however VSM is only possible when a lot of details of the process (such as: the used materials, cycle time, number of employees and the time needed per event) are clearly defined and fixed. Too much variation in the used materials and the needed time may cause the actions taken to be a short-term solution. A long-term solution can still be achieved if the averages of the details are taken, however, the averages should be reliable, so there cannot be too many extreme values in the details.

Another short-coming of VSM is that large complex processes, that do not necessarily start with raw materials and end with a client, may cause VSM to become too difficult. In that case, a simpler mapping tool might be more beneficial.

3.3.5 Process mapping

Process mapping provides insight into systems and processes, and it helps identify wastes and improvements using flowcharts of both the current process and the future process. Process mapping can improve the customer focus of the process, assist in eliminating the non-value-added activities and reduce the process complexity. (Soliman, 1998)

The level of mapping varies from an overview map “macro-map” to a very detailed map “micro-map”. The required level of mapping should be determined before improving a business process. (Soliman, 1998) When re-designing a process, it is important to micro-map the process and all its details, however, in some cases, just macro-mapping the process is already enough.

Process mapping is done by first setting a goal (in terms of improvement) and by determining how the current process works. This current process is mapped first. Then, the opportunities for improvement are identified. These will be the base for creating the new process. After identifying opportunities, a new improved process is mapped using the established goal and by improving the current process by eliminating wasteful elements or by re-designing current elements of the process. (Anjard, 1996)

Process mapping is very useful for identifying and eliminating wasteful elements in the process, since the flowchart of the current process made during process mapping shows all elements of the process and the flow between these elements. The made flowchart also clarifies which function does what task in the process. However, it is not as detailed as VSM, since it does not show details about materials, time, etc. This is not ideal for some processes. However, it is beneficial for processes that have a lot of variation in the materials, employees or time they need.

3.3.6 Kaizen

According to Sarhan, Xia, Fawzia & Karim (2017) Kaizen promotes the idea that every process can and should be continually evaluated and improved. This means that Kaizen stands for continuous improvement, which is very useful to every company and every process.

The Kaizen philosophy is said to be better suited to a slow-growing economy while innovation is better suited to a fast-growing economy, because kaizen means small improvements made because of continuing effort. (Cheng, 2017)

Kaizen events are any events where the results are intended to improve an existing process. A Kaizen event is a focused and structured improvement project, using a dedicated cross-functional team to improve a targeted work area, with specific goals, in an accelerated timeframe. (Cheng, 2017) The

idea behind the concept is: use kaizen techniques to achieve specific improvements in production lines but complete the improvements in a short time span. (Montabon, 2007) So, kaizen events are events that are held over a small-time span (i.e. 5 days), where improvements are made to specific processes. Kaizen events are usually combined with other Lean tools, if these tools help towards improvement.

An advantage of kaizen is that it promotes continuous improvement, which benefits processes. However, it can be hard for employees that are part of those processes to adept to all the continuous changes.

Kaizen is poorly suited for companies that are in immediate need of improvements in their process or organisation, since kaizen regularly focuses on slowly, but continuously, improving. Kaizen events are an exception, as they usually tend to focus on one or a few improvements.

4 Analysis of methodologies and tools

This chapter compares the methodologies and tools researched in Chapter 3, after this the right methodology and tool(s) are chosen for this research. Section 4.1 answers the following research question: “Which methodology suits AKOR and this research the best?”. Section 4.2 presents the selection of the chosen tool to use for solving the problem stated during this research by answering the following research question: “Which tool(s) will be used for creating a solution?”.

4.1 Selection of methodology

There are four methodologies discussed in Section 3.1, however, since not all these methodologies can be implemented at AKOR, one methodology will be chosen. The strengths and weaknesses of the methodologies as well as the compatibility with the goal and nature of the process and AKOR are considered whilst deciding.

Optimized production technology (OPT) and the theory of constraints (TOC) have a lot in common: both methodologies focus on utilizing bottlenecks as the drive for the entire process to prevent a high inventory and to ensure a smooth flow. However, both methodologies are also vulnerable to shifting bottlenecks. The methodologies are based on a process where one part of the process is the bottleneck and this bottleneck should be stationary. This is no problem in production and manufacturing processes since these processes usually have a stationary bottleneck. However, the service processes of AKOR have variables that keep changing every job, which cause the bottleneck in the processes to shift. This makes it inefficient to focus on one bottleneck in the service processes at AKOR. So, both these methodologies are not suitable for implementing in the service processes of AKOR.

The drum-buffer-rope (DBR) methodology is derived from OPT and TOC, which makes the methodology similar in some parts. An advantage of using this methodology is that little to no inventory will be wasted, so in the processes of the service department of AKOR, DBR would be useful to help get rid of abundant inventory, which reduces cost. Also, DBR can help improve the throughput time by helping the process to run more smoothly, since DBR prevents overloading of the system by letting the stationary bottleneck drive the process. However, due to the shifting nature of the bottlenecks at AKOR, it is not efficient to implement this methodology, just like OPT and TOC.

Lean provides the user with a variety of different tools, which make it a highly customizable methodology. This is beneficial since it means that it is suitable for many different goals, amongst them improving throughput time. However, all these different tools share one goal, that is to minimize wasteful events in the process. Waste is described here as time spent idle or useless hours worked or materials used. The throughput time of a process can be improved by eliminating this waste, so Lean is compatible with the goal of this research.

Since Lean contains a variety of tools that are applicable to different processes, it also useful for a process that has many variables, like the service processes of AKOR. Lean is also beneficial for creating uniformity in a process. By getting rid of wasteful events and making sure every step has as little waste as possible, Lean makes sure that the process changes as little as possible with every run. However, training and time is often needed to implement all the features and tools of Lean. This is not ideal when there is an immediate improvement needed. This does not create a problem for AKOR, since there is no immediate solution needed for the problem this research is tackling.

In conclusion, of the four methodologies discussed, one methodology comes forward as the best choice, this methodology is Lean. Lean is compatible with the goal of this research and it is applicable to the processes of both service sub-departments at AKOR. Lean is widely applicable, and it provides a variety of tools to create a well-suited solution for this research. Lean is used in many different sectors and its advantages have been proven by numerous applications in different situations.

4.2 Selection of tool

Chapter 3 describes 6 tools, all part of the Lean methodology. To proceed in finding a solution for the problem AKOR is facing, one or more tools should be chosen. These tools are chosen by giving each tool scores on various criteria. Section 4.2.1 provides information about these criteria and an explanation on why the criteria are chosen. The criteria chosen are:

- Expected time needed to implement the tool
- Expected impact of the tool
- Availability of the data that the tool requires for implementation
- Limitations of the tool
- Compatibility with AKOR

The weighted scoring method is used to assess these criteria. The weighted scoring method is a multi-criteria decision-making method used to find the relationship between the criteria and the alternatives (the alternatives are the Lean tools in this case). In this method, the weights of criteria are multiplied with the values of the tools and the sum of these scores indicate the overall score of a tool. (Muthu Baskaran, 2018)

$$Score\ of\ Lean\ tool = \sum w_i * t_j$$

Equation 1 | Formula for calculating the scores of the Lean tools

Equation 1 provides the formula for calculating the scores of each Lean tool, where w_i is the weight of criteria i and t_j is the score of tool j.

The weights given to each criterion are depicted in Table 7. The criteria are given weights between 1 and 3, where 1 is the least important criterion and 3 is the most important criterion. This decision is made in consideration with the stakeholders at AKOR. The stakeholders argue that this scale ensures enough distinction between the most important criteria and the less important criteria. The motivation for the values of the weights per criteria are given in Section 4.2.1.

Criteria	*Weights*
Expected time needed to implement the tool	1
Expected impact of the tool	3
Availability of the data that the tool requires for implementation	2
Limitations of the tool	2
Compatibility with AKOR	3

Table 7 | Weights of the criteria

4.2.1 Motivation and explanation of the assessment criteria and their weights

Expected time needed to implement the tool

This criterion is used to assess the tools on how much time is needed to implement the tool. This is important, since AKOR favours a tool that can be quickly implemented. It is more important for AKOR to get an effective tool that helps with a solution for the high throughput time than a tool that is only quick and less effective. However, it is preferable if an effective tool can be quickly implemented as well.

This criterion will be assigned a weight of 1 because although this criterion is important, it is less important than the others. This is because the stakeholders at AKOR prefer an effective tool over a fast-working tool, however, they do favour tools that can be implemented quickly. So, this criterion is important, but it is the least important of all criteria.

Expected impact of the tool

The expected impact of the tool is the degree of improvement that is achieved after implementing the respective tool. This is an important criterion since it determines whether a tool is worth implementing. However, this is the *expected* impact, which means that there is no guarantee of impact until a tool is implemented.

The expected impact of the tool is assigned the weight of 3, which means it is a very important criterion. This criterion is very important, since it measures the impact of the tool, which gives an indication of the degree of improvement that will be achieved after implementing the tool. The expected impact of the tool is assigned the largest weight, since improvement of the throughput times of the service processes is the goal of this research.

Availability of the data that the tool requires for implementation

This criterion determines whether data needed for implementing the tool is available. If this data is not available, it is not possible to implement the tool, that is why this criterion is chosen. However, if a variant of the tool can still be implemented by using other data, this tool can still be considered.

This criterion gets a weight of 2, which is an average level of importance. This is the case, because it is important to have access to all data needed when implementing a Lean tool. However, in some cases, data can be created from scratch, for instance, by timing the throughput times. That is why this criterion is assigned the average weight of 2.

Limitations of the tool

This criterion is used to assess the amount of limitations that will be faced by implementing the tool at AKOR. This criterion is chosen since a tool needs as little limitations as possible, because having too many limitations can cause the tool to cost more effort/money than it saves.

The limitations of the tool is assigned a weight of 2. The reason for this is that although it is important for a tool that there are not too many or too big limitations, since this will make the tool much less suitable. However, some limitations do not necessarily mean that the tool cannot be implemented.

Compatibility with AKOR

The compatibility of the tool with AKOR describes whether the tool is compatible with the processes

of both the housing sub-department and the retail sub-department. If the tool cannot be implemented in the processes of both sub-departments, it is not useful to implement the tool.

The compatibility with AKOR is assigned a weight of 3. This is because a tool needs to be compatible with AKOR, since the compatibility with AKOR determines whether the tool will be accepted by the users or whether the tool can be implemented in the process.

4.2.2 Scoring of the tools

The tools are given scores between 1 and 5, 1 being the worst score and 5 being the best score. These values are chosen, since it gives enough distinction between a perfect score and a bad score. The scores per tool and the total score per tool are given in Tables 8 to 13.

Standard Operating Procedure (SOP)

Criterion	*Score*	*Weight*	*Motivation*
Expected time needed to implement the tool	3	1	This tool needs preparation before it can be implemented, since research is needed, and elaboration on the SOPs is needed as well. So, there is a preparation period needed to implement the tool correctly. This period of research, and of preparing the employees will take AKOR roughly two months.
Expected impact of the tool	5	3	This tool helps clarifying the processes to the employees and it makes sure that every job is handled uniformly and via the same structure. That creates uniformity in the process, which will lower the number of mistakes made during the process and it will lower the throughput time since the employees know what to do in every step of the process. So, the expected impact is big.
Availability of the data that the tool requires for implementation	5	2	The only data needed for implementing this tool is how the processes works. This data is available, since the current process is known, and a new process will be self-designed.
Limitations of the tool	5	2	There are no relevant limitations to this tool.
Compatibility with AKOR	4	3	Although this tool is applicable to the processes from both sub-departments, it might be hard for the employees to follow the guidelines delivered with a SOP in the beginning.
Total score	50		

Table 8 | Scores Standard Operating Procedure

5S

Criterion	*Score*	*Weight*	*Motivation*
Expected time needed to implement the tool	3	1	5S is a philosophy which the employees of AKOR will need to adopt as their way of working. The adoption of the 5S philosophy cannot be installed instantly. It will take roughly one to three months to adopt the 5S philosophy and to work according to this philosophy.
Expected impact of the tool	2	3	5S will not have a large impact on the throughput time, since 5S does not improve the process, only the way of working and the cleanliness and order of the place of work. And since the place of work is often different in the service department, this cannot be affected. However, the van which the carpenters use at each place of work can be affected. Some improvement to the throughput time can be achieved by adopting the 5S philosophy, however, not enough to reach the goal of this research.
Availability of the data that the tool requires for implementation	5	2	No data is needed for the implementation of this tool.
Limitations of the tool	3	2	Since the place of work is not the same every job, it is very hard to keep it clean and organised in a lean manner, especially when the place of work is someone's house or store. However, the van that the carpenters use for inventory and travelling can be kept clean and organised.
Compatibility with AKOR	3	3	5S is applicable to the service sub-departments, however, it will be hard to implement all features due to the shifting places of work.
Total score	31		

Table 9 | Scores 5S

Pareto analysis

Criterion	*Score*	*Weight*	*Motivation*
Expected time needed to implement the tool	5	1	Since the Pareto analysis can be used immediately using the problems known, it does not take a significant amount of time.
Expected impact of the tool	3	3	This tool will have a significant impact, since it is very useful to discover the problems in a process and how often every problem occurs. This helps identifying the problems that occur the most and it can help creating a solution to tackle those problems. However, since the most impactful problems are known in this research, it will not have as large an impact as it could have.
Availability of the data that the tool requires for implementation	5	2	All data needed for implementing this tool is available.
Limitations of the tool	2	2	The data used for making a Pareto analysis consists mostly of data of the past, so the problems it measures might not be relevant anymore. A Pareto analysis measures qualitative data, since it measures how often problems occur. This might be inefficient when problems that occur rarely are responsible for a lot of costs or wasteful time spent.
Compatibility with AKOR	2	3	The biggest problems of the service department at AKOR are already known, so it is not entirely compatible during this research. However, this tool is certainly compatible when other problems in other departments of AKOR occur in the future.
Total score	34		

Table 10 | Scores Pareto analysis

Value Stream Mapping (VSM)

Criterion	*Score*	*Weight*	*Motivation*
Expected time needed to implement the tool	1	1	Since this tool depends on data which not available during this research. A lot of the needed data must be measured using instruments and it must be measured multiple times to ensure its validity. Since the timespan of this research is roughly 10 weeks it is not possible to implement this tool during this research.
Expected impact of the tool	3	3	This tool can have a positive impact on the throughput time of a process, it is however not applicable to this process.
Availability of the data that the tool requires for implementation	4	2	The data needed to make a VSM is not directly available at AKOR. However, the needed data can be measured using instruments for a large part.
Limitations of the tool	3	2	This tool depends on fixed amounts of materials, cycle time, number of employees needed and other details, which makes it not ideal for this company.
Compatibility with AKOR	1	3	Since the processes of both sub-departments have many variables, VSM is not a suited mapping tool for AKOR. The jobs differ in terms of used materials, time spent executing the job and number of employees needed, so a VSM cannot be made.
Total score	27		

Table 11 | Scores Value Stream Mapping

Process mapping

Criterion	*Score*	*Weight*	*Motivation*
Expected time needed to implement the tool	3	1	This tool can be implemented quickly if all the employees understand the new process. However, a tool or presentation to explain the new process is needed for all the employees to understand the new process. It will take roughly one to two months for the employees to understand and implement the new process accordingly.
Expected impact of the tool	5	3	Process mapping will have a big impact, since it helps change the whole process of an organization or department. It also makes wasteful elements of a process clear and it helps eliminating those elements. So, process mapping helps improving the throughput time.
Availability of the data that the tool requires for implementation	5	2	All needed data is available.
Limitations of the tool	2	2	Process mapping is less detailed than some other mapping tools, such as VSM. It shows less information about material flow, cycle times and other details.
Compatibility with AKOR	5	3	Process mapping is compatible with the processes of both service sub-departments, since process mapping does not look at unavailable data and it is not dependent on fixed materials, cycle times or personnel.
Total score	47		

Table 12 | Scores process mapping

Kaizen

Criterion	*Score*	*Weight*	*Motivation*
Expected time needed to implement the tool	2	1	Kaizen can be implemented directly. However, it will take a long time before enough improvement has occurred to reach the goal.
Expected impact of the tool	3	3	Kaizen will have a positive impact on the processes of the service department at AKOR. However, this impact is only achievable when other tools are used to continuously improve those processes.
Availability of the data that the tool requires for implementation	5	2	All the data needed is available.
Limitations of the tool	3	2	Kaizen cannot be used solely; other tools are needed as well to achieve improvement.
Compatibility with AKOR	3	3	Kaizen is compatible to any company or process, so AKOR is no exception. However, it can be hard for the employees to go from a process where hardly any iterations occur to a process of continuous improvement.
Total score	36		

Table 13 | Scores kaizen

Conclusion

Table 14 provides the final scores of each tool ranked from high to low, the tool(s) with the highest score(s) will be chosen to implement.

Tools	*Scores*
Standard Operating Procedure	50
Process mapping	47
Kaizen	36
Pareto analysis	34
5S	31
Value Stream Mapping	27

Table 14 | Final scores of all tools

So, the tools with the highest scores are the Standard Operating Procedure and process mapping. These tools complement each other nicely, since the newly created process made using process mapping can be implemented using SOPs to make sure that the steps of the newly created process are carried out correctly. This is the reason that both tools are chosen to be implemented. In conclusion, the tools that will be implemented in the solution of this research will be process mapping and Standard Operating Procedures.

5 Solution

This chapter gives the solution for the main problem faced during this research, which is that "The average throughput time of the service maintenance process at AKOR is too high". This is done by using the tools determined in Chapter 4. Section 5.1 explains the design of the solution and what solutions AKOR is already implementing. Section 5.2 presents the flowcharts describing the new processes from the housing and retail sub-departments, as well as an explanation of the choices made during the design of the new processes. This section answers the following research question: "How can the selected tool(s) be used to create a solution?". Section 5.3 gives an implementation plan on how the new processes can be implemented, this is done by presenting the standard operating procedures and explaining how these will be used to implement the new processes. Section 5.4 gives an educated estimation of the results from implementing the new processes. The research question answered in this section is: "What are the expected results of implementing the solution?".

5.1 Design of the solution and solutions AKOR is already implementing

This section elaborates on the solutions AKOR is already implementing or planning to implement and it will elaborate on how the solution in this research will be designed.

Solutions AKOR is implementing

AKOR is changing multiple processes next to the service process and one of these changes directly influences the service department and this research, namely the implementation of a new ERP system. This is a big change, so the new ERP system will be regarded in this research.

The new ERP system will be implemented together with the solution of this research, so the new ERP system and the solution created in this research will need to complement each other. This makes it important to take a closer look at the new ERP system.

The ERP system that the service department will use is a combination between AFAS[3] and Bouw7[4]. The service department will operate in Bouw7, which will have its own application for the employees of AKOR to work in. The changes in the process that the ERP system will have are:

- All the materials and hours worked, and other details will be registered digitally in the ERP system.
- Planning will be done in the Bouw7 application instead of in Outlook.
- Carpenters and service planners can place pictures and details of the job directly in the work order in the new ERP system.

These changes will be carried over to the new process designed in this research. How these changes are carried over is presented in Section 5.2.

[3] For further information about AFAS see: https://www.afas.nl/
[4] For further information about Bouw7 see: https://www.bouw7.nl/

Solution of this research

To improve the throughput times of the process from both the housing- and retail sub-department changes in the organisation of these processes should be made. Chapter 4 shows that the Lean tools *process mapping* and *standard operating procedures* are the best-suited tools to use for AKOR.

Process mapping will be used first. The flowcharts of the current situation will be used to identify the wasteful elements in the current processes. Elements that will not be needed anymore due to the new ERP system will be identified as well. These elements will be eliminated, replaced or altered, depending on whether the element has no specific use anymore or if the element can be altered in such a way that it will reduce waste.

When this is done, the remaining, replaced and altered elements will all be organised differently. They will be organised in such a manner that the processes flow as smoothly as possible. This flow will be presented in new flowcharts made of the new process. These flowcharts will form the basis of the standard operating procedures (SOPs).

The SOPs will consist of the steps in the process along with extra information about what must be done at each step. There will be an SOP made for each function. There are multiple tasks per function. That is why the SOP of each function will contain of multiple parts describing each separate task. Separate SOPs are not given per task to avoid having too many separate documents per function.

Since the employees will be working with a new ERP system, they will need explanation on how to use the new ERP system. However, this ERP system cannot yet be accessed. This means that no screenshots can be made of the system. These SOPs will help the employees involved in the housing- and retail sub-departments understand the new processes and the SOPs will make sure that the employees make as little mistakes as possible and work as uniformly as possible.

5.2 Alteration of current processes

Changes and eliminations in the current processes must be made to design new processes for the housing- and retail sub-departments. The changes and eliminations for respectively the housing- and retail sub-department are determined in Section 5.2.1 and Section 5.2.2.

The calculation part of the processes is not taken into consideration. This decision has been made in consideration with the stakeholders at AKOR. The stakeholders at AKOR requested that the calculation jobs will not be taken into consideration due to the limited time available.

The flowcharts of the processes from the housing- and retail sub-departments are divided into three parts to keep an overview of the processes that needs improvement. The first part shows the process until the carpenter travels to the appointment, the second part shows the process until the carpenter's job is done and the third part shows the process until the invoice is send out. The changes to both processes are determined per part of each process. After the changes per part are described and explained, the newly designed part of the future process is given. This is done to keep an overview of the changes in each part.

Recall that the flowcharts of the processes from both sub-departments can be found in Appendices 1 and 2. Also recall the legend explaining the different shapes and colours in the flowcharts of the current process, these are presented again in Tables 15 and 16. These legends are also applicable to the flowcharts from the new processes.

Colours	Function
	Administration
	Service planner
	Carpenter

Table 15 | Legend functions

Shapes	Type of event
Rounded rectangle	Start/end point
Rhombus	Decision
Rectangle	Regular event

Table 16 | Legend shapes

5.2.1 Alteration of the process from the housing sub-department

This section shows the changes made to the process from the housing sub-department, the changes made are described and motivated per part of the process. This section also provides the new process of the housing sub-department.

Changes made in the first part of the process from the housing sub-department

The first part of the process from the housing sub-department starts with an order coming in and ends with a notification to the housing association of the made appointment. This part is presented in Figure 22.

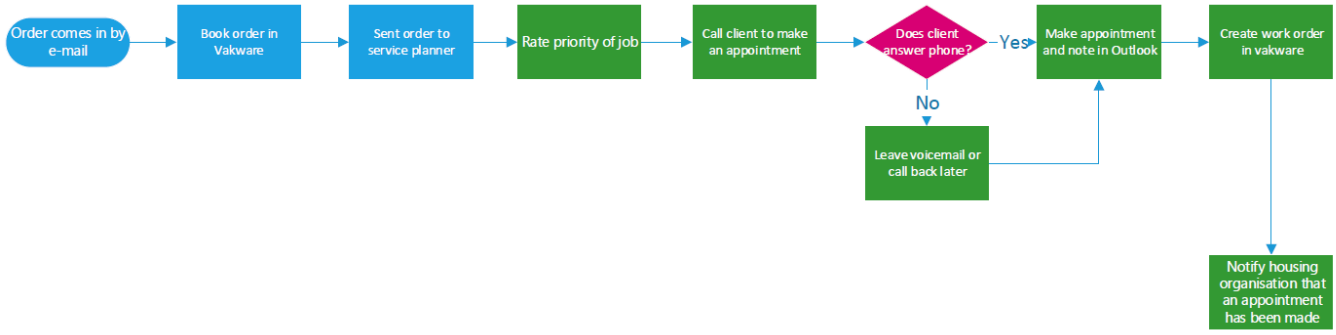

Figure 22 | First part of the current process of the housing sub-department

The first part of the current process shown in Figure 22 consists of preparing the job for the carpenters by planning the job and creating a work order. The process starts with an order coming in by e-mail, this step will be changed. The order will still be coming in via e-mail, but also via phone calls to a specific phone number linked to the service department of AKOR. The e-mail address on which AKOR can be contacted for a service job will also be a separate e-mail address linked to the service department. This decision is made because it makes sure that the process starts from the same point every time which creates uniformity and that no jobs are missed or forgotten since all jobs arrive at the same location.

Another change made to the beginning of the process is that the order will be coming in with a priority. AKOR will make it a prerequisite for the housing association and other clients to give a priority level. The priority levels are already agreed upon with the housing association, so the planners at AKOR will know the time available for the job. This is done to eliminate the wasteful activity of calling the client for a job description to determine the priority of a job when this is not clear.

The order will still be booked, but not in the current ERP system (Vakware). Recall that the current ERP system will be replaced with a new ERP system, this new ERP system is a combination between AFAS and Bouw7. Bouw7 will be the platform on which the service department will work, so an order will now be booked and planned in Bouw7. Bouw7 will ensure that all orders are open to all stakeholders of the process, so sending orders or details to other colleagues will no longer be needed.

The steps of checking if the materials that are needed are known and ordering those materials if needed are added to the process to improve the amount of jobs that can be executed during the first visit. When an order comes in, a description of the job is given as well. This description contains information about what needs to be repaired or replaced, so the materials needed for the job can be determined. However, not all descriptions are elaborated enough or give enough information about the type of materials. So, if the description contains enough information about what materials to use, then those materials are ordered immediately or gathered from the inventory whilst loading the van before traveling to the client. The amount of jobs that need multiple visits because the carpenter does not have the needed materials are reduced by adding these steps. This improves the throughput time since an extra visit that could be avoided is very wasteful and can add multiple days to the throughput time.

The client will still be contacted by the planner to make an appointment. This will not be changed since planning is still needed and letting clients plan themselves using a web-application will cause the planning to be inefficient and chaotic.

The flowchart of the current process shows a decision point where the client answers the phone or not, as seen in Figure 22. This will not be added into the flowchart of the new process, since this is more detailed than needed for a process map, especially since details will be added into the standard operating procedure.

The end of the first part of the process is marked by a notification sent to the housing association to inform them that an appointment has been made and when that appointment will take place. This is still needed in the new process, since the housing association wants to know when the job they

ordered takes place. The housing association does not know this instantly, since appointments are not directly made with the housing association but with the clients. The jobs are at the houses of the clients that rent the house from the housing association. These clients are the people that must be home at the time of the appointment and they are the ones who need the job. So, the appointments are made directly with the clients.

After having identified and described the changes needed in the current process, a new process is made. The first part of the new process from the housing sub-department is presented in Figure 23.

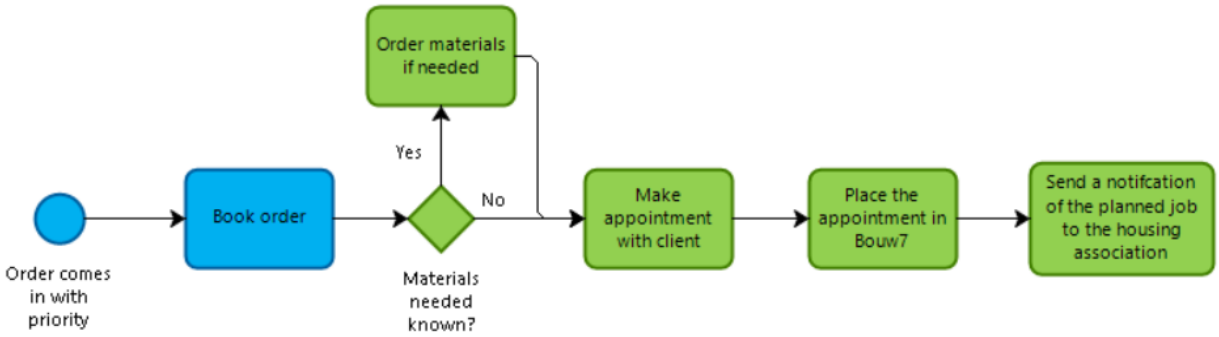

Figure 23 | First part of the new process for the housing sub-department

Changes made in the second part of the process from the housing sub-department

The second part of the current process starts with the carpenter noticing the appointment and it ends with the carpenter registering all details. This part consists of the execution of the job, the function that is mainly responsible for this part is the carpenter. The second part of the current process from the housing sub-department is presented in Figure 24.

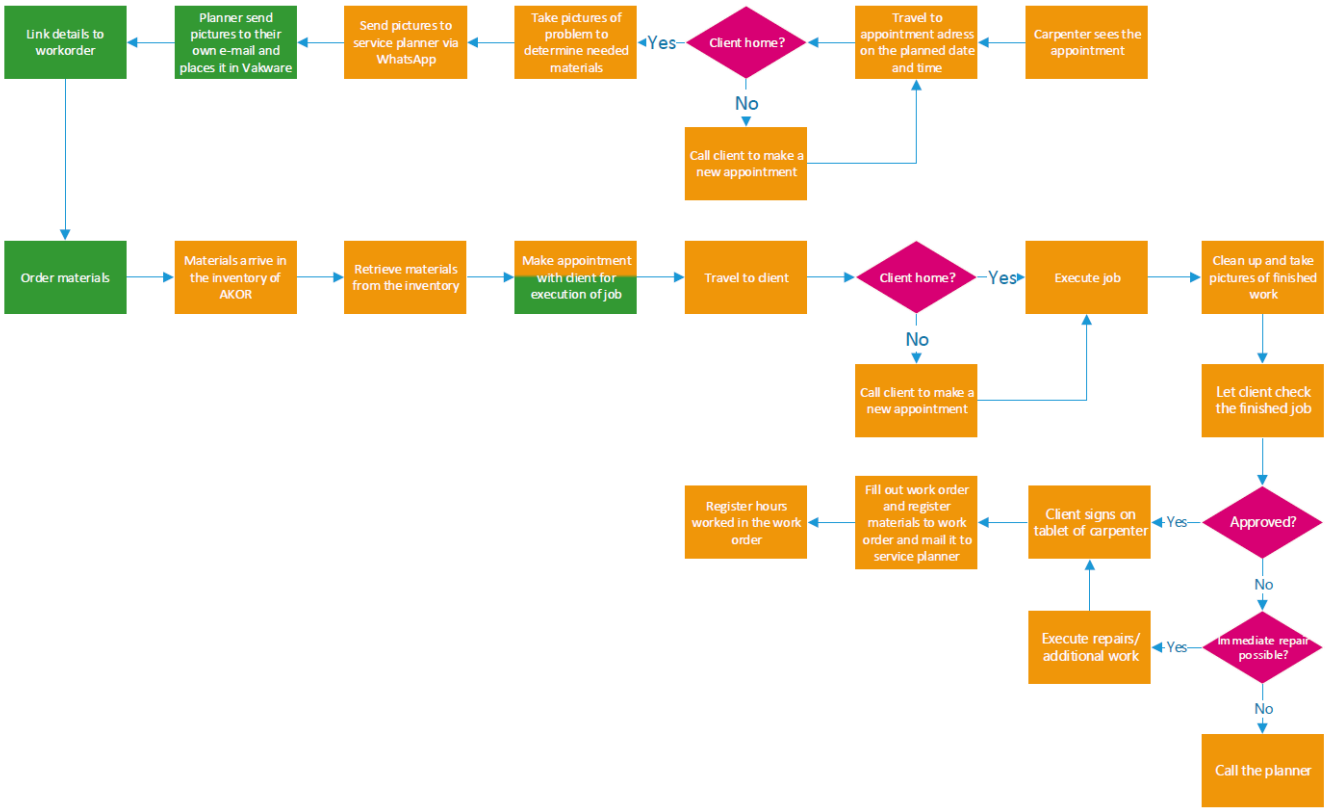

Figure 24 | Second part of the current process of the housing sub-department

The first wasteful element of the current process from the housing sub-department that needs improvement is that the carpenter travels twice to the client. The first visit is for gathering information about the job and the second visit is for executing the job. This is wasteful, since there is a lot of time spent between the first visit and the second visit. It would be ideal if all the jobs can be executed in the first visit, however, this is not possible when certain materials are not available during the first visit. Although, it is possible to maximize the amount of jobs that can be executed during the first visit. To do this, a well-organized inventory is needed with a register that contains the names, prices and other details of all materials used often. However, this is not further elaborated or worked out, since inventory management is beyond the scope of this research. This research does help with the amount of jobs being finished in the first visit. This is done by letting the carpenter determine the needed materials and by then checking whether the job is possible. If it is possible, the job gets executed right away. If the job is not possible, the missing materials are noted in Bouw7 and the planner will then order them and make another appointment with the client. The appointment for a second visit which requires less than an hour of working is made by the carpenter in the current process, however, this will not be done in the new process. Since planning should be done by an employee that is trained to plan to minimize inefficiency in planning. Also, ensuring that the planning is done by one function creates a clearer flow and a more organized process. These changes can be found in Figure 25, which shows the second part of the new process from the housing sub-department.

Another change is that very detailed steps are no longer shown in the flowchart of the new process from the housing sub-department. This is done to keep the flowchart clear and easy to understand. The details of the process that are worth mentioning will be added in the standard operating procedure.

Due to the new ERP system, all the details and pictures do not have to be send via e-mail or WhatsApp anymore, since the details and pictures added by the carpenters on the Bouw7 application will become instantly available for the planners and administration at the office.

There are some aspects of the process that will not be changed. A signature by the client is still needed since this is required by the housing association and to ensure that the client is happy and that the job is executed in correctly.

The second part of the new process from the housing sub-department is presented in Figure 25.

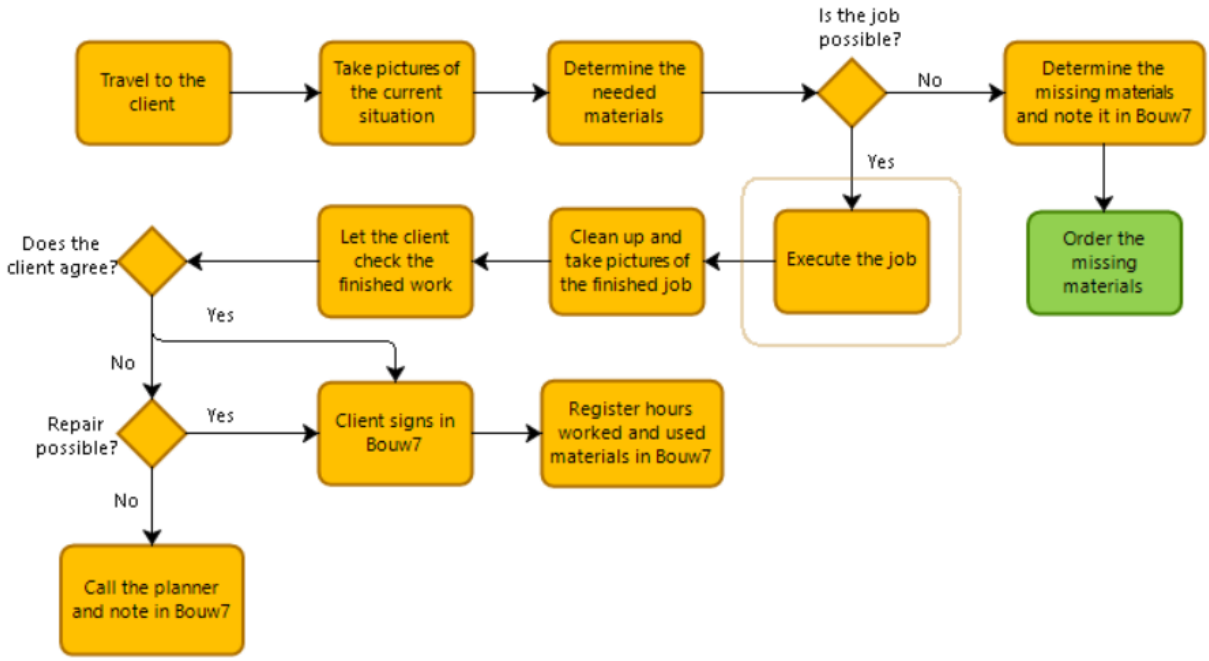

Figure 25 | Second part of the new process for the housing sub-department

Changes made in the third part of the process from the housing sub-department

The third part of the current process starts with a notification of the finished work order to the service planner and it ends with sending the invoice. This is the final part of the process from the housing sub-department and it contains the administrative part of collecting all details of the job needed and making an invoice. Figure 26 presents the third and final part of the process.

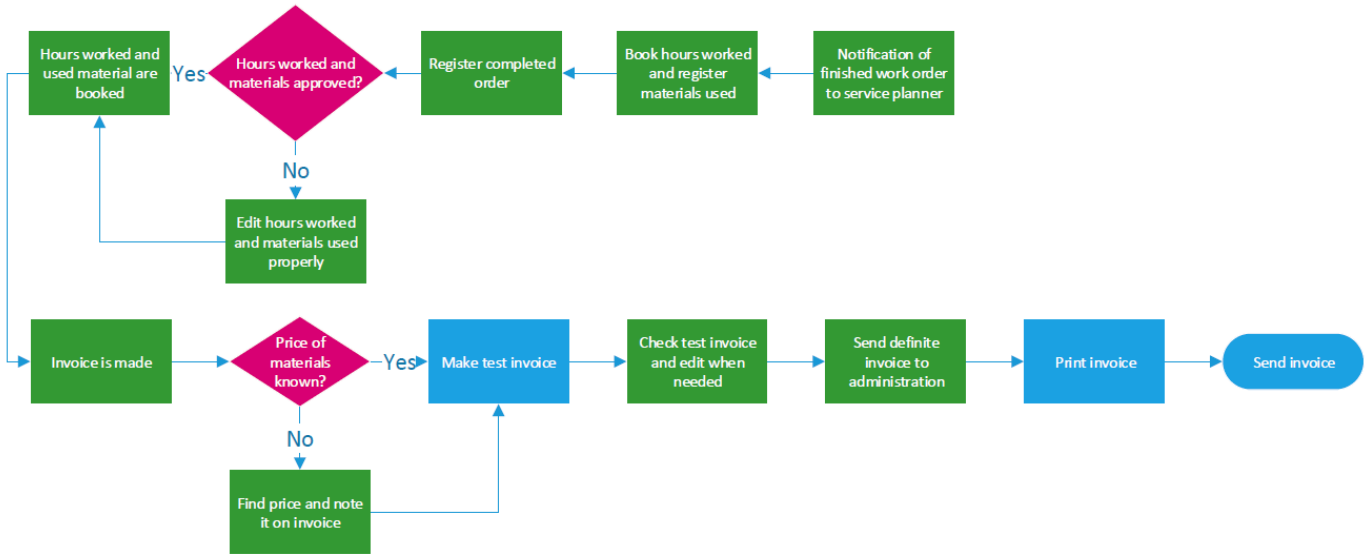

Figure 26 | Third part of the current process of the housing sub-department

The first change in this part is due to the new ERP system, since this system ensures that the hours worked, and the registered material are already booked when the carpenter registers them, since the details of the job are registered in the Bouw7 application. The Bouw7 application directly updates the order, so the planners do not have to book additional data, which saves time. The planners will only have to check if the hours worked and the used materials registered by the carpenter are

correctly registered. This change can be seen in Figure 27, which shows the third part of the new process from the housing sub-department.

Sending a notification to the planner is not needed as well, since the Bouw7 application works with build-in notifications when details are registered.

The next change is that the planner will not have to search for the prices of materials anymore when these are not directly known. This will be done by administration in the new process. The administration has enough knowledge to do this, since the used materials are already determined. This means that the only task left is finding the right prices in the register of AKOR or in the registers of the suppliers. The reason that the administration will perform this task is that the planner will then have more time to perform the primary tasks, like planning, ordering materials, and maintaining client relations. When the planner has more time for these tasks, the planner will also have more time to plan efficiently. Also, the task of finding prices when these are not immediately known is often neglected by the planner, because this task is seen as less important than the other tasks. So, invoices will be sent out faster and neglected less by moving the task of finding the correct prices to the administration. Especially since administration will see this task as necessary, since it needs to be done before they can send out the invoice, which is one of the main tasks for the administration.

Another change is that the planner will not have to check the invoice before sending it out anymore, since the planners already checked all the details before the invoice is made. So, another check will not be necessary.

Printing the invoice before sending the invoice will not be included in the new process. All invoices will be sent out using e-mail, to save paper and to save time. This saves time because sending out printed invoices via postal mail costs significantly more time than sending out invoices using e-mail.

Figure 27 presents the third part of the new process from the housing sub-department.

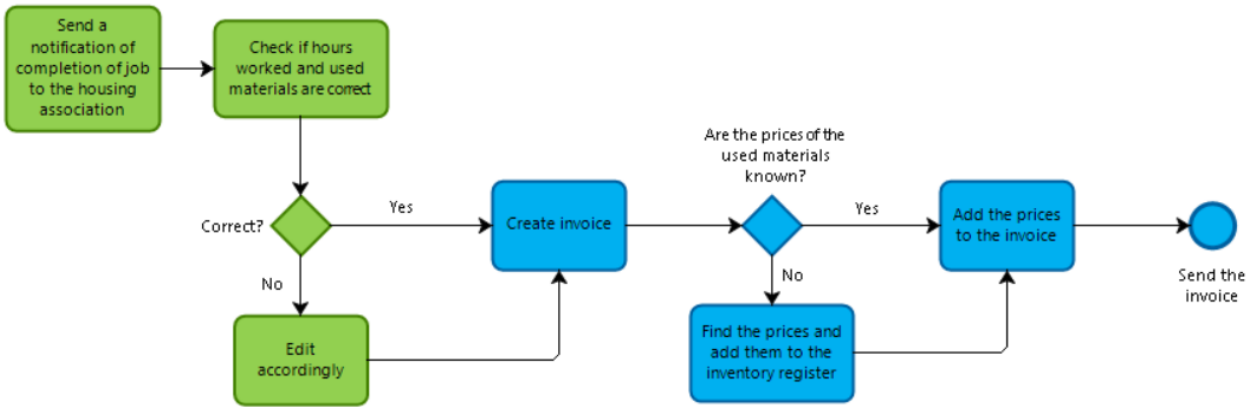

Figure 27 | Third part of the new process for the housing sub-department

The third part marks the end of the new process. Figure 36 in Appendix 3 provides the flowchart of the total process, combining the three parts.

5.2.2 Alteration of the process of the retail sub-department

This section shows the changes made to the process from the retail sub-department, the changes made are described and motivated per part of the process. This section also provides the new process of the retail sub-department.

Changes made in the first part of the process from the retail sub-department

The first part of the process from the retail sub-department starts with an order coming in and ends with contacting the carpenter to inform him or her about the planning. This part is presented in Figure 28.

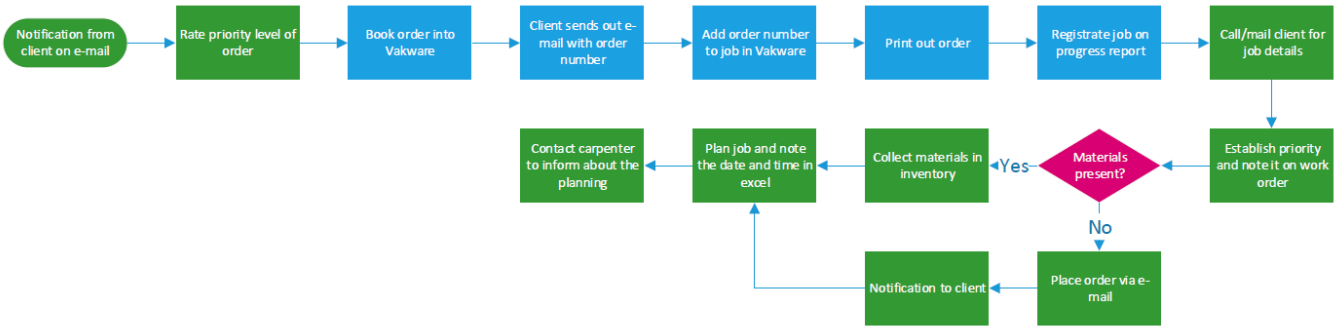

Figure 28 | First part of the current process of the retail sub-department

Many of the changes made to the current process from the retail sub-department are the same as the changes made to the housing sub-department. This can be seen in Figure 29, which presents the first part of the new process from the retail sub-department. The flowchart seen in Figure 29 shows many similarities with the flowchart of the first part of the new process from the housing sub-department presented in Figure 23. The reason and explanation behind the changes applied to both new processes can be found in Section 5.2.1. Changes applied to both new processes are not explained in this section to prevent repetition.

However, not all the changes made to the current process of the retail sub-department are the same as those made to the current process of the housing sub-department. The first change that differs is that planners will not be the recipients of the job anymore. This is the case in the current process. This was needed since the clients did not give the priority of the job when sending the order, so the planners had to rate these themselves. However, the priority level will be sent along the order in the new process, so there is no need for the planner to rate this anymore. So, these orders will now arrive in the e-mail inbox or on the phone line of the service department at AKOR. After this, the administration can immediately book the order without having to wait for the planners to rate the priority level, which causes less waste.

Another change is that the planning will not be done in excel anymore. This is due to the new ERP system, so the planners from the retail sub-department will plan in the Bouw7 application. Also, there is no additional phone call needed to the carpenters, since the Bouw7 application, that all stakeholders have access to, notifies the stakeholders of a planned job.

There is no need for printing orders as well, since the progress report will not be needed anymore. All the progress and details of the job will be available for the stakeholders to find in the Bouw7 application.

These changes delivered the first part of the new process from the retail sub-department, presented in Figure 29.

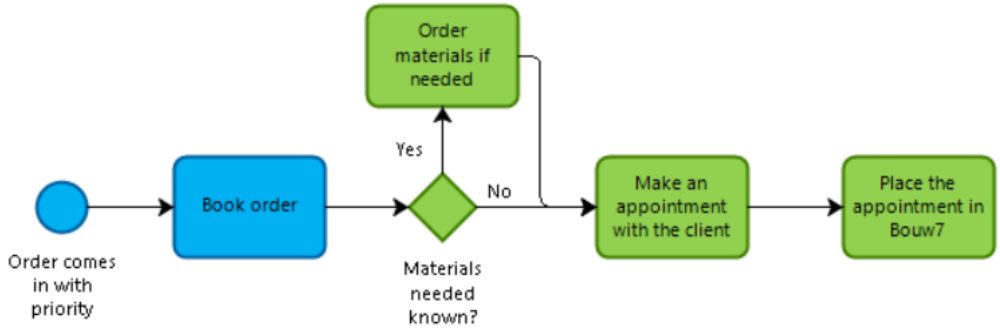

Figure 29 | First part of the new process for the retail sub-department

Changes made in the second part of the process from the retail sub-department

The second part of the current process starts with the carpenter gathering the needed materials and it ends with the delivering the work order at the office. This part consists of the execution of the job. The function that is mainly responsible for this part is the carpenter. The second part of the current process from the retail sub-department is presented in Figure 30.

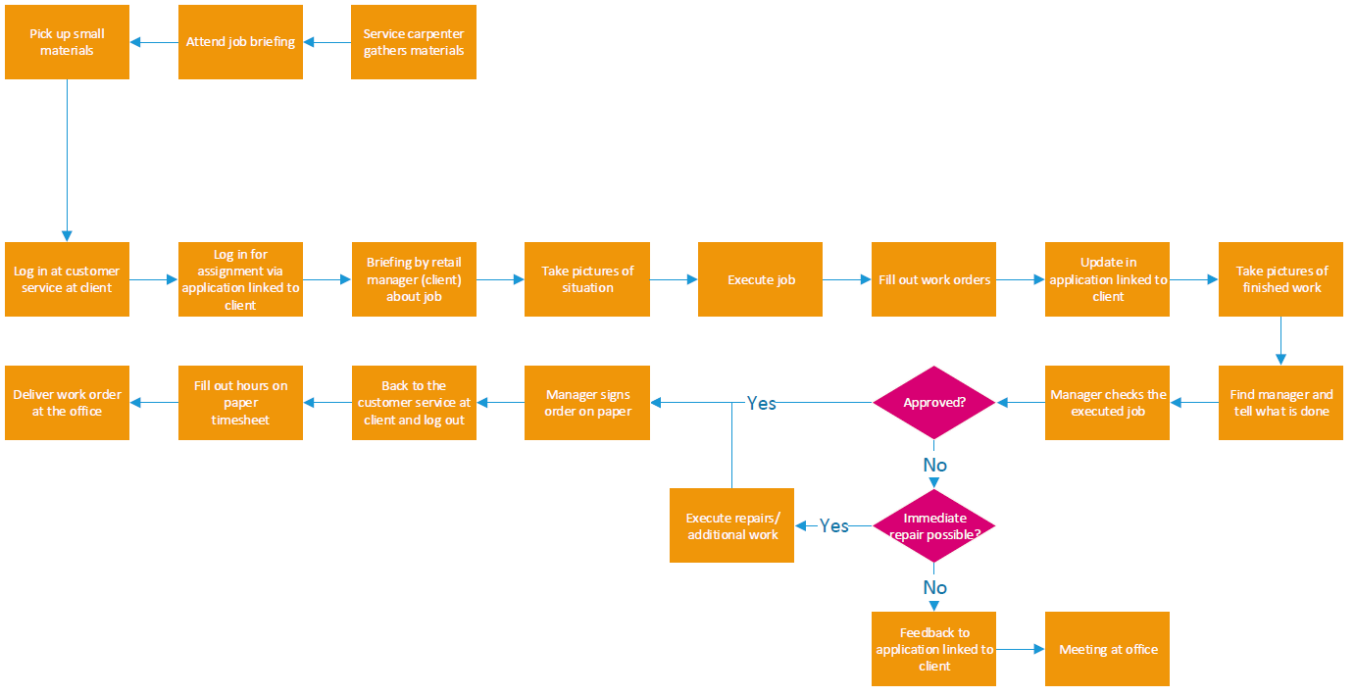

Figure 30 | Second part of the current process of the retail sub-department

The first change is that the moments were the application linked to store X should be used, is displayed as a grey box as seen in Figure 31, since there are more clients than just store X and these clients do not use their own application. However, store X does deliver the most work, about 90%.

The next change is that a decision moment is added into the flowchart. This is a check whether the right materials are present. This did not feature in the current process, since the materials are almost always determined correctly beforehand by the planners. This will still be the case in the new process, as can be seen in Figure 29, however, the decision point featuring the check whether the

right materials are present will serve as a control moment. If the materials ordered or gathered are not the right materials, it is important that the situation is handled in a well-organized manner to prevent more mistakes or wasted time.

The paper timesheets containing the worked hours and the paper orders containing all the used materials and details will no longer be needed. This is due to the Bouw7 application, the carpenters will be using this application to register all details needed online without the use of paper. Also, pictures of the job can be uploaded to the Bouw7 application as well, so these will not be sent via WhatsApp or another media application anymore. This will save time, since the carpenters will not have to deliver the paperwork to the office anymore, and the administration/planners will not have to type all details into the order.

These changes are used to create the second part of the flowchart from the new process of the retail sub-department, this is shown in Figure 31.

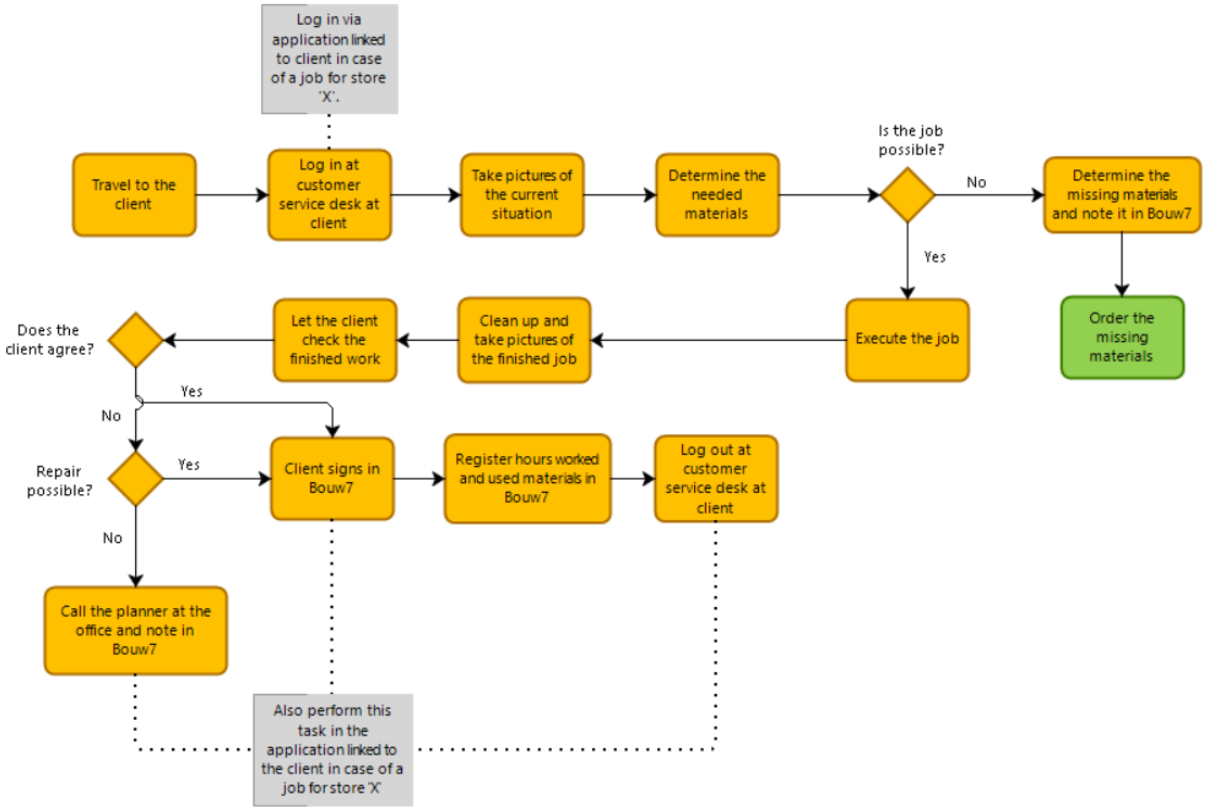

Figure 31 | Second part of the new process for the retail sub-department

Changes made in the third part of the process from the retail sub-department

The third part of the current process starts with the registration of the finished job in the progress report and it ends with sending the invoice. This is the final part of the process from the retail sub-department and it contains the administrative part of collecting all details of the job needed and making an invoice. Figure 32 presents the third and final part of the process.

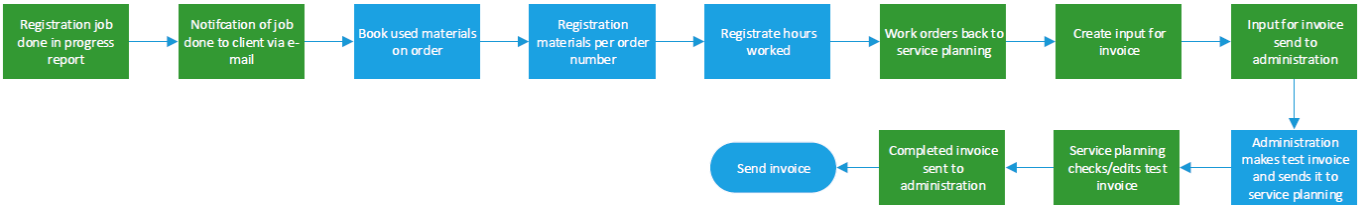

Figure 32 | Third part of the current process of the retail sub-department

As mentioned earlier, the progress report will no longer be needed due to the automatic progress registration of the Bouw7 application. This means that this event will not be present in the flowchart of the new process from the retail sub-department.

Another important change is that the order will not be sent back and forth between the administration and the planners, since the Bouw7 application will make the order available for all stakeholders. Also, after the planners checked whether the hours worked and used materials are correct, their job is done. This is done to ensure that every employee in the function can finish their work without having to wait for other employees to send the order back or to finish their work, which will improve the throughput time because there is less time wasted waiting.

The carpenters will register all the details needed to make an invoice on the Bouw7 application, so the planners will no longer have to create the content for the invoice. The planners will only have to check if the details are registered correctly and edit them accordingly if this is not the case. This causes the planners to have to spend less time on administrative tasks, so the planners will have more time to spend on planning jobs and their other tasks.

The changes described are used to create the third part of the new process from the retail sub-department shown in Figure 33. Figure 37 in Appendix 4 presents the flowchart of the whole new process from the retail sub-department.

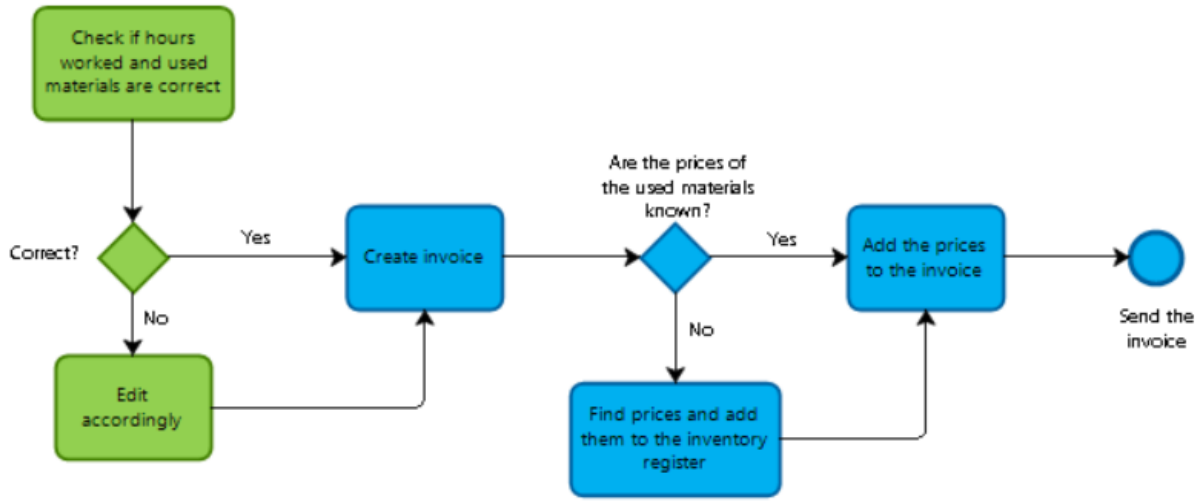

Figure 33 | Third part of the new process for the retail sub-department

5.3 Implementation of Standard Operating Procedures

Various standard operating procedures (SOPs) are made to implement the new process into the service department, these SOPs can be found in Appendix 5. This section explains how the SOPs will be implemented into the service department and it gives further elaboration on the SOPs and how they are designed.

5.3.1 Further elaboration on the Standard Operating Procedures

There are 5 SOPs made, one for each different function, the different functions are: administration, planners (housing), planners (retail), carpenters (housing) and carpenters (retail). There is only one SOP for the administration, this is done because the tasks that the administration must perform are the same for both sub-departments. There are 2 SOPs for each of the other 2 functions: planners and carpenters. The reason for this is that there are some differences in the tasks of the functions when the job is a housing job or a retail job. All SOPs can be found in Appendix 5. This section will give further elaboration on the SOPs and what additional information they provide to the steps of the new processes.

SOP for the administration

The first SOP is to be used by the administration. This SOP describes the tasks that the administration has divided into two parts. These parts are the 'arrival of the job' and 'sending the invoice', these mark respectively the start and the end of the processes for both sub-departments. Information on which tasks the administration have in the new processes and why is given in Section 5.2. However, the SOPs give additional information to these tasks, which is described in this section.

The administration must check whether the information of the job given by the client is elaborated enough. This must be done since gathering as much information as possible increases the chance that all needed materials can be determined correctly, which helps finishing the job on the first visit. Finishing the job on the first visit as much as possible improves the throughput time, since an extra visit costs a lot of wasteful time.

The administration must keep updating the inventory register during their job if materials are not yet registered. This will save a lot of time, because the administration will no longer have to wait for invoices from suppliers if the materials including prices are already present in the inventory register. Also, updating the inventory register continuously will ensure that carpenters can easily select used materials from the inventory register instead of having to add them manually.

SOPs for the planners

The SOPs for the planners consist of three parts: planning, ordering materials and preparing the order. The SOP for the planner from the housing sub-department and the SOP for the planners from the retail sub-department do not differ a lot. This can also be seen in the flowcharts of the new processes from both sub-departments (Appendices 3 and 4). The only difference is that the planner from the housing sub-department must send notifications to the housing association of a job being planned and of a job being finished. This is done for the housing association, since the appointment is made with the clients, who rent their home from the housing association. So, the housing association wants to be updated on all work that is done to their houses. This is not the case for the retail sub-department, since the clients are the stores, so the planners and carpenters directly work with the people responsible for the store.

The SOPs provide additional information on the planning part of the process. The information needed for planning a job and how to use that information is given to make sure that the planners all plan within the timeframe and that they order needed materials in time. By making sure that the planners will not have to figure out what priority needs to be assigned to the job, they can plan a job faster and always within the timeframe that the client desires, since the client gives the priority.

SOPs for the carpenters
The SOPs for the carpenters consist of three parts as well: preparation of the job, execution of the job and administration of the job. The SOPs for the carpenters of both sub-departments are very similar. The only difference is that the carpenters of the retail sub-department are required to log in and log out at the customer service desk of the store that they are working for. Also, the carpenters also must log in and out on the application linked to the client when they are working for store X, they also must update the progress in this application. This is demanded by store X for all work done in their locations.

The SOPs for the carpenters contain information on how to start the job. This includes checking the Bouw7 application to find out where and when the next job is and to find out what kind of job it is. The carpenters can check the description of the job including pictures of the current situation. This helps the carpenters prepare for the job, so that they can start executing the job as fast as possible, which reduces throughput time.

The carpenters will need less time for registering all details needed, especially due to the new ERP system. However, since this task will change for the carpenters, additional information on how to work with the application and what they need to do with the application is given. Detailed steps on how to work with the application cannot be given, since the application is not yet available for the AKOR.

5.3.2 Implementation of the Standard Operating Procedures

The implementation of the SOPs is unfortunately not possible in this research due to the time limit. However, it is possible to formulate how to implement the SOPs, which is done in this section.

Separate presentations per function should be given to make sure that every stakeholder understands what the SOPs entail for them. Giving a presentation helps the stakeholders accept the SOPs and it gives them a chance to understand the logic behind it and the improvements that will come along with the SOPs. This means that it is very important to explain the positive effects.

After the presentations are held and after the stakeholders understand the SOPs, it is time for the implementation to really begin. The SOPs will be printed and laminated, these SOPs will be given to each stakeholder to hold and use as a guide to the new process. The stakeholders will get digital copies as well, which is especially beneficial for the carpenters, since they will not have to carry around a piece of laminated paper to every job. So, by just checking the SOPs, every stakeholder will always know what the next step in the process is.

5.4 Expected results of implementing the new processes

Since implementing the new processes using the SOPs is not possible during this research and since this is not a simulation study, no hard results in terms of throughput time can be given. However, an

educated estimation based on the change of the processes can be made, which is done in this section.

The new processes from both sub-departments will be implemented using the SOPs in Appendix 5. The improvement in throughput time is estimated by looking at the new process of each sub-department and estimating the time it takes for a regular non-calculated job to flow through the process. These estimations are based on the time each task in the process takes. Since the goal is measured in days, the estimations will be measured in days as well.

Estimation of the throughput time from the housing sub-department
The process starts with an order coming in and being booked by the administration. The order coming in will be checked first, to make sure all needed details are included. Checking the order does not take a significant amount of time, however, if the details must be determined by contacting the client, it may take longer. The time it will take to determine these details may vary, if the client cannot be contacted right away it is assumed that it can take up to a day before contact has been made. So, the throughput time for this part is 0-1 days.

The job can be booked when the details are known, this takes no significant amount of time since the order can be “dragged” into the new ERP system.

Then, the planners determine the needed materials based on the description of the job and the pictures send by the client. This does not take a significant amount of time. However, the needed materials must be ordered if the needed materials are not present in the inventory of AKOR or in the van of the carpenter(s). Ordering these materials and waiting for them to arrive may take multiple days, depending on the type of materials and whether the supplier has them in stock right away. If the supplier does have them in stock (which is the case in a regular job), it will take about a day for the materials to arrive. However, if the needed materials are present in the inventory of AKOR or in the van of the carpenters, it will take no significant amount of time to collect these. So, the throughput time for this part is 0-1 days in the case of a regular job.

Contacting the client to plan the job may take 0-1 days, since it is assumed that coming into contact with the client may take up to a day. Planning the appointment does not take a significant amount of time, since all details needed are directly known and the planning shows when which carpenters are available. After this, a notification must be sent to the housing association of the planned job, which takes no significant amount of time as well. So, the throughput time for this part is 0-1 days.

The job will be started again when it is time for the carpenter to execute the job, the time this takes varies. Jobs with high priority will be executed in a day, however, normal jobs must be executed within 15 days. However, a job can be executed in less days, an estimation for this is 2-8 days for regular jobs. The first visit is possible within 2 to 4 days, however, if another visit is needed to complete the job, it may take an additional 4 days to execute the job. Since the regular non-calculated jobs are small jobs, a third visit is highly unlikely. The estimate for the time it takes for the carpenter to reach the client is within 2 to 4 days, since the jobs for the housing sub-department are regularly close to AKOR. These jobs are close to AKOR since the housing association which are the owners of the houses of almost all clients only owns houses within the vicinity of Rijssen, where AKOR is based. So, the throughput time for this part is 2-8 days.

Regular jobs without calculation can be fixed within the first visit if the client is home and if the needed materials are present, so the execution can take 0-1 day depending on what the job entails.

The planner must check the registered hours worked and used materials that the carpenter has registered in the Bouw7 application. This took some time in the current situation since the planner puts this task on hold before handling it, since other tasks were seen as more important. However, this task is important, since it needs to be done before an invoice can be made and send out. So, to improve the throughput time, it is important that the details registered by the carpenter are checked and edited when needed within a day. This is certainly possible, since the task of checking and editing the hours worked and the used materials does not take a significant amount of time. So, the estimated throughput time for this part is 0-1 days.

After the planner has checked and edited the details needed, an invoice is made by the administration. Sending this invoice does not take a significant amount of time if the prices of the used materials are known. However, if the prices are not known, they must be determined first. The prices must be added to the inventory register as well. This does not have to take a significant amount of time.

The total throughput time of the new process from the housing sub-department is estimated by adding up the estimated throughput times per part, the total estimated throughput time is 2-12 days.

Estimation of the throughput time from the retail sub-department
The process from the retail sub-department does not differ a lot from the housing sub-department, so the throughput time estimated for the tasks from the process of the housing sub-department can be used to estimate the throughput time for the process of the retail sub-department.

The planners from the retail sub-department do not have to send notifications to a housing association, so these tasks will not be executed by the planners from the retail sub-department. However, these tasks do not cost a significant amount of time, so this does not subtract any days from the estimated throughput time of the process from the retail sub-department.

The carpenters from the retail sub-department must log in and log out at the customer service desk at the client and via the application linked to the client if the job is for store X. The carpenters must update the details of the job in the application linked to the client as well if the job is for store X. However, these tasks do not take a significant amount of time as well, so the estimated throughput time of the process from the retail sub-department does not increase due to these extra tasks.

The priority level of a regular non-calculation job for the retail sub-department requires the job to be finished within 30 days instead of the 15 days for the housing sub-department. This does not mean that the estimated throughput time of the process should be higher. However, the jobs of the retail sub-department are often located further away than jobs executed by the housing sub-department. This is because a lot of stores from store X and other clients are located across the Netherlands. This means that the planners must account for more travel time, which means that less jobs can be planned per day. So, more days will be spent before the carpenters travel to the client. An estimation of the amount of days that should be added to the estimated throughput time of the retail sub-department can be made by calculating the mean values of the time it takes for a job to be started in

both sub-departments. This is done by using the values for the throughput time it takes for a job to be started per sub-department given in Figures 16 and 18 in Chapter 2 for respectively the housing- and retail sub-department. These values can be added and divided by 9 to calculate the average time it takes for a non-calculated job to start per sub-department. These values are for respectively the housing sub-department and the retail sub-department: 4.8 and 8.7. The difference between these averages is 3.9. This difference in days gives an indication of the extra time needed for a job from the retail sub-department to be started. Adding this difference to the estimated throughput time of the new process from the housing sub-department gives an estimation of the throughput time of the new process from the retail sub-department. So, the estimated throughput time of the new process from the retail sub-department is 6-16 days.

5.5 Conclusion

The new processes are designed by using the Lean tool: Process Mapping. Appendices 3 and 4 present these new processes. These processes are created by eliminating and altering the steps in the current processes according to the Lean methodology. These eliminations and alterations led to a shortened process with fewer steps and an organisation where each task of every function is clearly defined. Standard Operating Procedures (SOPs) are created as well, to give more insight on how to execute each task. Appendix 5 provides these SOPs. The SOPs will help the employees follow the newly designed process correctly, and it will ensure that the employees do not forget about tasks or when to provide other functions with details about a job.

By using the data analysis made in Chapter 2 and by analysing the new processes, educated estimates of the new throughput times are made during this research. These were for respectively the housing sub-department and the retail sub-department: 2-12 days and 6-16 days. Which is a large improvement compared to the current throughput times of respectively 30.65 days and 51.32 days for the housing sub-department and the retail sub-department

6 Conclusion, recommendations and discussion

This chapter contains the conclusions, recommendations and discussion of this research. Section 6.1 gives the main findings of this research. Section 6.2 presents the recommendations derived from this research given to AKOR. Section 6.3 contains a critical discussion on the limitations and repercussions of this research.

6.1 Conclusion

The main action problem of this research is that the throughput time of the service department at AKOR is too high. The service department consists of two separate sub-departments, namely the housing sub-department and the retail sub-department. These sub-departments had different throughput times, which were discovered during this research, namely 30.65 and 51.32 days for respectively the housing and retail sub-department. The throughput times estimated of the new processes from the housing and retail sub-departments are respectively 2-12 days and 6-16 days. Which gives an estimated reduction in throughput time of at least 18.65 and 35.32 days for respectively the housing sub-department and the retail sub-department.

The goal of this research was to reduce the throughput time from the housing and retail sub-department to respectively 5 and 8 days. These values lie in the range of estimates found in this research. However, there is no time available during this research to test the new processes and the SOPs. So, it is not possible to give empirical evidence that the goal is reached.

This research has delivered other contributions to AKOR as well, namely flowcharts of their current processes and flowcharts of improved processes, SOPs for every function within the processes, and a data analysis that shows the weakest and strongest parts of each process.

6.2 Recommendations

This section presents three recommendations to AKOR, these all regard different subjects: inventory management, data gathering and the continuation of this research.

Recommendation on inventory management

To keep shortening the throughput time, AKOR needs to improve the inventory management. There is still too much time spent waiting for materials to be delivered and it is very wasteful if a carpenter arrives at the client with the wrong materials or without enough materials. So, it is recommended that AKOR improves the inventory management.

Recommendation on the analysis of data

Analysing the data during this research was possible, however, it has cost a lot of time. To improve this, it is recommended that AKOR implements a live dashboard that presents various KPIs to keep a real-time overview of the new processes and their statuses. This will also help detect and fix problems without having to spend a lot of time analysing data.

Recommendation on the arrival of orders by clients

Further research is recommended on the arrival of the orders by clients. This research provides AKOR with which information is needed when an order arrives, however, it is important that the clients deliver this information in such a way that the needed materials can be determined correctly as often as possible. More jobs can be finished during the first visit by determining the needed materials for the jobs correctly, which improves the throughput time.

Recommendation on the continuation of this research
To continue on the findings of this research it is recommended to implement the processes by using the SOPs in Appendix 5, as described in Chapter 5. During the start of the implementation, it is recommended that the employees are guided whilst following the SOPs, to make sure that the SOPs are used correctly and not ignored.

It is recommended to make new processes and SOPs for the calculated jobs of both sub-departments as well. These jobs occur often enough to be relevant. It is recommended that the parts of the new processes from calculated jobs that overlap with the new processes from non-calculated jobs are directly taken from this research, to ensure uniformity.

6.3 Discussion
The discussion consists of three parts: a discussion on the lack of time, a discussion on the variety of the jobs, a discussion on the validity of the data analysis, and a discussion on the validity of the estimated throughput times from the new process.

Lack of time
Since the time for this research was limited, it was hard to account for all variabilities in the processes from the service department. To make sure that this research was done within the time limit and that the research was thorough, AKOR requested to focus on the processes of the non-calculated jobs only. That is why it is recommended for AKOR to research the calculated jobs further to improve the processes of these as well.

Variety of the jobs
Due to the variety of the jobs, it is very hard to make an SOP on how the carpenter must execute their jobs. Every job is different and different materials and techniques must be used often. That is why the SOPs for the carpenters do not contain information on how the jobs must be executed.

Validity of the data analysis
The data analysis conducted in Chapter 2 contains an analysis of the different parts of the processes and the throughput times caused by these different parts. The amount of jobs used for the analysis is nine per process, which is not a lot. This may cause that specific part of the data analysis to be invalid. However, the jobs are not chosen randomly, since the jobs are chosen by their description. The jobs chosen are all average, normal jobs that occur often. This means that the throughput times of these jobs can be considered as average and normal as well, which increases validity.

Discussion on the estimated throughput times from the new processes
Due to the limited time available during this research, no tests of the new processes could be made. This means that no empirical results can be gathered. Due to this, educated estimations has been made to measure the throughput times from the new processes. Since these are estimations, there is no certainty that the actual throughput times will lie in the range of values given by the estimations. So, to get valid and definite results, more time is needed to test the new processes along with the SOPs.

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Appendix 1

Flowchart of service sub-department housing

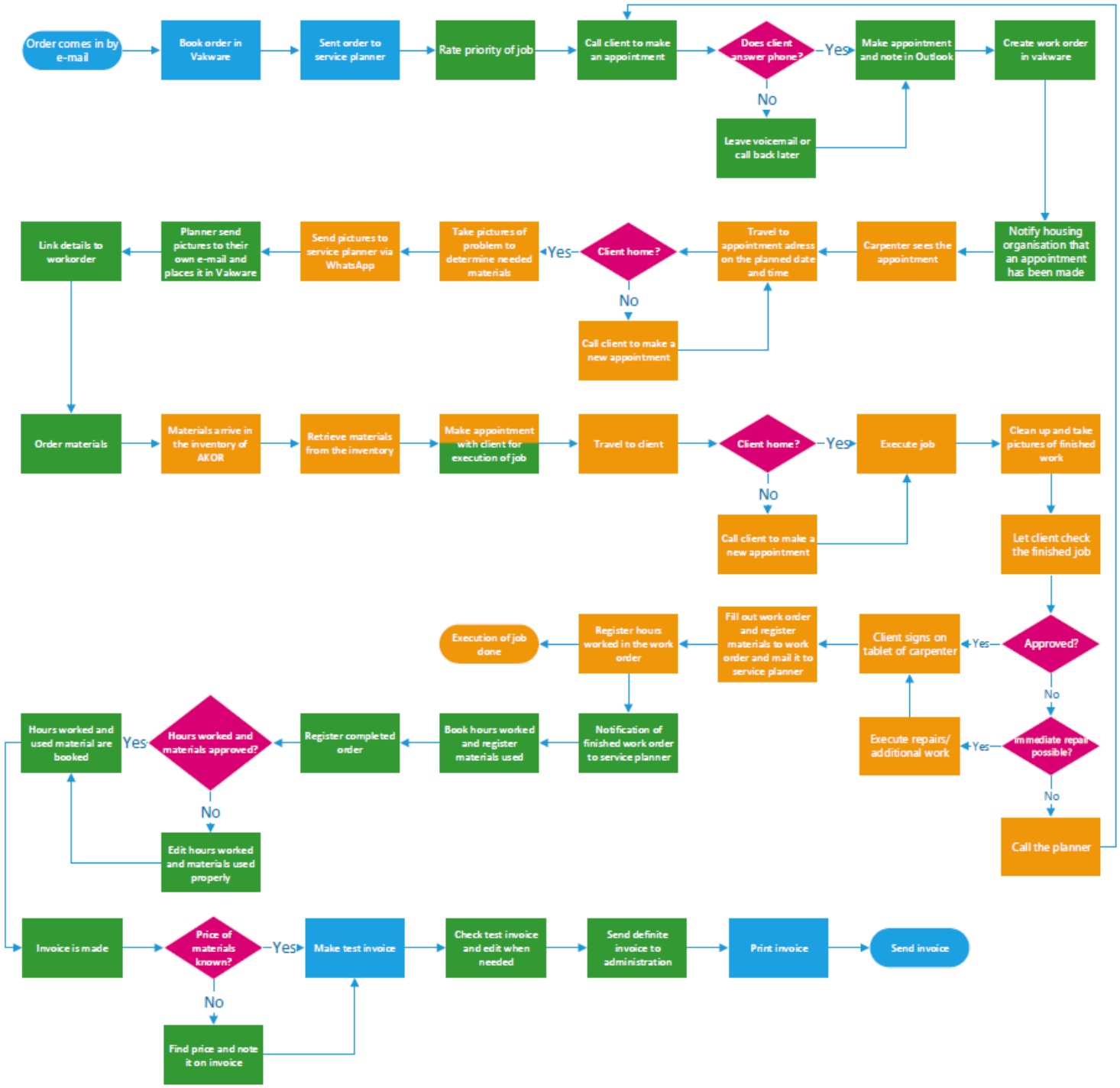

Figure 34 | Flowchart current process of housing sub-department

Appendix 2

Flowchart of service sub-department retail

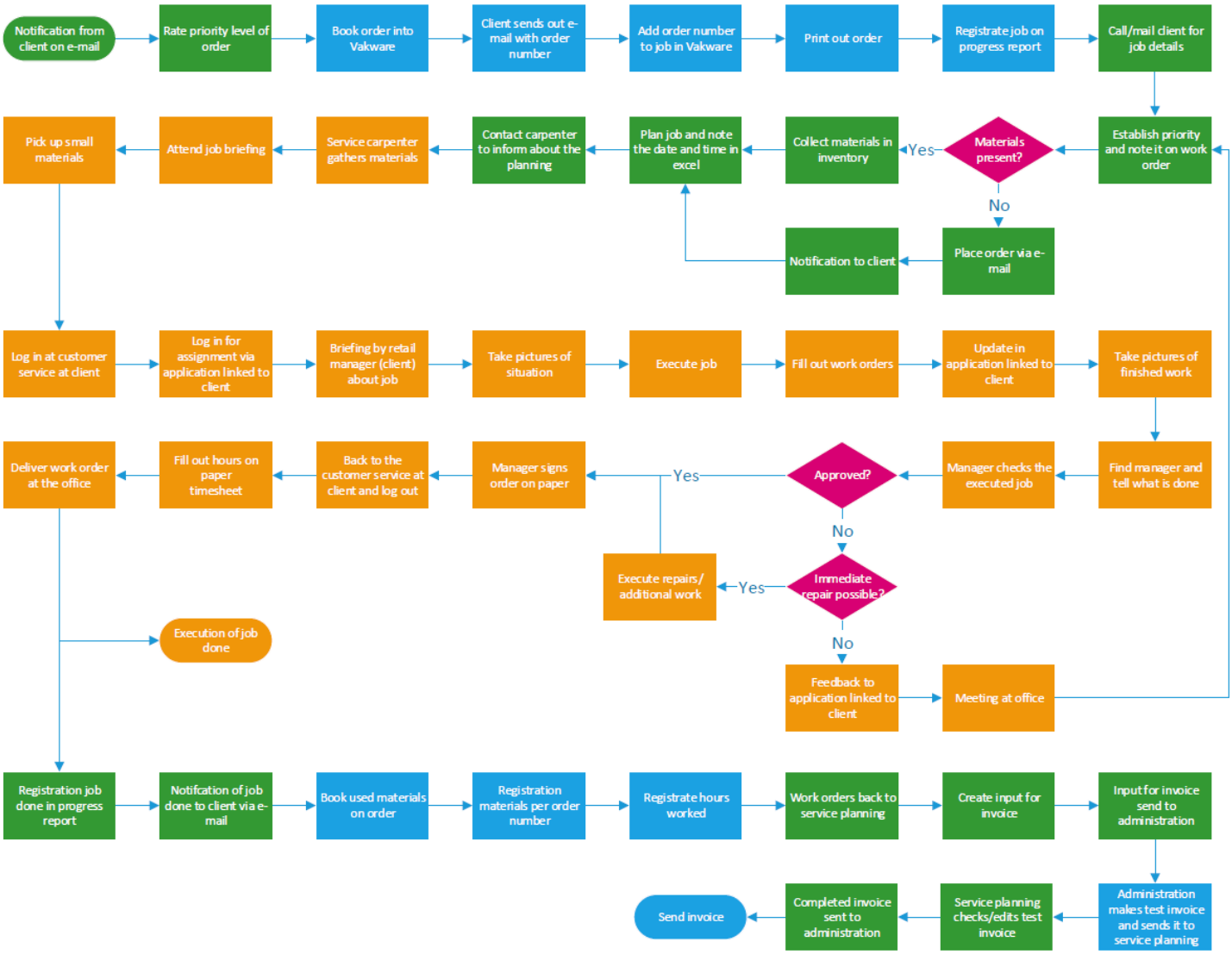

Figure 35 | Flowchart current process of retail sub-department

Appendix 3

Flowchart of the new process from the housing sub-department

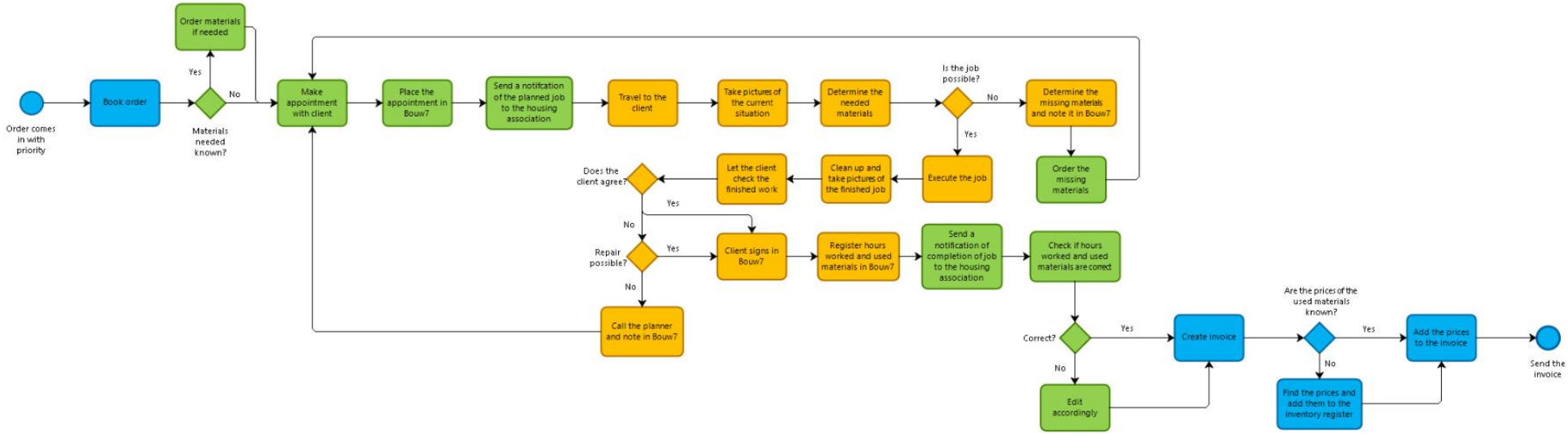

Figure 36 | Flowchart of the new process from the housing sub-department

Appendix 4

Flowchart of the new process from the retail sub-department

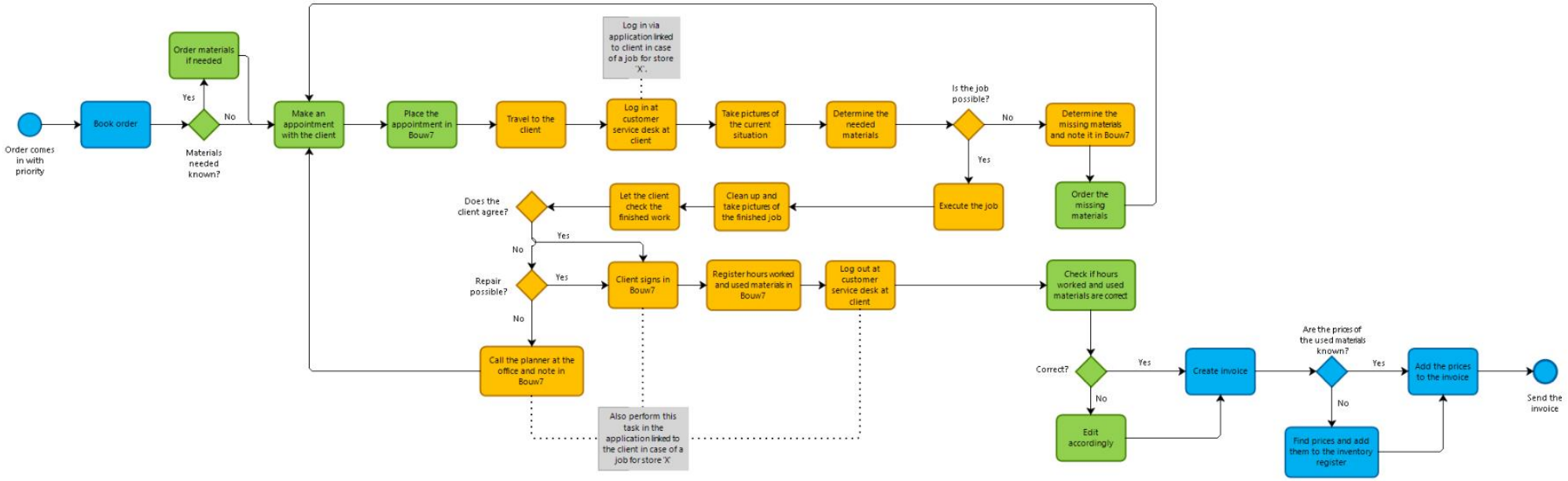

Figure 37 | Flowchart of the new process from the retail sub-department

Appendix 5

Standard Operating Procedures for the service department

Standard Operating Procedure

Service department AKOR (administration)

Arrival of job

1. The order for a job comes in via telephone or e-mail
    - The information given by the client about the job must contain:
        - Description of the job and what must be done
        - Priority level
        - Pictures of the current situation
2. Book the order into Bouw7
    - Book the order into Bouw7 by dragging the order from the e-mail inbox to the Bouw7 application
    - Check whether the order is placed in Bouw7 correctly and if all necessary details are added (see Step 1 for the necessary details)

Sending the invoice

1. Create the invoice
    - Create the invoice in Bouw7
    - Check whether all prices of the used materials are known. If these are known, then add them to the invoice
    - If the prices of the used materials are not known, then find those prices in the inventory register or in the invoice(s) send by the supplier
    - If the prices cannot be found in the inventory register or in the invoice(s) send by the supplier, then contact the supplier to find the prices
2. Send the invoice
    - Send the invoice to the client via the Bouw7 application

Standard Operating Procedure

Service department AKOR (planners housing)

Planning

1. Check the booked order
   - Check the description of the job on the order
   - Check the priority level
   - Check the pictures made of the current situation
2. Determine the needed materials if possible
   - Use the description of the job and the pictures of the current situation to determine the needed materials
   - Find out if the needed materials are already available in the van from the carpenter or in the inventory
   - Order the needed materials that are missing (for more information about ordering materials, see '**Order materials**')
   - The ordered materials are stored in the inventory
3. Make an appointment with the client
   - Determine the time it may take before the job has to be started using the given priority levels
   - Estimate the time it takes for the job to be executed based on the given description of the job
   - Determine how many carpenters will be needed to execute the job and find out which carpenters are available during which dates and times by checking the planning schedule in Bouw7
   - Contact the client and make an appointment within the timeframe and on an available date and time for both the client and the carpenter(s)
4. Place the appointment in Bouw7
   - Open the Bouw7 application and open the planning schedule
   - Find the date and time of the appointment made with the client and with the carpenter(s)
   - Place the job on the correct date and time, and assign the correct carpenter(s) to the job in the planning schedule
5. Send a notification of the planned job to the housing association
   - Contact the housing association
   - Inform the housing association about the date and time of the job and about the details of the job

Order materials

1. Determine the materials that need to be ordered (see '**Planning**' for more information about determining the needed materials)
2. Check whether the materials including a price are already included in the inventory register
   - If so, go to Step 3
   - If not, add the materials to the inventory register, including the price of the materials
3. Order the respective materials at the supplier

Preparing the order

1. Send a notification to the housing association to inform them that the job is finished
   - This notification should be sent when the carpenters have registered the hours worked and the used materials
2. Check whether the hours worked and used materials are registered correctly by the carpenters
   - Check whether typing errors are made
   - Check whether the number of hours worked registered is not too much or too little
   - Check whether the right measuring units are used
   - Edit the wrongly registered hours worked and used materials
3. Approve the registered hours worked and used materials

Standard Operating Procedure

Service department AKOR (planners retail)

Planning

1. Check the booked order
   - Check the description of the job on the order
   - Check the priority level
   - Check the pictures made of the current situation
2. Determine the needed materials if possible
   - Use the description of the job and the pictures of the current situation to determine the needed materials
   - Find out if the needed materials are already available in the van from the carpenter or in the inventory
   - Order the needed materials that are missing (for more information about ordering materials, see '**Order materials**')
   - The ordered materials are stored in the inventory
3. Make an appointment with the client
   - Determine the time it may take before the job has to be started using the given priority levels
   - Estimate the time it takes for the job to be executed based on the given description of the job
   - Determine how many carpenters will be needed to execute the job and find out which carpenters are available during which dates and times by checking the planning schedule in Bouw7
   - Contact the client and make an appointment within the timeframe and on an available date and time for both the client and the carpenter(s)
4. Place the appointment in Bouw7
   - Open the Bouw7 application and open the planning schedule
   - Find the date and time of the appointment made with the client and with the carpenter(s)
   - Place the job on the correct date and time, and assign the correct carpenter(s) to the job in the planning schedule

Order materials

1. Determine the materials that need to be ordered (see '**Planning**' for more information about determining the needed materials)
2. Check whether the materials including a price are already included in the inventory register
   - If so, go to Step 3
   - If not, add the materials to the inventory register, including the price of the materials
3. Order the respective materials at the supplier

Preparing the order

1. Check whether the hours worked and used materials are registered correctly by the carpenters
    - Check whether typing errors are made
    - Check whether the number of hours worked registered is not too much or too little
    - Check whether the right measuring units are used
    - Edit the wrongly registered hours worked and used materials
2. Approve the registered hours worked and used materials

Standard Operating Procedure

Service department AKOR (carpenters housing)

Preparation job

1. Check the planning schedule in the Bouw7 application
   - Check the address, time, and (estimated) duration of the forthcoming job
   - Check the job description
   - Check the pictures taken of the current situation
2. Collect the needed materials
   - Check the Bouw7 application to see which materials are needed for the job and retrieve these materials from the inventory
   - Place the needed materials in the van
3. Travel to the client
   - Check the time needed to travel to the client
   - Travel to the client on the correct date and time and keep the travel time in mind
   - Open the Bouw7 application and start the navigation inside the application
4. Arrival at the client
   - Take pictures of the current situation via the camera-function in the Bouw7 application
   - Check the situation to determine whether the materials needed are in the van
   - Check whether the job can be finished in the first visit and within the estimated duration of the job
   - If the job is not possible, then note this in the Bouw7 application and call the planner to plan a new appointment
   - If more materials are needed to finish the job, then note this and the needed materials in the Bouw7 application as well

Execution job

1. Execute the job
    - Only execute the job when it is safe to do so
2. Clean up and take pictures of the finished job
    - Clean up and place the unused and the still useable materials back in the van
    - Use the camera-function in the Bouw7 application to make pictures of the finished job
3. Let the client check the finished job
    - Go to the following steps 2 steps if the client agrees or if a direct repair is possible:
        - Make sure that the job is completed
        - Let the client sign his or her signature in the Bouw7 application
    - Go to the following steps if the client does not agree and if no direct repair is possible:
        - Note in Bouw7 that the job is not correctly executed and note the reason that the job is not correctly executed as well
        - Call the planner to notify that the job is not correctly executed and that a new appointment has to be made with the client

Administration job

1. Register hours worked
    - Determine the duration of the execution of the job
    - Enter the number of hours worked in the Bouw7 application under ‘hours worked’
    - Determine the travel time in hours
    - Enter the number of hours travelled in the Bouw7 application under ‘travel hours’
2. Register used materials
    - Determine which materials are used and how much of each material is used
    - Find the used materials in the inventory register and select the right materials
    - Determine the right measuring units and enter the correct quantities

Standard Operating Procedure

Service department AKOR (carpenters retail)

Preparation of the job

1. Check the planning schedule in the Bouw7 application
   - Check the address, time, and (estimated) duration of the forthcoming job
   - Check the job description
   - Check the pictures taken of the current situation
2. Collect the needed materials
   - Check the Bouw7 application to see which materials are needed for the job and retrieve these materials from the inventory
   - Place the needed materials in the van
3. Travel to the client
   - Check the time needed to travel to the client
   - Travel to the client on the correct date and time and keep the travel time in mind
   - Open the Bouw7 application and start the navigation inside the application
4. Arrival at the client
   - Log in at the customer service desk at the client and report what the job is
   - Log in on the application linked to the client as well when the job is for store X
   - Take pictures of the current situation via the camera-function in the Bouw7 application
   - Check the situation to determine whether the materials needed are in the van
   - Check whether the job can be finished in the first visit and within the estimated duration of the job
   - If the job is not possible, then note this in the Bouw7 application and call the planner to plan a new appointment
   - If more materials are needed to finish the job, then note this and the needed materials in the Bouw7 application as well

Execution of the job

1. Execute the job
    - Only execute the job when it is safe to do so
2. Clean up and take pictures of the finished job
    - Clean up and place the unused and the still useable materials back in the van
    - Use the camera-function in the Bouw7 application to make pictures of the finished job
3. Let the client check the finished job
    - Go to the following steps 2 steps if the client agrees or if a direct repair is possible:
        - Make sure that the job is completed
        - Let the client sign his or her signature in the Bouw7 application and in the application linked to the client if the job is for store X
    - Go to the following steps if the client does not agree and if no direct repair is possible:
        - Note in Bouw7 (and in the application linked to the client if the job is for store X) that the job is not correctly executed and note the reason that the job is not correctly executed as well
        - Call the planner to notify that the job is not correctly executed and that a new appointment has to be made with the client
4. Log out at the client
    - Sign out at the customer service desk (and log out in the application linked to the client if the job is for store X) when the job is finished and when the administration of the job is finished

Administration of the job

1. Register hours worked
    - Determine the duration of the execution of the job
    - Enter the number of hours worked in the Bouw7 application under ‘hours worked’
    - Determine the travel time in hours
    - Enter the number of hours travelled in the Bouw7 application under ‘travel hours’
2. Register used materials
    - Determine which materials are used and how much of each material is used
    - Find the used materials in the inventory register and select the right materials
    - Determine the right measuring units and enter the correct quantities