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Improvement of the picklist process for the logistical centre of Kolb

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This report is intended for Kolb Cleaning Technology GmbH and the examiners of the University of Twente.

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Improvement of the picklist process for the logistical centre of Kolb

A study on how to improve the picklist process of the logistical centre of Kolb

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Management summary

Introduction

This research is conducted at Kolb cleaning technology GmbH. Kolb manufactures cleaning systems and sells chemicals for the electronics producing industries. The focus of this research is on reducing the processing time of the picklist process. The CEO and logistics manager of Kolb wants to automate the existing picklist process to decrease processing time since they consider it too high. The main reason for reduction is the expected demand growth of 25% within 7 years for the chemicals division. The current average processing time per picklist is 11 minutes. The ideal situation of Kolb is an automated picklist process with an average processing time per picklist beneath 5,5 minutes. Before the implementation of a digital picklist, first, it should be clear if a paper picklist is the only bottleneck of the high processing time. Therefore, the following research question is set:

"How can the processing time of the picklist process be reduced by at least 50% and be structured efficiently such that it can be digitized?"

Methodology

With a case study, the current situation of Kolb is analysed. During a two weeks visit at Kolb, observation, record analysis and interviews are held primarily with the logistics manager to analyse the process and the processing times. After this case study, information is gathered on methods for improving business processes. Systematic business process re-engineering appeared to be the most suitable technique. Systematic re-engineering makes use of the ESIA rule which stands for eliminating waste, simplifying and integrating the remaining activities and investigating automation possibilities. The ESIA rule first creates an efficient and effective process and then looks at automation. At the elimination phase, possible bottlenecks at the picklist process are identified with help of value-added analysis. Solutions for these bottlenecks are established with help of integration and automation.

Results

Concluded from the case study at Kolb is that the average processing time per picklist is 11 minutes. The steps of the picklist process can be divided into four categories: remaining activities (34% of the total processing time), transportation and motion (33% of the total processing time), internal checks (27% of the total processing time) and defects (6% of the total processing time).

During the value-added analysis, two non-value-added activities were found. These steps can be eliminated immediately:

- Sign the picklist (1% of total processing time)
- Archive the picklist (1% of total processing time)

However, there exist a lot of necessary but non-value-added activities. These activities do not add value to the product or service but exist because they are needed due to the current way of working. Three bottlenecks are creating a high amount of necessary but non-value-added activities:

1. The use of a paper picklist (31% of total processing time)
2. Lack of experience and data about ordering chemicals at the purchasing department (26% of total processing time)
3. Incorrect determination of the shipment day (7% of total processing time)

Improvement plan

The bottlenecks previously mentioned are used as input for the improvement plan. It is recommended but not required to implement the improvement steps in the given order. The following improvement steps are established:

Step 1: Implement a digital picklist and hand scanner
Step 2: Conduct data analysis and implement an inventory policy for the chemicals division
Step 3: Implement Available-To-Promise (ATP) and Capable-To-Promise (CTP) in Navision

The first step focuses on implementing a digital picklist. A digital picklist can be implemented by acquiring 2 Warehouse Management System licenses and one hand scanner. A digital picklist allows to process the picklist digitally and store the information automatically to the ERP-system Microsoft Dynamics NAV. This solutions needs to be implemented by a consultant. This will cost approximately 6-8 months. This solution is not worth the investment for only the picklist process and the pay-back period of 8 years is not accepted by Kolb. So more research on the benefits for other processes is needed to assess the feasibility of implementing a digital picklist. In the meantime, two short-term solutions can be implemented:

- Logistics manager prints picklist each morning, the processing department only sends express picklists during the day
- Add checklist with standard packages on the picklist

Together, these two short-term solutions already lead to a 7% reduction in total processing time.

The second step focuses on analysing and implementing an order policy for the chemicals division. With an order policy, the purchasing department knows when and how much to purchase from which chemical. First, a suitable order policy needs to be chosen. Then data analysis needs to be done on historical sales data. After these two steps, the order policy can be created. These steps can be executed by a purchasing employee of Kolb and will cost approximately 300 hours.

The third step focuses on implementing ATP and CTP functionality in Navision. With this functionality, the order processing department of Kolb can automatically derive the first possible shipment date of a sales order. The functionality is available for Kolb, but the implementation of an ERP software planning tool is necessary because this tool gives input for the ATP and CTP calculation. This ERP software planning tool will already be implemented for project planning. After implementation, the ATP and CTP functionality can be set up by an employee of Kolb. The time needed for set up is negligible for Kolb.

Table 1 shows the impact of the improvement steps on the processing time of the picklist process. After the implementation of all solutions and reduction of the non-value-added steps, 52% reduction of the total processing time can be achieved.

TABLE 1: IMPACT OF PROPOSED IMPROVEMENT STEPS

Improvement step	Impact on the processing time	Savings per year	One-time investment	Yearly cost	Pay-back period
Step 1	-17%	€ 2,043	€ 16,224	€1,824.80	8 years
Step 2	-26%	€ 3,197	€8,400	€0	5,2 months
Step 3	-7%	€831	€0	€0	-

Acknowledgement

Dear reader,

I would like to present you with my bachelor thesis. This bachelor thesis is written to finalize the bachelor programme Industrial Engineering and Management at the University of Twente. This thesis is about the improvement of a paper picklist process at the logistical centre of Kolb cleaning technology GmbH.

First, I would like to thank Kolb cleaning technology GmbH for providing a bachelor assignment. I especially want to thank Christian Ortmann for being my external supervisor, for helping me and for providing me valuable information whenever I asked for it. I also want to thank Günter Schymik, for providing valuable information about the logistics process and especially the picklist process. He was always available for questions, also during the difficult corona pandemic which forced me to execute the bachelor thesis from home.

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Thirdly, I want to thank Odin Groep for a visit to their logistics centre. With this visit, I received valuable information about a fully digitalized logistics centre and especially about digital picklists.

Last, I would thank my family, my friends and boyfriend for showing their interest in my research and supporting me during the executing of this bachelor thesis, especially, during the Covid-19 pandemic.

I hope you enjoy reading it!

Mirthe Zwanenburg
Ootmarsum, November 2020

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Glossary of terms

AB	Auftragsbearbeitung. This is the German word for sales order processing department. This abbreviation is used by the logistics employees.
ATP	Available-To-Promise. A concept which calculates a delivery date based on available products in inventory or on planned receipts
AV	Arbeitsvorbereitung. This is the German word for work preparation department. This abbreviation is used by the logistics employees.
BPR	Business Process Re-engineering. The business process improvement tool used in this research.
CTP	Capable-To-Promise. A concept which calculates the earliest delivery date for products that are not available at this moment but are available when they are to be produced, purchased or transferred.
ESIA	Elimination, Simplification, Integration, Automation. A rule used for systematic re-engineering.
Navision	Microsoft Dynamics NAV. The ERP-system of Kolb Cleaning Technology GmbH. The employees call it Navision.
WMS	Warehouse Management System. A software application that helps to control and manage daily tasks in a warehouse.

1. Introduction

1.1. Company introduction

Kolb Cleaning Technology GmbH (hereinafter referred to as Kolb) is a manufacturer of cleaning systems and chemicals for the electronics producing industries. Kolb mainly provides cleaning products for tools- and product cleaning but also other services. Figure 1 shows all the services from Kolb. Well-known clients of Kolb are Airbus, Asus, Dyson, Honeywell and Siemens (Kolb, n.d.). Their headquarter and logistical centre are based in Willich, Germany. Kolb also has a branch office in Bankstown (Australia), a branch office in Longmont/Colorado (USA) and a demo centre and sales & service office in Shanghai (China).

Kolb has two product divisions, cleaning chemicals and cleaning machines. The machines are produced and shipped from the headquarters of Kolb. The cleaning chemicals are produced at Linker GmbH in Sprockhövel and are stored and shipped from the logistical centre of Kolb in Willich.

Kolb has two different shipping methods. The first shipping method is order by order, this means delivering directly to their customers. This method is used for Germany customers of Kolb and Benelux customers of SMANS N.V. SMANS N.V. is a sales partner of Kolb and sells the machines and chemicals of Kolb. The second method is using sales partners, this method is used mainly for export deliveries. Kolb ships large quantities to the sales partners or directly to the customers of these sales partners.

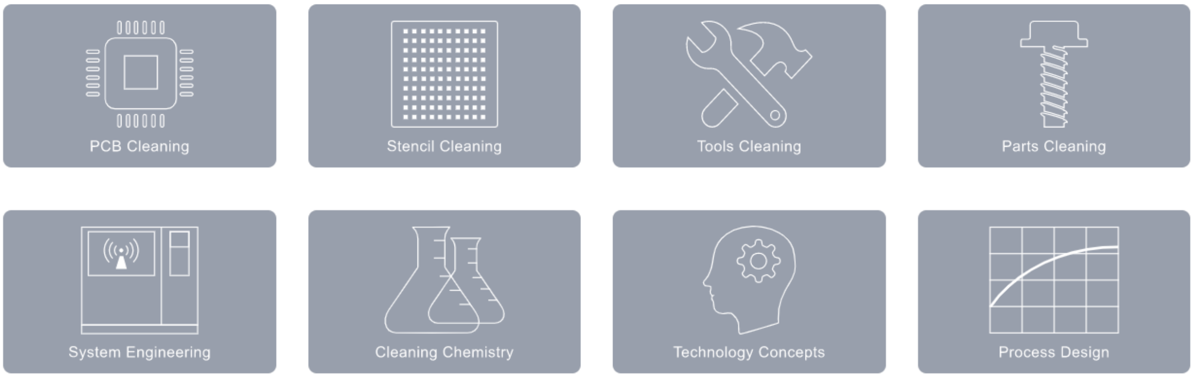


FIGURE 1: SERVICES OF KOLB CLEANING TECHNOLOGY GMBH

1.2. Problem identification

1.2.1. Problem context and research motivation

The logistics employees of Kolb use picklists to know which products they need to retrieve from the warehouse, to pack and fulfil a customer or internal order. These picklists are prepared at the sales order process department (hereinafter referred to as AB) at the headquarter of Kolb and are sent to the printer of the logistics department at the logistical centre. The logistics manager checks the picklists and gives them to the logistics employees. The logistics employee puts package information of the packed order on the picklist and scans the picklist back to the AB. According to the CEO and logistics manager, this process is cumbersome and includes too much transportation between different locations and employees.

The processing time of one picklist is on average 11 minutes. This is estimated during a two-weeks visit at Kolb (section 2.4). Based on data from the ERP-system, on average 11 picklists are processed per day based on five working days a week. The total processing time per week equals 10.3 hours per week, this equals 1.3 working days.

The CEO and logistics manager of Kolb consider the processing time too high and want it to be reduced by 50%. This reduction is based on the two reasons below and the fact that the CEO of Kolb think that this is a realistic goal after analysing and improving the picklist process.

One reason for the reduction of the processing time is the expected demand growth for the cleaning chemicals division. Kolb expects average demand growth of 25% within the next 7 years (they even expected growth of 25% within 5 years before the corona crisis). This demand growth will lead to processing 14 picklists per day based on five working days a week. When the process remains the same this will cost on average 13 hours per week, this equals 1.6 working days. Spending 1.6 working days on checking information that also can be checked and derived automatically is a waste of time.

Another reason is digitization. Since a few years, Kolb is working on digitization. Most processes at the headquarter of Kolb are already digitized, such as the sales order handling process and the finance process. The next step is to digitize the processes at the logistical centre. The first process to digitize is the picklist process. The CEO and logistics manager of Kolb believe that the picklist process contains a lot of transportation and motion between employees, which can be reduced by a digitized process. To digitize the picklist process, Kolb first wants it to be as efficient as possible.

Continuing with the current picklist process leads to the loss of valuable time, in which other important tasks can be executed. Therefore, the next step is digitizing the picklist process. One important question is if only digitizing solves the problem of the high processing time. The CEO of Kolb and logistics manager believe that the process contains a lot of transportation and motion, but this is never analysed. Before digitizing the picklist process, an analysis needs to identify if transportation and motion is the only bottleneck of a high processing time. So, Kolb asked to analyse the current picklist process and give advice on how to improve the picklist process and if digitization is a suitable solution for the reduction of the processing time.

1.2.2. Problem cluster

Possible causes for the high processing time of the picklist process are identified during a two-weeks visit at Kolb. The causes are identified based on interviews with the CEO and logistics manager. Figure 2 shows the identified problems. Section 1.2.3 explains the problems in more-depth.

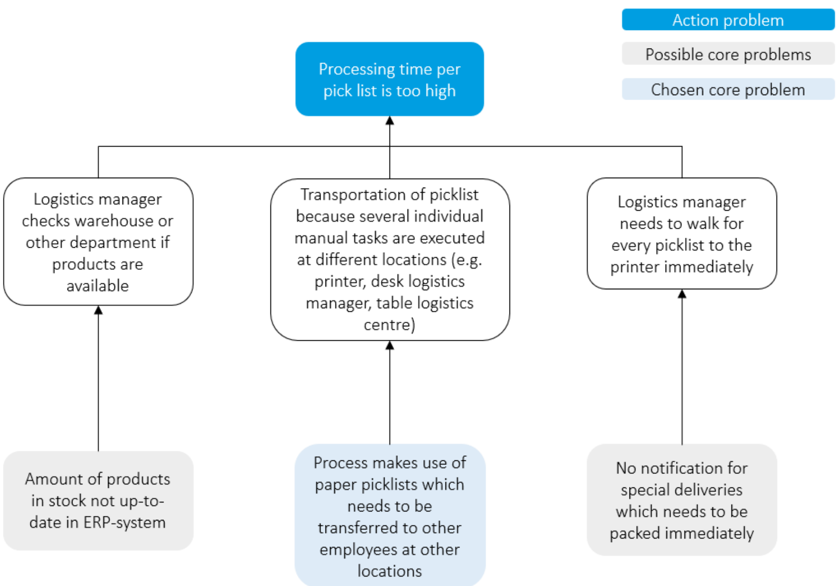


FIGURE 2: PROBLEM CLUSTER OF KOLB

1.2.3. Core problem

Figure 2 shows the problem cluster of Kolb. To find the core problem of Kolb, an action problem is identified. An action problem is a gap between the current and desired situation (Heerkens & van Winden, 2017). The CEO and the logistics manager of Kolb aim for a decrease in the processing time of 50%, so from 11 minutes per picklist to 5.5 minutes per picklist. Another aim is a digitized picklist process. Since the current and ideal situation consists out of two statements, it is presented in a table. Table 2 shows the current and desired satiation of the CEO and logistics manager of Kolb.

TABLE 2: GAP ANALYSIS ACTION PROBLEM OF KOLB

Current situation	▪ The processing time is on average 11 minutes ▪ The process is executed with paper picklists
Desired situation	▪ The processing time is less than 5,5 minutes. ▪ The process is executed with digital picklists

Concluded from the gap analysis of the problem of Kolb is the following action problem:

"Reducing the processing time of the picklist process by at least 50% and structuring the picklist process efficiently such that it can be digitized"

The problem cluster in Figure 2 shows three potential core problems:

- **Amount of spare parts in stock not up-to-date in ERP-system**
  The logistics manager of Kolb always checks the warehouse or machine department if a spare part is available because he cannot rely on the data in the ERP-system Microsoft Dynamics NAV (hereinafter referred to as Navision) due to inaccurate stock levels. According to the logistics manager of Kolb, the inaccurate stock levels for the spare parts in Navision are primarily caused by the following reasons:
  - Employees taking spare parts out of stock without documentation, so no correction booking is made
  - Wrong admission to the warehouse, for example, the product is wrongly placed at the warehouse
  - Picklist defects at the assembly group which leads to the incorrect booking of the spare parts in Navision
  - Defect or incomplete spare parts

  Kolb already works on updating the stock levels. For example, they implemented the rule that only logistics employees can take out spare parts from the warehouse. Kolb also makes use of yearly stock counting. Every end of the year, the logistics employees of Kolb execute a two-days stock count. This year, they even did a volunteering stock count at September because Kolb implemented improvements which needed accurate stock levels. Because Kolb is already working on the problem, this is not the core problem.
- **No notification for special deliveries which needs to be packed immediately**
  The logistics manager checks every printed picklist immediately because it can be an express picklist. An express picklist is a picklist that needs to be packed as soon as possible. The logistics manager cannot see from his desk if the printed document is an express picklist. Therefore, he checks the document immediately to reduce the chance of being too late.

When an express picklist is packed too late, a logistics employee of Kolb needs to deliver the package at the depot of the transportation company to ensure that the package will be sent that day. This problem can easily be solved by using two different paper trays at the printer. The standard one with normal white A4 paper and a second one with red A4 paper. When the AB sends an express picklist, the second paper tray needs to be selected. When the logistics manager sees a red paper, he knows that it is an express picklist. This problem has less potential in terms of reducing the processing time then changing the paper picklist to a digital picklist. Besides, by using a digital picklist this problem can be solved by adding notification for special deliveries with high priority.

- The process makes use of paper picklists which needs to be transferred to other employees at other locations

  At this moment, the paper picklists are transferred manually between the logistic manager and logistics employees. The logistics manager walks to the printer to receive the picklist. He will check if the products are on stock and if other information on the picklist is correct. Then the picklist is stored at the desk of the logistics manager. The logistics employee takes the picklists from the desk and puts them in the order folder. Every morning, the logistics employee checks the order folder to see which picklists need to be processed that day. When processing the picklist, the logistics employee puts package information on the picklist with a pen. Eventually, the logistics employee scans the picklist to the AB and archives the picklist in a cabinet at the office of the logistics manager. All these steps contain transportation of the picklists and motion of the employees. Also, the chance of defects is higher with a paper picklist. The picklist can get lost, the AB forgot to print the picklist, the AB cannot read the hand-written information of the logistics employee or the picklist is printed twice so the order is packed twice. According to the CEO and logistics manager, transportation of a paper picklist contributes a lot to the processing time and leads to high chances of errors. Therefore, the chosen core problem of Kolb is:

"The process is executed using paper picklists which results in a lot of transportation and motion"

1.3. Problem-solving approach

The research questions and report structure are based on the Managerial Problem-Solving Method (MPSM) by Hans Heerkens and Arnold van Winden (Heerkens & van Winden, 2017). The MPSM method allows a systematic, but creative way to solve problems (Heerkens & van Winden, 2017). Figure 3 shows the Management Problem Solving Method cycle.

FIGURE 3: MPSM (KOOT, 2020)

1.4. Research scope and goal

This bachelor thesis is executed to help Kolb with their next digitization step. This thesis provides information about the current picklist process and on how to improve it such that it can be designed as efficient as possible and can be digitized. This bachelor thesis focuses on the activities performed at the logistical centre of Kolb and will not look at the process of the AB, since the logistical centre is the department where the manual steps of the picklist process start.

This bachelor thesis will mainly focus on improving the picklist process instead of designing and executing a digitization method for the picklist process. Solutions for digitization are given so Kolb can implement the solutions with help of their IT consultant.

All picklists will be in the scope of this bachelor thesis. The picklists can include chemicals, spare parts and assembly products for internal and external orders.

The main tasks of the logistics employees are picking and packing orders and handling incoming goods. The process of handling incoming goods will not be further discussed as it is not part of the picklist process.

The goal of this bachelor thesis is an implementation plan on how to improve the efficiency of the picklist process at the logistical centre of Kolb with the help of an improvement method such that the total processing time decreases with 50%. The intended deliverable is a recommendation on how to improve the picklist process at Kolb such that it can be digitized and the other activities are organised most efficiently.

1.5. Report structure

The report structure is based on the MPSM method provided in section 1.3. Also, the research questions are defined per chapter. To solve the action problem, a research question is formulated. The main research question of this bachelor thesis is:

"How can the processing time of the picklist process be reduced by at least 50% and be structured efficiently such that it can be digitized?"

This chapter already covers the phases of problem identification and problem approach.

Chapter 2 covers the problem analysis phase. This phase is about finding more information about the problem and the current situation. The following research question is answered in chapter 2:

- **What does the current picklist process of Kolb look like?**
    - What is the current processing time of the picklist process?
    - To what extent do transportation and motion contribute to the total processing time?
    - What are other contributions to the processing time?

This research question is answered with help of a case study. A case study includes interviewing, record analysis and observation (Cooper & Schindler, 2014). The first result of this question is a Business Process Model of the picklist process. A second result is a table with all the process steps including their processing time and occurrences per week. A third result is an analysis of the different process steps which steps need to be tackled to solve the core problem of Kolb.

Chapter 3 covers the literature which is needed to analyse and solve the problem. First, different process improvement techniques are analysed and the one which suits best to the problem of Kolb is chosen. Afterwards, more information about the best technique is gathered.

The following research question is answered in chapter 3:

- **Which business process improvement technique is most suitable for the problem of Kolb?**
    - Which business process improvements techniques are available in literature?
    - What does the most suitable business process improvement technique look like?

Chapter 4 is focused on applying the theory of chapter 3 to the current situation of Kolb. The following research question is answered in this chapter:

- **Which bottlenecks need to be solved to improve the picklist process?**
    - What are the bottlenecks within the picklist process?
    - How can these bottlenecks be solved?

Chapter 5 provides an implementation plan. This implementation plan provides solutions found with information gathered during the application of the theoretical framework. The following research question is answered in this chapter:

- **Which improvements steps should Kolb take to improve the picklist process?**
    - What are the improvement steps to solve the bottlenecks?
    - How can the improvement steps be implemented at Kolb?
    - What are the investment costs of the improvement steps?
    - What is the impact of the solutions on the total processing time?

Chapter 6 provides a conclusion and discussion.

2. Current situation of Kolb

This chapter provides an analysis of the current situation of Kolb. Section 2.1 gives a broad explanation of the logistical process. Section 2.2 explains the different types of picklists of Kolb. Section 2.3 provides a broad process map, specified process maps and explanations of the different steps of the picklist process. Section 2.4 provides an analysis of the processing time for the picklist process. Section 2.5 gives a conclusion on the research question: what does the current picklist process of Kolb look like?

2.1. Broad explanation logistical process

Kolb sells machines, chemicals and spare parts to their sales partners and customers. The machines are built at the headquarter of Kolb and stored at the warehouse in the logistical centre. The chemicals are produced at an external company, Linker GmbH in Sprockhövel.

Kolb has two logistic employees and one logistics manager. The most important daily operations of the logistics employees are picking internal orders, picking and packing the external orders and handling the incoming goods:

- Internal orders contain products which are needed within other departments of Kolb, mainly the production. There are three moments a day in which the logistics employees interchange products with the other departments, at 09:00, 12:00 and 14:00. Sometimes it occurs that a product is needed immediately and cannot wait until one of these three moments, then the employee will walk immediately to the production department. Every extra walk to other departments costs time and money.
- External orders are orders coming from the customers and sales partners from Kolb. These orders can contain chemicals, spare parts or machines. There are two fixed time windows in which two transportation companies arrive. Between 11:00 and 12:00, Norbert Redemann KG Spedition arrives for the pallet orders. These pallet orders contain mostly machines or high volumes of chemicals. Between 15:00 and 16:00, United Parcel Service (UPS) arrives for the parcel orders. Parcel orders mostly contain spare parts or small volumes of chemicals. Redemann and UPS are two fixed transportation companies from Kolb which they have special agreements with. Other transportation companies arrive the whole day between 07:30 and 16:00 and on Fridays between 07:30 and 15:00. Other transportation companies are used for export deliveries and for customers that want to use a transportation company they have special agreements with.
- The process of handling incoming goods will not be further discussed as it is not part of the picklist process.

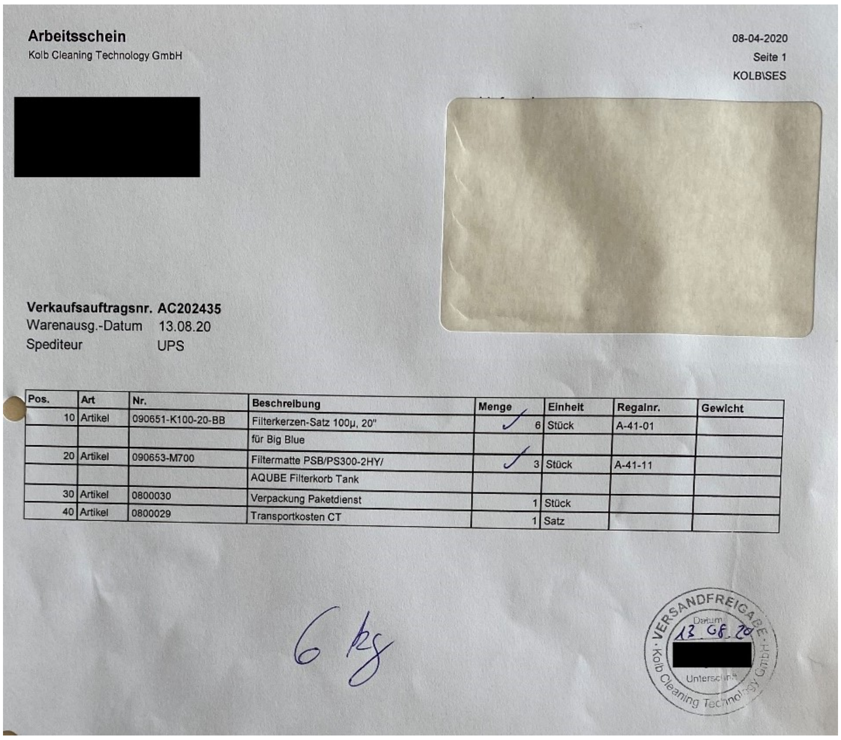
A picklist is used to know which products need to be picked for which order. This picklist is created at the AB and checked and approved by the logistics manager. The next section gives information about the picklist formats.

2.2. Types of picklists

The process of Kolb knows three types of picklists: a normal picklist (Auftrag in German), a changing picklist (Anderüngsauftrag in German) and an express picklist (Express Auftrag in German). Figure 4 shows an example of a normal picklist. This is the base for all the picklist formats.

All picklists contain:

- The name and contact information of the company (positioned under the left black square due to confidentiality)
- The sales order number (Verkaufsauftragnr.)
- The name of the transportation company (Spediteur)
- The shipping date (Warenausg.-Datum)
- The ordered products
- Signature of approval (positioned under the right black square due to confidentiality)



Arbeitsschein
Kolb Cleaning Technology GmbH

08-04-2020
Seite 1
KOLB\SES

[redacted]

Verkaufsauftragsnr. AC202435
Warenausg.-Datum 13.08.20
Spediteur UPS

Pos.	Art	Nr.	Beschreibung	Menge	Einheit	Regalnr.	Gewicht
10	Artikel	090651-K100-20-BB	Filterkerzen-Satz 100µ, 20"	6	Stück	A-41-01	
			für Big Blue				
20	Artikel	090653-M700	Filtermatte PSB/PS300-2HY/	3	Stück	A-41-11	
			AQUBE Filterkorb Tank				
30	Artikel	0800030	Verpackung Paketdienst	1	Stück		
40	Artikel	0800029	Transportkosten CT	1	Satz		

6 kg

VERSANDFREIGABE · Kolb Cleaning Technology GmbH
Datum 13.08.20
[redacted]
Unterschrift

FIGURE 4: EXAMPLE NORMAL PICKLIST KOLB

It also contains one sticker with the shipping address, the sales order number, the shipping date and the name of the distributor. This sticker is put on the package.

A changing picklist is made when a customer changes the sales order. It looks like a normal picklist but contains the sentence: "!!! Änderungsauftrag- Bitte Auftrag wechseln.". This means that the employee should replace the normal picklist in the order folder by the changing picklist. Figure A2 shows an example of a changing picklist.

The express picklist is a picklist from a sales order that needs to be sent as soon as possible. Therefore it should be packed immediately. When an express picklist arrives at the logistics manager, he checks the picklist immediately and brings it to the logistics employee such that it is packed before the transportation company arrives. When the package is not packed in time, an employee of Kolb needs to go to the depot of the transportation company so that it still can be shipped that day. Figure A3 shows an example of an express picklist

There is no difference in format for internal or external orders. They all use the format of a normal pick list, a changing picklist and an express picklist.

2.3. Picklist process

The picklist process sounds simple, however, there are a lot of steps which are executed. These steps are executed by the AB, the logistics manager and the logistics employee. Together with the logistics manager, a process map is created. This process map is based on his experience.

Figure 5 shows a high-level overview of the picklist process. Every task is further explained in more detail in Figure 6 until Figure 15. Appendix D: investment costs solutions shows the explanation of all the symbols used in the process maps of this section.

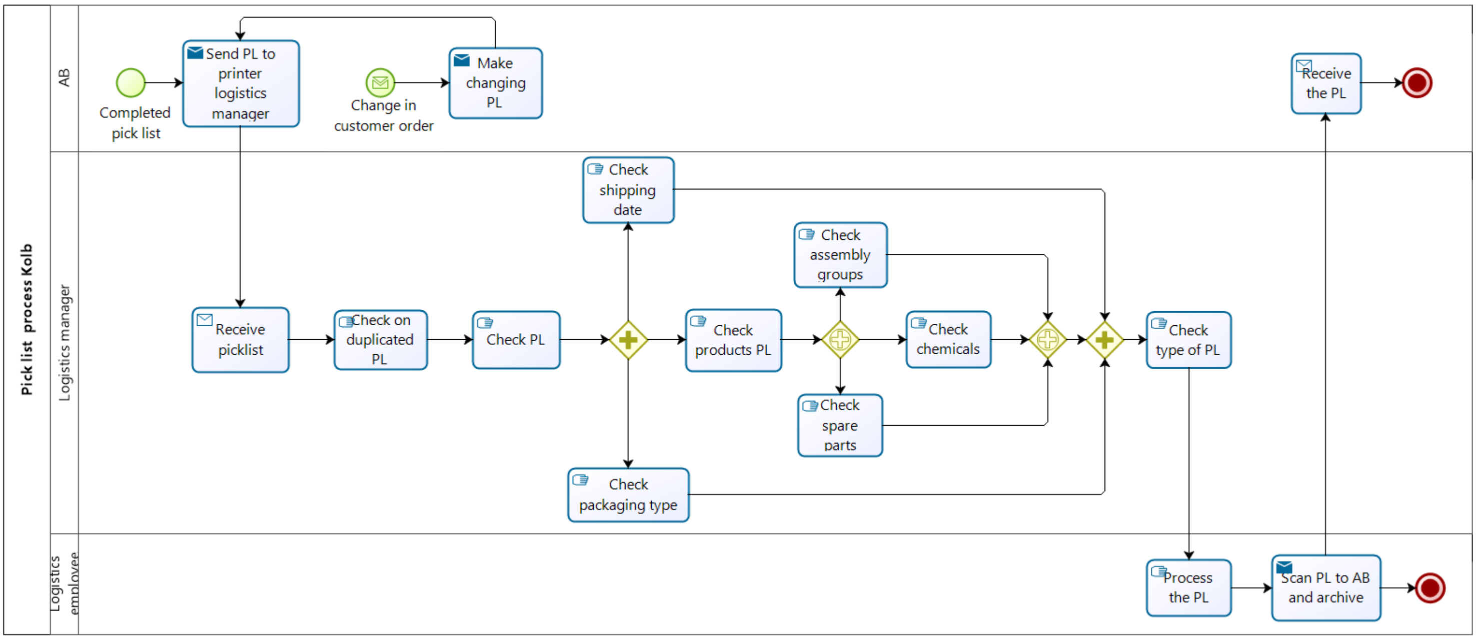


FIGURE 5: BROAD OVERVIEW PICKLIST PROCESS

Figure 6 shows the start of the picklist process at the AB. The AB sends a completed picklist to the printer of the logistics manager. This can happen at any moment, there is no specific moment where all picklists of that day are sent. When the customer makes a change in the sales order, the AB sends a changing picklist to the logistics manager. At the period from 01-2017 until 07-2020, the average amount of changes per picklist is 3. This means that on average one normal picklist and two changing picklists per sales order are processed.

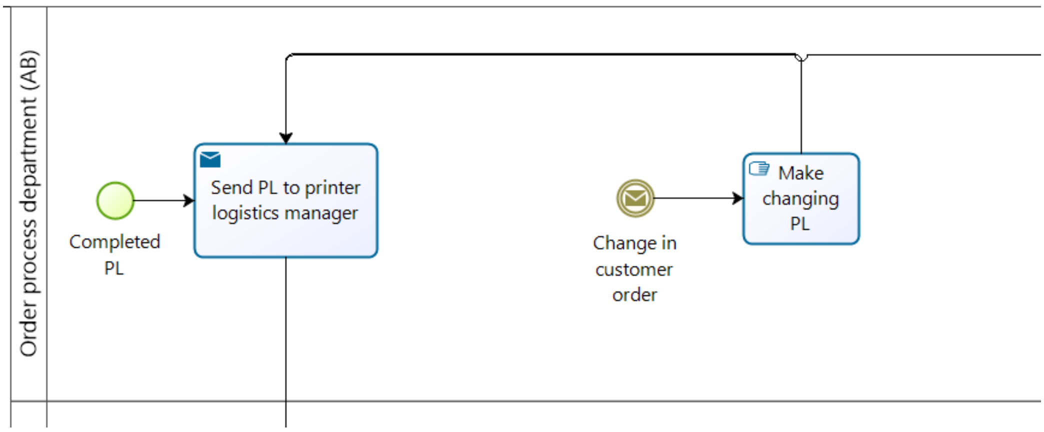


FIGURE 6: PROCESS MAP START PL PROCESS AT AB

After receiving the picklist from the AB, the process of the logistics manager starts. Normally, the logistics manager checks every printed picklist immediately. However, it happens that the logistics manager is occupied and checks a couple of picklists at the same time as soon as he has time.

First, the logistics manager checks if duplicates are printed. It can happen that the AB is not sure if the picklist is already printed so it is printed again. The AB cannot check this because they are located in the headquarter of Kolb and walking to the logistics manager is a waste of time. One possibility is to call the logistics manager to ask if the picklist is printed. However, one disadvantage is that the logistics manager is not always in his office and has to walk to the printer to check if the picklist is printed. Having a duplicate happens on average once a day. Because the employees process a lot of picklists, they do not recognize that they are packing the same order twice. This is wasted time and the employee has to repack the order and put the products back in stock. Therefore, it is necessary to check on duplicates all the time. Figure 7 shows the process steps of checking the duplicates.

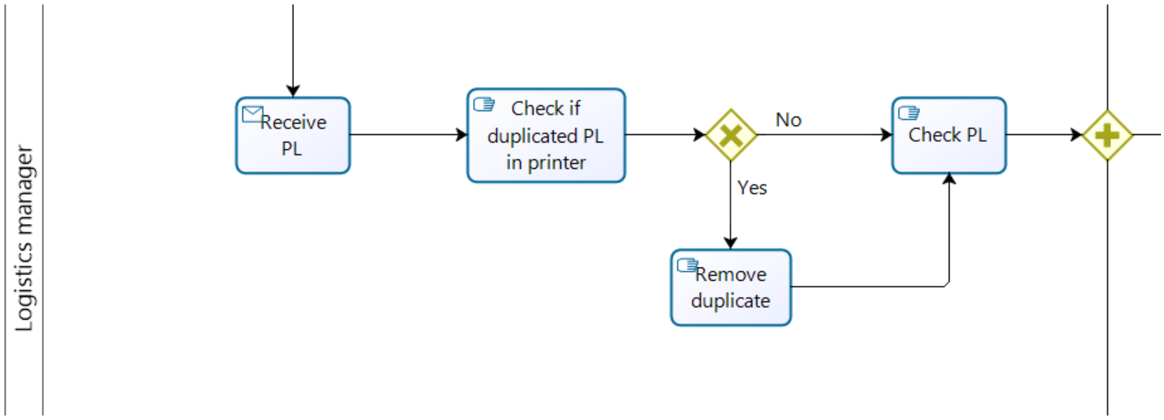


FIGURE 7: PROCESS MAP CHECK ON DUPLICATES BY LOGISTICS MANAGER

After checking on duplicates, the logistics manager performs three parallel checks. First, he checks if the shipping date is feasible. Sometimes the AB determined a shipping date which is not feasible. This happens on average twice a week. When it is not feasible, the logistics manager discuss a new shipping date with the AB. The AB then informs the customer. When the customer agrees, a changing picklist is made and sent to the printer of the logistics manager. According to the logistics manager of Kolb, the customers usually agrees immediately because the logistics manager provides reasons for the new shipping date. Figure 8 shows the process steps of checking the shipping date.

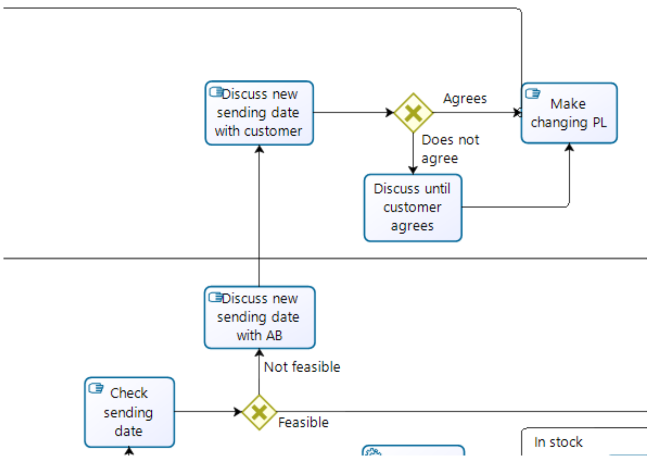


FIGURE 8: PROCESS MAP CHECK FEASIBILITY SHIPPING DATE BY LOGISTICS MANAGER

The second check is the packaging type. Based on experience, the AB provides a way of packaging on the picklist. Sometimes this way of packaging is not feasible and will be changed by the logistics manager. A wrong packaging type happens on average twice a week. Figure 9 shows the process steps of checking the packaging type.

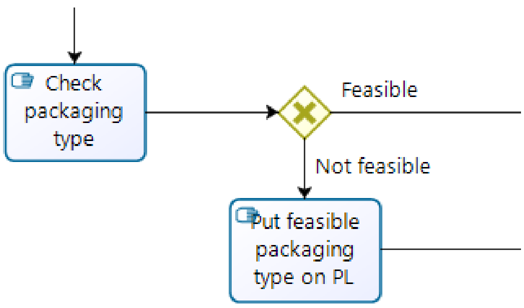


FIGURE 9: PROCESS MAP CHECK OF FEASIBILITY PACKAGING TYPE BY LOGISTICS MANAGER

The third check is the type of products which the picklist contains. A picklist can contain three kinds of products which are processed differently. Figure 10 shows the process steps for the chemicals and assembly products.

First, the chemicals. The logistics manager checks in Navision if the chemicals are on stock. The logistics manager orders the chemicals every Tuesday for Wednesday one week later. If needed the logistics manager can order extra chemicals until Friday, this happens on average 1 to 3 times a week.

Secondly, the assembly parts. Assembly products are products that are assembled by Kolb itself, such as machines. The logistics manager first checks if the raw materials are available, if not these are ordered. Then the manager informs the work preparation department (hereinafter referred to as AV) that an assembly product is needed. To keep track of the assembly products, the logistics manager has a holder behind his desk with blue folders. Each folder contains one assembly product.

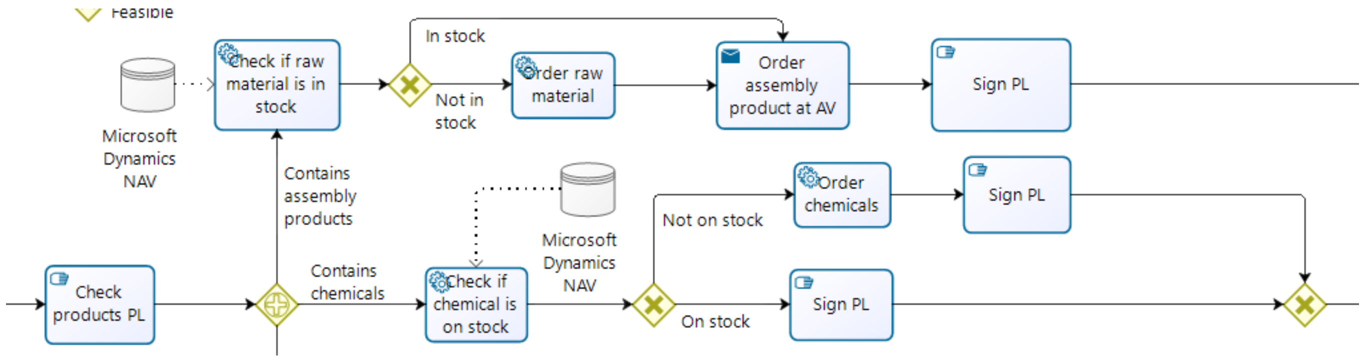


FIGURE 10: PROCESS MAP CHECK ON CHEMICALS AND ASSEMBLY PRODUCTS BY LOGISTICS MANAGER

Figure 11 shows the first part of the process steps for the spare parts. The logistics manager checks in Navision if the spare part is on stock. After checking Navision, the manager also checks the warehouse and machine department if the product is really on stock because the ERP-system does not contain the actual stock levels at the moment. If the spare part is not available, it is ordered.

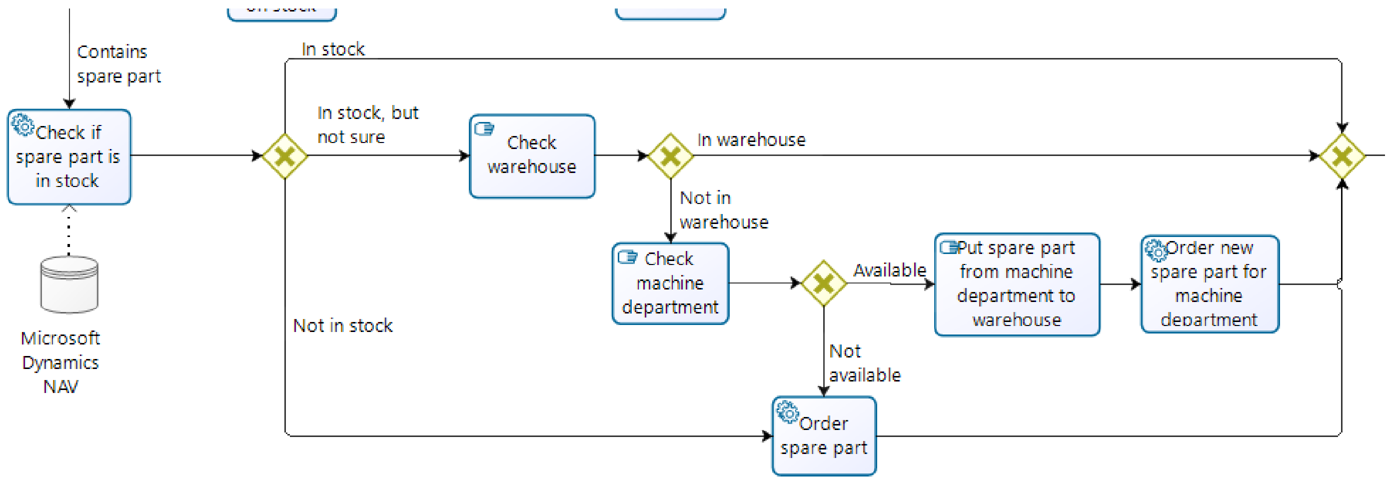


FIGURE 11: PROCESS MAP CHECK ON SPARE PARTS BY LOGISTICS MANAGER

Figure 12 shows the second part of the process steps for the spare parts, modification. Spare parts such as a display for a machine may need to be prepared by the electronic department of Kolb, for example, the right software should be installed on the display. This can happen to the electronics department but also the mechanical department.

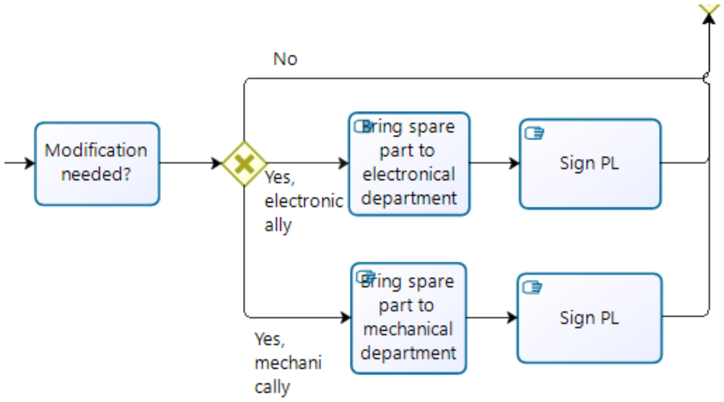


FIGURE 12: PROCESS MAP CHECK ON MODIFICATION BY LOGISTICS MANAGER

After the three parallel checks, the logistics manager checks the type of picklist. Figure 13 shows the process steps of checking the type of picklist. The express picklist needs to be processed immediately, so the logistics manager brings it immediately to the logistics employee as soon as he checked everything. A normal and changing picklist are put in a tray so that the logistics employee can take them to the picklist folder. When the shipment day equals the current day, the logistics manager brings the picklist immediately to the logistics employees.

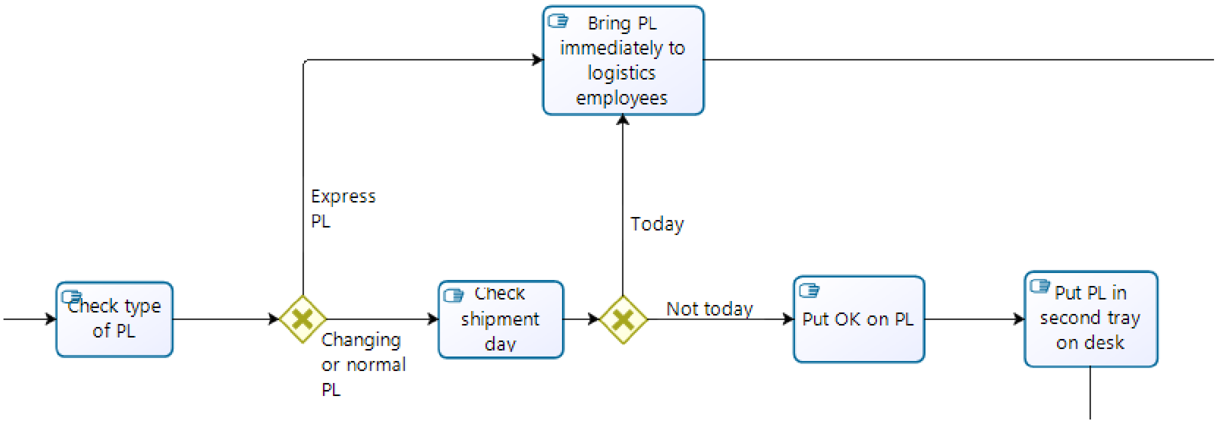


FIGURE 13: PROCESS MAP CHECK ON TYPE OF PICKLIST BY LOGISTICS MANAGER

After all the checks and approval of the logistics manager, the process continues with the logistics employee. Figure 14 shows the process steps of the logistics employee. The employee checks every morning which picklists need to be processed that day. He will pack the order and will add the weight of the package, the height of the package, the batch number, a signature of the logistics employee and remarks if needed. Afterwards, the logistics employee scans the processed picklist to the AB and archives the picklist in a special box at the logistics office.

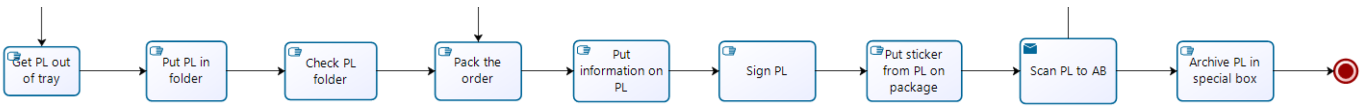


FIGURE 14: PROCESS MAP LOGISTICS EMPLOYEE

The process stops at the AB by receiving the picklist from the logistics department. Figure 15 shows this step.

FIGURE 15: PROCESS MAP RECEIVING PICKLIST BY AB

2.4. Process time of the picklist process

After creating a process map of the picklist process, the processing times per step are estimated. During the case study, all process times are estimated together with the logistics manager based on his experience. Usually, the manager processes multiple picklists at once. Therefore, the processing time per picklist is reconsidered from the time needed for processing multiple picklists. The numbers are rounded since the numbers are estimates based on experience. Due to lack of time and number of replications to have a validate experiment, the processing times are not measured exactly.

The occurrence per process step per week is estimated as follows:

- The average amount of processed picklists per week equals 55. This is based on data from the ERP-system. On average, 11 picklists are processed per day for five days a week. Appendix B: extra information current situation Kolb Table B15 shows the data of the ERP-system.
- Appendix B: extra information current situation Kolb Figure B1 shows that the chemicals and spare parts are 55% of the total turnover of Kolb and the assembly products 37%. Therefore, all process steps relating to chemicals and spare parts occur 30.25 times per week ($0{,}55 * 55 = 30.25$). All process steps relating to assembly products occur 20.35 times per week ($0{,}37 * 55 = 20.35$). Since this is accurate data from the ERP-system the numbers are not rounded.
- The ratio between putting picklists in the tray and bringing them immediately to the logistics employee equals $1\colon 4.5$. This is based on the experience of the logistical manager.
- The number of picklists getting out of the tray equals 8. This is based on the fact that the logistics employee walks on average 1 time per hour to the office of the logistical manager to get all picklists out of the tray.
- The occurrence of checking the order folder equals 5. Usually, the logistics employee checks the older folder every morning.
- All other occurrences are based on the experience of the logistics manager.

Table 3 shows the processing time per process step sorted from the highest part of total processing time to the lowest. The process steps are categorized into four activity types:

- Manual transport of the picklist and motion of employee (indicated in yellow)
- Internal checks (indicated in blue)
- Extra activities due to errors (indicated in orange)
- Remaining activities – (no indication)

TABLE 3: PROCESSING TIMES PER PROCESS STEP

Process step	Processing time (seconds)	Occurrence (per week)	Total processing time per week (seconds)	Total processing time per week (minutes)	Part of total processing time (%)
Order chemicals	300	30.25	9075	151	24%
Check raw material Navision + order raw material + order assembly product	300	20.35	6105	102	16%
Put information on picklist	60	55	3300	55	9%
Scan picklist	60	55	3300	55	9%
Bring spare part to electrical or mechanical department	900	3	2700	45	7%
Check spare part warehouse	60	30.25	1815	30	5%
New shipment day discussion	885	2	1770	30	5%
Put picklist in tray	30	45	1350	23	4%
Put WIDs in folder	30	45	1350	23	4%
Check chemicals Navision	30	30.25	908	15	2%
Check spare part Navision	30	30.25	908	15	2%
Check shipment day	15	55	825	14	2%
Bring picklist immediately to the employee	60	10	600	10	2%
Check type of packaging	10	55	550	9	1%
Check modification	15	30.25	454	8	1%
Check spare part machine department + changing spare part	180	2	360	6	1%
Receive picklist (incl. walking to the printer)	5	55	275	5	1%
Check on duplicates	5	55	275	5	1%
Put sticker on package	5	55	275	5	1%
Archive picklist	5	55	275	5	1%
Sign picklist	5	55	275	5	1%
Order spare part	120	2	240	4	1%
Check order folder	15	5	75	1	0%
Removal of duplicates	10	7	70	1	0%
Get picklists out of tray	5	8	40	1	0%
Change type of packaging	5	2	10	0	0%
Total processing time per week			**37179**	**620**	**100%**
Total processing time per picklist			**676**	**11**	

2.4.1. Processing time per picklist

Processing one picklist cost on average 11 minutes. This is calculated by dividing the total processing time per week in seconds by 55. However, there are outliers. For example, when a picklist contains all products groups and has all possible defects, the processing time per picklist increases to an average of 57 minutes per picklist.

2.4.2. Processing time per activity type

Table 4 shows the processing time per activity type.

TABLE 4: CURRENT TOTAL PROCESSING TIME PER WEEK PER ACTIVITY TYPE

Activity type	Processing time per week (seconds)	Processing time per week (minutes)	Part of total processing time
Remaining activities	12650	211	34%
Manual transportation of the picklist and motion of employees	12415	207	33%
Internal checks	10024	167	27%
Extra activities due to errors	2090	35	6%
Total	**37179**	**620**	**100%**

The first thought of the CEO and logistics manager of Kolb was that transportation and motion contribute most to the total processing time. Table 4 shows that there is one activity contributing more to the total processing time, the remaining activities (34%). A bit less, but also more than one-fourth of the total processing time comes from internal checks (27%).

The remaining activities include three steps from which the order chemicals has the highest contribution. The process of how to order chemicals is out of the scope of this dissertation, but it can be considered if the order chemicals process step belongs to the logistics manager. At this moment, the logistics manager orders the chemicals because he has a lot of experience and the purchasing department does not have that experience and data available. Since the remaining activities contribute more than one-third of the total processing time and an answer is needed for the question mentioned in this section, the activity type remaining activities is a focus point for the solution analysis.

The second highest contribution to the total processing time is the activity type of manual transportation of the picklist and motion of the employees (33%). Most of the activities are a waste of time such as walking to the printer, putting the picklists in a folder or putting the picklist in a tray. These activities are needed at the moment because the process is executed on paper and these papers need to be stored and transported. Since the transportation and motion contributes one-third of the total processing time and an answer is needed for the question mentioned in this section, the activity type remaining activities is a focus point for the solution analysis.

The third focus point is internal checks (27%). Internal checks are mostly needed to prevent defects and because the purchasing department does not purchase all products. But can the internal checks be eliminated when the causes of the existence of the internal checks are tackled? To get an answer to this question, the internal checks is also a focus point for the solution phase.

The last activity type is defects (6%). All steps relating to defects have a connection with a step of internal checks. For example, a wrongly determined shipping date causes a new shipping date discussion with the customer. When providing a solution to reduce the internal checks, the steps relating to defects are also influenced. Therefore, the activity type of defects is combined with the focus point internal checks and is no focus point on its own.

2.5. Conclusion

In this chapter, the current picklist process of Kolb is analysed. The following research question is answered:

- What does the current picklist process of Kolb look like?
    - What is the current processing time of the picklist process?
    - To what extent do transportation and motion contribute to the total processing time?
    - What are other contributions to the processing time?

The picklist process of the logistical centre of Kolb contains a lot of steps. This did not seem to be the case when first discussing the picklist process with the logistics manager of Kolb. The total processing time of one picklist is on average 11 minutes but it can increase to an average of 57 minutes per picklist. Processing picklists cost on average 620 minutes per week. This equals 10.3 hours per week, which is more than one working day.

According to the CEO and logistics manager, transportation and motion contribute most to the total processing time. A conclusion from the processing time analysis is that there are four activity types at the picklist process of Kolb:

- Remaining activities (34%)
- Transportation and motion (33%)
- Internal checks (27%)
- Defects (6%)

The most contributing activity type is the remaining activities and not transportation and motion. Transportation and motion and the internal checks contribute more than one fourth to the total processing time. Since all three activity types contribute almost the same percentage to the total processing time, all three are a focus point for the solutions phase.

Defects contribute only 6% to the total processing time and have a relation with the internal checks. Therefore, the activity type defects is not a focus point but is taken into account when providing a solution to reduce the processing time of internal checks.

The next chapter provides a theoretical framework about the business process improvement method to use for Kolb to find the exact bottlenecks and a solution for the high processing times of remaining activities, transportation and motion and internal checks.

3. Theoretical framework: business process improvement

This chapter covers the literature review of business process improvement. Section 3.1 provides an analysis of the most well-known business process improvement techniques and explains the most suitable tool for Kolb. Section 3.2 explains the most suitable tool for Kolb (business process re-engineering) and the belonging methodology. Section 3.3 provides a conclusion on the research question: which business process improvement technique is most suitable for the problem of Kolb?

3.1. Overview most well-known process improvement techniques

There are a lot of business process improvement techniques available in literature. According to Mark Gershon, the most well-known methodologies for process improvement are Total Quality Management (TQM), Six Sigma, Re-engineering, Just-In-Time (JIT), Lean Thinking, ISO 9000 and Theory of Constraints (TOC) (Gershon, 2010). Not all methods available in literature can be discussed. Therefore, the methods provided by Mark Gershon are used during this literature review.

To decide what improvement methods apply to the problem of Kolb, it should be clear what the process improvement method should be able to do. The requirement for the improvement method for the situation of Kolb is: "the improvement method should be able to improve the picklist process in such a way that it will be more efficient, the processing time will decrease and it is designed such that it can be digitized easily."

To discover which methodologies fit the problem of Kolb, a brief explanation and the characteristics of each methodology are given:

- Total Quality Management (TQM) - according to Hammett (2000): "TQM is a management philosophy which seeks to integrate all organizational functions (marketing, finance, design, engineering, production, customer service …) to focus on meeting customer needs and organizational objectives." TQM focuses on continuous improvement of the business performances and improving product quality. The key value is doing things the first time right to save correction time, failing products and service guaranteed repairs. TQM does not solve a certain type of problem but is a philosophy which needs to be implemented at the company from a top-down perspective (Ehigie & McAndrew, 2005).
- Six Sigma - according to multiple authors of articles and management experts, Six Sigma has multiple definitions (Gershon, 2010). According to these definitions, Six Sigma focus on the following aspects: error-free production of customer-defined products and services, maximizing customer satisfaction, earning customer loyalty, improving profitability for shareholders, improve employee job satisfaction and improve the market position of the organization (Gershon, 2010). The Six Sigma level of performance is 3.4 defects per million opportunities for each core process (Gershon, 2010). The main problem of lacking quality, reliability and predictability is too many variations within the process, these variations should be identified, analysed, measured, improved and controlled systematically with help of the DMAIC model. (Gershon, 2010).
- Business Process Redesign/Business Process Re-engineering - Business Process Redesign (BPR) focuses on analysing and designing workflows and business processes within an organization. It restructures the organization radically instead of making improvements in the existing process. According to Michael Hammer, information technology should not be used to automate an existing process, but to make a new process including information technology (Hammer, 1990).
- Just-In-Time (JIT) - Just-In-Time is an inventory policy, which says to order exactly what is needed when this is needed.

JIT aims to have a zero inventory (Gershon, 2010). To successfully implement JIT, two things have to be the case: the exact quantities delivered should all be good to use and schedules should be maintained exactly as planned.

- **Lean Thinking -** Lean Thinking focuses on eliminating waste (Gershon, 2010). Within the Lean Thinking methodology there exist 7 types of waste. The 7 types of waste are transportation, inventory, motion, waiting, over-processing, overproduction and defects (The Lean Six Sigma Company, n.d.).
- **ISO 9000 -** ISO 9000 is an international quality standard, formally accepted by the European Union (Gershon, 2010). It is not an improvement method but more an administrative system with standards on how to guarantee quality. The ISO 9000 range contains the following standards: ISO 9000, ISO 9001, ISO 9004 and ISO 19011. Kolb is already certified for the ISO 9001 since 2010, in July 2020 Kolb succeeded a new audit for ISO 9001.
- **Theory of Constraints (TOC)** - the Theory of Constraints (TOC) focuses on managing the bottlenecks in a process, these bottlenecks are called the constraints (Gershon, 2010). One assumption of the TOC is that the process will be measured by inventory, throughput and operation expense.

All these methods have disadvantages and advantages for the specific situation of Kolb. Table 5 provides an overview of all the advantages and disadvantages per process improvement method for the specific situation of Kolb.

TABLE 5: ADVANTAGE AND DISADVANTAGE PER PROCESS IMPROVEMENT METHOD

Process improvement method	Advantage	Disadvantage
Total Quality Management (TQM)	Focus on continuous improvement and improving product quality.	Does not solve a specific problem but is a philosophy which should be integrated into the whole company.
Six Sigma	Provides a systematic way to solve a problem with help of the DMAIC model.	Focus on reducing variability and minimizing defects.
Business Process Redesign (BPR)	Provides a way to make a new process including IT.	Changes the process radically.
Just-In-Time (JIT) **Lean Thinking**	Aims to have an inventory of zero. Focus on reducing waste in the process.	It is an inventory policy. Best applicable and provides a lot of tools for manufacturing and logistics process, not for administrative processes.
ISO 9000	Give standards on how to guarantee quality.	Kolb already has an ISO 9001 certification.
Theory of Constraints (TOC)	Focus on managing bottlenecks in a process.	Focused on the manufacturing process and uses the KPI's inventory, throughput and operation expense.
Business Process Management (BPM)	Focus on continuous improvement and gives a representation of the process.	Does not provide tools to improve the process.

Concluded is that TQM and ISO are not appropriate since they are philosophies. JIT is about an inventory policy, this is not the topic of this research. Six Sigma cannot be used since the situation of Kolb is not about reducing defects and variability, besides Six Sigma is also more appropriate for manufacturing processes. TOC is also more appropriate for manufacturing processes. Besides, the KPIs given for TOC do not apply to the situation of Kolb. ISO 9000 is more about quality standards and Kolb already has an ISO 9001 certificate.

The two most appropriate tools are BPR and lean thinking. Both methods can be used for the situation of Kolb. However, lean thinking provides a lot of tools for manufacturing and logistics process and not for administrative processes. Besides, lean thinking does not focus on automation. Since the only disadvantage from BPR is the radical change aspect, BPR is the best tool for the situation of Kolb. Especially, since BPR also focus on automation and eliminating non-value-added activities. Therefore, BPR is chosen as the most suitable tool for this research. The next section explains BPR.

3.2. BPR: Business Process Redesign

3.2.1. Definition and history

According to Mansar & Reijers (2007), there is a difference between the concepts of Business Process Reengineering and Business Process Redesign. Reengineering has a broader scope, it can refer to all the aspects of restructuring an organization (Mansar & Reijers, 2007). Redesign focuses more on the interdependent tasks and resources instead of a whole organization (Mansar & Reijers, 2007). This distinction is mostly made by academics. For this bachelor thesis, there is no distinction made between Business Process Re-engineering and Business Process Redesign. From now on, the term BPR is used.

In 1990, Michael Hammer published the article “Reengineering Work: Don’t Automate, Obliterate”. According to Hammer (1990), companies in the 1990s made huge investments in information technology (IT) but the results of these investments have been disappointing. Companies digitized old ways of doing business, they used the same process and digitized them to speed them up but they were not improved (Hammer, 1990). According to Hammer (1990), companies should reengineer their businesses in the following way: “use the power of modern information technology to radically redesign our business processes to achieve dramatic improvements in their performance.”

According to Saad (2019), BPR has the following characteristics:

- It emphasises innovation and improvements
- It involves the process of redesigning
- It utilizes IT
- It helps reduce cost and improve quality of service.

According to Hammer (1990), BPR consists out of 7 principles:

- **Organize around outcomes, not tasks -** one person should execute all the steps in the process. The steps of that person should be designed around an object or outcome, not around single tasks.
- **Have those who use the output of the process perform the process** - a lot of companies have specialized departments which execute one type of task, accounting does accounting and purchasing purchase. This principle tells that, due to automation, the person who uses the output can also perform the process himself.
- **Subsume information-processing work into the real work that produces the information** - the person who collects information should also processes the information.

- **Treat geographically dispersed resources as though they were centralized** - when a company has multiple business units with its own purchasing department, this should be coordinated by one central department to benefit from economies of scale.
- **Link parallel activities instead of integrating their results** - parallel functions should be coordinated while they are in the process and not after they are completed.
- **Put the decision point where the work is performed, and build control into the process** - the persons who execute the process should also make decisions about the process. The process should have built-in controls. The result of this principle is a more flattened organisation, with fewer layers of managers.
- **Capture information once and at the source** – store all information within one database.

3.2.2. Methodology

There does not exist a uniform methodology for BPR. There is a lot of literature available about methodologies for BPR. Bøjrn Andersen (2013) provides a BPR methodology in his book Business Process Improvement Toolbox (2nd Edition). Figure 16 shows the methodology proposed by Bøjrn Andersen (2013).

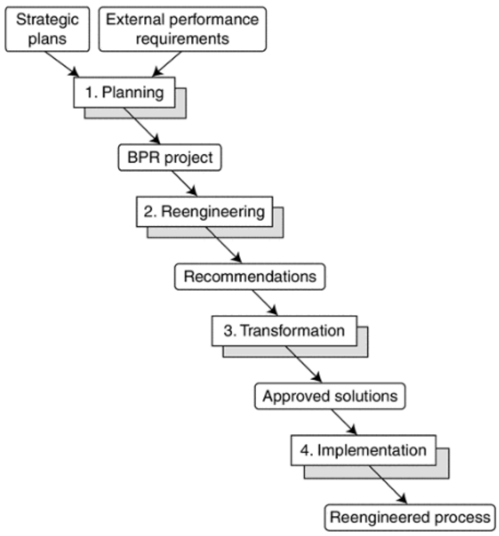


Figure 11.24 The process for conducting a BPR project.

FIGURE 16: THE PROCESS FOR CONDUCTING A BPR PROJECT (ANDERSEN, 2013)

The process consists of the following four phases:

Planning

In the planning phase, the focus of the BPR project is selected. The project is formed and objectives are defined. There exist four central tasks in the planning phase:

- Select the process to be improved through BPR and consider its scope
- Assess the possibilities for achieving improvements and establish targets
- Establish a project team to perform the work in the project
- Produce a plan for the BPR project

The planning phase is already executed. Chapter 1 covers the aspect of selecting a process, considering the scope, establishing targets and producing a plan. Chapter 2 established the possibilities for achieving improvements and section 3.1 checked if BPR is a suitable tool for the problem.

Reengineering

In the reengineering phase, a set of techniques is executed to reengineer the process to a level that will result in significant improvement. The three steps of the reengineering phase are:

- Document the existing process
  (Chapter 2.3 already covers the documentation of the existing process)
- Reengineer the process
- Develop recommendations for improvement

According to Bøjrn Andersen (2013), there are two types of reengineering:

- **Systematic reengineering** – understanding and analysing the current process so a new and better process can be created systematically.
- **Clean sheet reengineering** – creating a new process from scratch through fundamental rethinking.

Since the only disadvantage of BPR for the situation of Kolb is the radical approach, the systematic BPR is a great opportunity to use. Systematic reengineering is based on the ESIA rule. ESIA stands for elimination, simplification, integration and automation. Figure 17 shows the focus areas for the ESIA rule.

Table 11.3 Focus areas for systematic reengineering.

Eliminate	Simplify	Integrate	Automate
Excess production	Forms	Jobs	Dirty work
Waiting time	Procedures	Groups	Difficult
Transport	Communication	Customers	Dangerous
Processing	Technology	Suppliers	Boring
Storage	Problem areas		Data capturing
Defects/Errors	Flow		Data transfer
Duplication	Processes		Data analysis
Reformatting			
Inspection			
Reconsolidation			

FIGURE 17: FOCUS AREAS ESIA RULE (ANDERSEN, 2013)

The first step of the ESIA rule is elimination. The aim of elimination is reducing and eliminating non-value-added activities. The first column in Figure 17 shows all types of waste activities according to Bøjrn Andersen (2013). These activities look quite similar to the types of waste defined in the lean methodology. The types of waste in the lean methodology are overproduction, waiting, unnecessary motion, transport, over-processing, inventory and defects (Bicheno & Holweg, 2016).

To define which process steps need to be eliminated, a value-added analysis needs to be conducted. With a value-added analysis, each step in the process is assessed whether it provides value to the customer or not. There are three questions to ask when assessing the steps (Andersen, 2013):

- Does the task provide an element required for the product to be delivered?
- Does the task provide an enhancement or addition to the original product?
- Does the purchase price include an amount for conducting the task?

In the value-added analysis, there exist three types of activities. With two types of activities, no discussion is possible. All academic resources found, give the same definitions (Beels, 2019):

- Non-value added – activities that do not increase the value to the customer or are not needed for a business requirement
- Value-added – activities that the customer is willing to pay for. It physically transforms the product, document or information and is being done right the first time

The third activity type is vaguer, the necessary but non-value-added activities. According to Beels (2019), a necessary non-value-added activity is an activity that does not add value to the product and/or service but is currently necessary to execute. Two examples of necessary but non-value-adding activities are:

- Time registration of employees working on a machine is necessary for management analysis but does not add value to the machine.
- A purchase employee has to ask the sales order employee for the products he needs to purchase for a specific order because the company has no ERP-system with all data centrally stored.

According to Bøjrn Andersen (2013), this type of activity is called organizational value-added activities, activities that do not add value to the product and/or service but are necessary from the organizational point of view. According to the Gartner Glossary, necessary non-value-adding activities are necessary under the current way of working (Gartner Glossary, n.d.). Concluded from these three points, the following description of necessary but non-value-added activities is used:

- Activities that do not add value to the product and/or service from a customer point of view, but are necessary because of the current way of operating.

The second step is simplifying. All remaining activities after eliminating the non-value added activities, should be simplified. Figure 17 shows the areas which are often too complex (Raimondi, n.d.):

- Forms – simplifying forms lead to eliminating the need to ask for clarification of the form and reduces the chance of incorrectly completed forms
- Procedures – procedures can be complicated and difficult to understand, especially when they are too long
- Communication – communication should be clear and understandable to both the customers and employees. Jargon should be avoided as much as possible
- Technology – technology can be a great support to a process but do not use high-tech solutions when low-tech solutions sustain. The interfaces should also be designed properly such that the software is easy to use
- Flows – mostly flows are designed to have a natural flow. Due to changes over time, this natural flow can change. Simplifying the flow can be achieved by changing the order of tasks. A helpful tool to identify flow improvement is a process map
- Processes – sometimes companies serve different type of customers in one process. Simplifying the process can be achieved by breaking down the process and identify activities which are dedicated to one customer segment
- Problem areas – ask employees, customers and suppliers for potential problem areas such as difficult, dirty or dangerous tasks

The third step is integration. After eliminating and simplifying, the remaining tasks should be integrated to further improve the process flow. For example, several smaller jobs can be integrated into one single job. Interesting areas for integration are (Raimondi, n.d.):

- **Jobs** – several jobs could be integrated into one. The advantages of completing a range of tasks by one employee is an increased flow of material or information and a decrease in mistakes
- **Teams** – when a job cannot be executed by one single person, a combined team of specialist can be used
- **Customers** – customer integration is often called value-added-services, additional services to the basic need purchased
- **Suppliers** – the advantages of supplier integration are huge savings and the elimination of needless bureaucracy

The last step is automation. When the process is efficient, automation can be investigated. Information technology is a support aid for business processes. The following areas are interesting for automation (Raimondi, n.d.):

- Dirty, difficult or dangerous work
- **Boring work** – for example, repetitive tasks
- **Data capture** – for example using bar code scanners instead of implementing the data manually
- **Data transfer** – for example transferring data from format to another format or from one system to another
- **Data analysis** – this includes receiving insightful und accessible conclusions from the data in the databases of a company

Transformation

Within the transformation phase, it is determined how the reengineered process can be implemented concerning the existing process, the need for investment, training et cetera. The main tasks of this phase are:

- Evaluating the changes required to implement the new process
- Planning the need for investment, training et cetera
- Creating a favourable climate for change
- Planning the implementation

Implementation

Within the last phase, the reengineered process is implemented and the process will change. The implementation phase is out of the scope of this bachelor thesis. However, an implementation plan is provided. The main steps of this phase are:

- Set targets for improvement
- Create a favourable climate for change
- Carry out the implementation plan
- Monitor the process of implementation and handle deviations

3.3. Conclusion

In this chapter, a theoretical framework is created around a suitable business process improvement tool for Kolb. The following research question is answered:

- **Which business process improvement technique is most suitable for the problem of Kolb?**
  - Which business process improvements techniques are available in literature?
  - What does the most suitable business process improvement technique look like?

A lot of business process improvement techniques are available in literature. The most suitable method for Kolb is Business Process Re-engineering. The only disadvantage for BPR is the aspect of radical change. Bøjrn Andersen (2013) provides two types of BPR, systematic and clean sheet. Systematic re-engineering deals with radical change. It allows a new and better process based on understanding and analysing the current process. Clean sheet re-engineering creates a new process from scratch. Therefore, systematic re-engineering is the most suitable technique to solve the problem of Kolb.

Systematic re-engineering is based on the ESIA rule. ESIA stands for eliminating waste, simplifying the remaining activities, integrating remaining activities and investigating automation. The ESIA rule allows a systematic way to create an efficient and effective process that can be automated eventually.

After systematically re-engineering the business process, a transformation phase is executed. In the transformation phase, the need for investment and evaluating the changes required to implement the process are discussed. The transformation phase is executed in the implementation plan. The next step is applying the theoretical framework to the situation of Kolb.

4. Application theoretical framework

This chapter applies the theoretical framework provided in chapter 3 to the current situation of Kolb. Section 4.1 identifies the bottlenecks of the picklist process that need to be eliminated with help of value-added analysis. Section 4.2 identifies which phase of the ESIA rule (simplification, integration and automation) suits best to solve the bottlenecks. Section 4.3 provides a conclusion on the research question: which bottlenecks need to be solved to improve the picklist process?

4.1. ESIA rule - elimination

The first phase of systematic BPR is the elimination of waste activities. For every activity type, a value-added analysis is executed. Section 3.2.2 explains three types of activities of value-added analysis. The following abbreviations are used for the types of activities for the value-added analysis:

- VA = value-added
- NVA = non-value-added
- N = necessary, but non-value-added

The value-added analysis is based on information received during the case study at Kolb and several discussions with the CEO and logistics manager. Also, more questions are answered by the logistics manager by e-mail. Unfortunately, no physical meetings could take place because of Covid-19. Based on the information received from the CEO and logistics manager of Kolb, the type of activities for all process steps shown in section 2.4 are estimated by myself and discussed with the CEO of Kolb.

The next three sections provide the value-added analysis of the remaining activities and defects, manual transportation and motion and internal checks.

4.1.1. Value-added analysis of remaining activities and defects

Table 6 shows the analysis of the remaining activities.

TABLE 6: VALUE-ADDED ANALYSIS OF REMAINING ACTIVITIES

Process step	Minutes/week	Part of total processing time	Type of activity (VA/N/NVA)	Waste
Order the chemicals	151	24%	VA	
Put package information on the picklist	55	9%	N	
Sign the picklist	5	1%	NVA	
Total	**211**	**34%**		

The remaining activities contain one non-value-added activity. Signing the picklist is executed to be able to search for the responsible logistics employee when an error is made. When a logistics employee makes the same errors multiple times, Kolb can provide training to that logistics employee. However, this step does not add value for the customer and is not necessary. Kolb has 2 logistics employees and can simply track down which employee processed the picklist on a specific day. Therefore, this step is non-value-added. Eliminating this step saves 5 minutes per week.

It contains two necessary but non-value-added activities. These two activities are executed because the picklist is processed manually on paper. The logistics employee puts package information and an approval sign on the picklist with a pen. According to the CEO of Kolb, this leads sometimes to unreadable hand-written information, especially when a lot of picklists are processed.

These two steps also contribute in total 10% to the total processing time. The high contribution to the processing time and the unreadable hand-written information lead to the following bottleneck: manual processing of a paper picklist.

The remaining activities contain one value-added step, ordering the chemicals. This step is value-added because the customer is willing to pay for this step. When the chemicals are not ordered, the customer does not receive the chemicals. This step has the highest contribution of all picklist process steps to the total processing time (24%). One important question is why the logistics manager orders the chemicals instead of the purchasing department. The chemicals are ordered by the logistics manager because they are ordered based on experience. Every Wednesday, the logistics manager places an order at Linker GmbH. This order consists of two parts:

- Chemicals independent from sales orders. Kolb has the most sold products always on stock because they promise a delivery time of three working days for normal sales orders. A normal sales order is an order that does not contain high volumes of chemicals, export deliveries or assembly groups.
- Chemicals for sales orders with high volumes or export deliveries. Kolb promises a delivery time of 8 working days for these kinds of chemicals. These chemicals are ordered in the quantity from the sales order.

The logistics manager exactly knows which products and quantities need to be on stock to fulfil customer orders. The logistics manager indicated that it is not ideal that logistics orders products and that this is a bottleneck of the picklist process. The high contribution to the total processing time and the fact that it is not ideal that the logistics manager order products lead to the following bottleneck: lack of experience and data for the purchasing department to order chemicals.

Table 7 shows the analysis of defects.

TABLE 7: VALUE-ADDED ANALYSIS DEFECTS

Process step	Minutes/week	Part of total processing time	Type of activity (VA/N/NVA)	Waste
New shipping date discussion	30	5%	N	Excess processing
Order spare parts	4	1%	VA	
Removal of duplicates	1	0%	N	Excess processing
Change the type of packaging	0	0%	N	Excess processing
Total	**35**	**6%**		

The defects do not contain non-value-added activities that can be eliminated. It contains one value-added step, order spare parts. Most spare parts are purchased by the purchasing department. However, sometimes not all materials are purchased when the logistics manager checks the picklist. The logistics manager then purchases the missing spare parts, but like the chemicals, it is not ideal that logistics orders products. During the execution of this research, Kolb already implemented a solution for this problem. The solution is a filter in Navision for the production orders. With this filter, the purchasing department can filter on missing parts at the production orders of the assembly products. The missing parts can immediately be purchased by the purchasing department. The only communication with the logistics manager is the determination of the goods receipt date so the logistics manager can implement the production order into the production planning. Therefore, this is not a bottleneck anymore.

The remaining steps are necessary but non-value-added. These steps exist because mistakes are made earlier in the process. However, the contribution of these steps is negligible relative to the total processing time. So solving the defect steps on its own is not worth the investments. Therefore it needs to be clear how much time the steps cost in combination with the related internal check step. This is done at the value-added analysis of the internal checks at section 4.1.3.

The following non-value-added step is found and can be eliminated immediately:

- **Sign the picklist** (1% of the total processing time)

The following two bottlenecks are identified during the value-added analysis of the remaining activities and defects:

- **Manual processing of a paper picklist**
- **Lack of experience and data for the purchasing department to order chemicals**

4.1.2. Value-added analysis manual transportation and motion

Table 8 shows the value-added analysis for the process steps related to transportation and motion.

TABLE 8: VALUE-ADDED ANALYSIS TRANSPORTATION AND MOTION

Process step	Minutes per week	Part of total processing time	Type of activity (VA/NVA/N)	Type of waste
Scan picklist to AB	55	9%	N	Transport and motion
Bring the spare part to the electrical or mechanical department	45	7%	VA	Motion
Check availability spare part warehouse	30	5%	N	Motion
Put picklist in the tray	23	4%	N	Transport and motion
Put picklist in the picklist folder	23	4%	N	Transport and motion
Bring picklist immediately to the logistics employee	10	2%	N	Transport and motion
Check availability machine department + interchanging	6	1%	N	Motion
Receiving the picklist and walking to the printer	5	1%	N	Transport and motion
Put picklist sticker on the package	5	1%	VA	Transport and motion
Archive picklist in cabinet	5	1%	NVA	Transport and motion
Check the picklist folder	1	0%	N	Transport and motion
Get picklist out of the tray	1	0%	N	Transport and motion
Total	**207**	**33%**		

The transportation and motion steps do not contribute a lot to the total processing time individually. Together, they contribute 33%. 20% of the transportation and motion comes from the transportation of the picklist and motion from the employees to transport the picklist. The remaining 13% comes from transportation of spare parts and checking the warehouse and machine department.

Transportation and motion contain one non-value-added step. Archiving the picklist does not add value for the customer and is not necessary. The picklists are archived to check which logistics employee processed a picklist when an error is found. However, when a logistics employee scans a processed picklist to the AB, the AB stores it in an electronic folder. According to the CEO of Kolb, the archived picklists in the cabinet are seldom used. Searching for a picklist in an organized electronic folder is easier and faster than searching through all the papers in the archive cabinet. Therefore, this step is non-value-added and can be eliminated immediately. Eliminating this step saves 5 minutes per week.

Transportation and motion also contain two value-added steps. One value-added step is bringing the spare part to the electrical or mechanical department, this is needed because some spare parts need to be modified before they can be shipped to the customer. For example, a machine display needs to be programmed by the electrical department. Another value-added step is putting a sticker on the package. This sticker contains information about the products and shipment and is needed for the transportation company.

All other steps are necessary but non-value-added. Most steps exist because of manual processing of the paper picklist. The picklist needs to be scanned to the AB when it is processed, the picklist needs to be stored in trays and folders to ensure that a picklist does not get lost, the picklist needs to be brought to the logistics employee when it should be sent that day and the picklist needs to be archived. For all these activities, the picklist is transported through the process. The high contribution of transporting the picklist through the process leads to the same bottleneck as with the remaining activities: manual processing of a paper picklist.

Another remarkable necessary but non-value-added step is spare part check at the warehouse or machine department. The logistics manager cannot rely on the data of Navision and always checks if a spare part is available at the warehouse or machine department. Section 1.2.3 explains multiple reasons for the inaccurate stock levels of the spare parts in the ERP-system. That section also explains that the inaccurate level of spare parts at the ERP-system is out of the scope of this bachelor since Kolb already solved this problem by themselves. Therefore, the inaccurate stock level of the spare parts in Navision is not further discussed.

The following non-value-added step is found and can be eliminated immediately:

- Archive the picklist (1% of the total processing time)

The following bottleneck is identified during the value-added analysis of transportation and motion:

- Manual processing of a paper picklist (same as bottleneck identified at section 4.1.1)

4.1.3. Value-added analysis internal checks

Table 9 shows the value-added analysis for the internal checks.

TABLE 9: VALUE-ADDED ANALYSIS INTERNAL CHECKS

Process step	Minutes/week	Part of total processing time	Type of activity (VA/N/NVA)	Waste
Check availability raw material Navision + order raw material + order assembly product by AV	102	16%	N	Inspection
Check availability chemicals Navision	15	2%	N	Inspection
Check availability spare part Navision	15	2%	N	Inspection
Check feasibility shipping date	14	2%	N	Inspection and duplication
Check feasibility type of packaging	9	1%	N	Inspection and duplication
Check need of modification	8	1%	N	Inspection
Check on duplicated picklists	5	1%	N	Inspection
Total	**167**	**27%**		

The internal checks do not contain non-value-added activities that can be eliminated, it only contains necessary but non-value-added steps.

First the check of the chemicals, spare parts and raw materials. The raw materials and spare parts are checked because not all products are purchased by the purchasing department. This is not further discussed here, since this is already explained at the value-added analysis of the defects at section 4.1.1. The value-added analysis of the defects also explains the solution that Kolb already found to this problem. The chemicals are checked because the logistics manager orders the chemicals. The value-added analysis of the remaining activities already explains this problem at section 4.1.1. The chemicals check does not contribute a lot to the total processing time but it has the same underlying bottleneck as ordering the chemicals: lack of experience and data for the purchasing department to order chemicals.

Secondly the step of duplicated picklists. Sometimes AB forgot if a picklist is sent, so it is sent again. Section 2.3 Figure 7 explains the impact of a duplicated picklist in the process and why the logistics manager checks on duplication. Together with the defect step removing a duplicated picklist, this step cost in total 1% of the total processing time. The contribution is negligible but it has the same underlying bottleneck as a lot of steps at transportation and motion: manual processing of a paper picklist.

At last the shipping date and packaging type check. Together with the defect step discussing a new shipping date, the shipping date check contributes 7% to the total processing time. Together with the defect of changing the packaging type, the packaging type check contributes 2% to the total processing time. The packaging type and shipping date are mainly based on experience and therefore contains occasionally mistakes. Only the shipping date check and discussion is a bottleneck because of the high contribution of 7% to the total processing time.

The errors at the packaging type are not ideal but contribute a small amount of time to the total processing time of the picklist process. Due to the low contribution and the occurrence of two times a week, this is not seen as a bottleneck.

The following three bottlenecks are identified during the value-added analysis of the internal checks:

- **Manual processing of a paper picklist** (same as bottleneck identified at section 4.1.1)
- **Lack of experience and data for the purchasing department to order chemicals** (same as bottleneck identified at section 4.1.1)
- **Incorrect determination of the shipping date**

4.2. ESIA rule – simplification, integration and automation

After identifying the bottlenecks at the elimination phase, the second step is to simplify, integrate and automate the remaining activities. Two process steps are already eliminated at the value-added analysis. These steps together contribute 10 minutes per week to the total processing time. The old processing time is 620 minutes per week, so the remaining processing time is 610 minutes per week.

Section 4.1 explains three bottlenecks that need to be solved to improve the picklist process and decrease the total processing time. These bottlenecks are focus points for the solution generation phase. Section 3.2.2 Figure 17 shows 7 areas that often need to be simplified, 4 areas that often need to be integrated and 7 processes that often are suitable for automation.

The next sections explain which ESIA phase (simplification, integration or automation) is needed to solve the bottleneck and how a solution is generated.

4.2.1. Manuel processing of a paper picklist

The manual processing of a paper picklist is repetitive work. The logistics manager and employee execute the same task every day in the same order. It also includes data capture. Data capture is the process of collecting and changing information in a format that can be processed by a computer (Cambridge Dictionary, n.d.). Currently, the paper picklist cannot be processed by a computer and is processed manually. This also means that the data is not collected by a computer. One aim of Kolb is to have a picklist that can be processed by a computer. Section 3.2.2 Figure 17 shows that repetitive work and data capture are two areas from automation. A possible automation solution is a digital picklist. Processing a digital picklist is also repetitive work but the time needed to process the picklist will reduce. With a digital picklist, the information is collected and processed to the ERP-system Navision.

During the two-week case study at Kolb, a solution for a digital picklist is discussed multiple times. The CEO and logistics manager of Kolb think that a digital picklist helps to reduce transportation and motion and the chance of defects. Besides, a digital picklist is a future technology aim of Kolb. During this research, I gathered more information about digital picklist software. Information is gathered from the websites of MobileNAV, Tasklet Factory and Insight Works. Also, several video’s are analysed to see how the software works. Also, a demo application from MobileNAV is analysed to get insights into how a digital picklist software operates. The CEO of Kolb also requested an offer for a digital picklist software to see what the investments are. Section 5.2 describes the improvement step together with the corresponding benefits and investments.

4.2.2. Lack of experience and data for the purchasing department to order chemicals

At this moment, the logistics manager and purchasing department both order products. The aim of Kolb is that the purchasing department can purchase all products. This means that the order chemical job of the logistics manager needs to be integrated into the purchasing department. This integration can be achieved with data analysis. Data analysis is part of the automation phase. At this moment the chemicals are ordered based on experience while this can be done with help of data. Kolb has an ERP-system with all sales data available. So this bottleneck needs to be solved with integration while keeping in mind automation. A solution to this bottleneck is to analyse the historical sales data and create an inventory policy. An inventory policy tells when and how much to reorder from a specific product.

The solution is created based on knowledge gained during the bachelor module Supply Chain Management of Industrial Engineering and Management. During this course, we gained knowledge about inventory problems. This knowledge leads to the idea of inventory policies. After creating the idea, more research is executed about inventory policies to create this solution. The solution is also discussed with the CEO of Kolb, his experience and opinions are added to the solution. Section 5.2 describes the improvement step together with the corresponding benefits and investments.

4.2.3. Incorrect determination of the shipping date

The incorrect determination of the shipping data is repetitive work. Repetitive work is an area for automation. The AB establish the shipping date for every picklist. Determining the shipping date is not difficult but because not all data is available right now, the shipping date is sometimes determined wrong. Currently, the shipping date is established by the AB. According to the logistics manager, there are three ways of determining a shipping date:

- **Standard articles** – AB checks at Navision if the product is on stock. When the product is on stock, the shipping date preferred by the customer is put on the picklist. Otherwise, the shipping date is based on the delivery time of the article.
- **Assemblies** – in accordance with the AB, procurement and logistics a feasible shipping date is established. The overall process is based on data in the ERP-system and experience.
- **Modified articles** – 1 to 2 working days are added to the preferred shipping date of the customer. This is based on experience and not based on the processing time of modifying the articles.

For standard articles, the shipping date is easy to establish based on data in Navision. However, the assemblies and modified articles are mainly established manually based on experience instead of data. This can be solved by automation. A possible automation solution is to implement Available-To-Promise (hereinafter referred to as ATP) and Capable-To-Promise (hereinafter referred to as CTP).

To create this solution, I visited the logistical centre of Odin Groep. Odin Groep is a mother company of three IT companies and is based in Hengelo (Odin Groep, n.d.). I had the opportunity to visit their logistical centre to see how they use digital picklists. Odin Groep showed that they use ATP and CTP to determine the first possible shipment day. That is where this solution is coming from. After this visit, more information is gathered about ATP and CTP and the possibilities at Navision. The solution is also discussed with the CEO of Kolb, his experience and opinions are added to the solution. Section 5.3 describes the improvement step together with the corresponding benefits and investments.

4.3. Conclusion

In this chapter, the theoretical framework is applied to the situation of Kolb and the following research question is answered:

- **Which bottlenecks need to be solved to improve the picklist process?**
  - What are the bottlenecks within the picklist process?
  - How can these bottlenecks be solved?

There are two non-value-added steps found during the value-added analysis. These steps can immediately be eliminated since they do not add value to the customer and are not needed. The following steps are non-value-added:

- Sign the picklist (1% of the total processing time)
- Archive the picklist (1% of total processing time)

In total, these two steps lead to a decrease of 10 minutes per week for the total processing time.

One remarkable aspect found during the value-added analysis is the high amount of necessary but non-value-added activities. These activities are needed because of the current way of working. Three bottlenecks that cause a high amount of necessary but non-value-added activities are:

- **Manuel processing of a paper picklist**
  The logistics employees of Kolb use a paper picklist to pick and pack orders. A paper picklist causes transportation and motion (20%), manually added package information and signatures (10%) and duplicates check and elimination (1%). In total, this bottleneck leads to 31% of the processing time.
- **Lack of experience and data for the purchasing department to order chemicals**
  The logistics manager orders the chemicals based on experience. This lead to the steps checking and ordering the chemicals. In total, this bottleneck leads to 26% of the processing time.
- **Incorrect determination of the shipping date**
  The shipping date and packaging type are determined by the AB based on experience. In total, this leads to 7% of the processing time.

After identifying the bottlenecks, the solution generation approach is analysed. Table 12 shows the bottlenecks with the corresponding solution generation approach from the ESIA rule.

TABLE 10: BOTTLENECK WITH CORRESPONDING SOLUTION GENERATION APPROACH

Bottleneck	Approach
Manuel processing of a paper picklist	Automation
Lack of experience and data for the purchasing department to order chemicals	Integration and automation
Incorrect determination of the shipping date	Automation

After identifying the corresponding solution generation approach, three solutions are found:

- **Implement a digital picklist**
  This solution is created based on discussions with the CEO and logistics manager of Kolb. After creating this solution more information is collected about digital picklist software. Section 5.2 describes the solution together with its corresponding benefits and investments.

- **Conduct data analysis and implement an inventory policy for chemicals division**
  This solution is created based on knowledge gained during the bachelor module Supply Chain and Management from Industrial Engineering and Management. After creating this solution more information is gathered from literature about inventory policies. Section 5.3 describes the solution together with its corresponding benefits and investments.
- **Implement Available-To-Promise (ATP) and Capable-To-Promise (CTP) in Navision**
  This solution is created based on information gained during a visit to the logistical centre of Odin Groep. During this visit is explained that Odin Groep uses ATP and CTP to calculate the first possible shipment date automatically. After creating this solution more information is collected about ATP and CTP and the opportunities within Navision. Section 5.4 describes the solution together with its corresponding benefits and investments.

The next chapter explains the solutions found for the bottlenecks identified in this chapter.

5. Improvement plan

This chapter provides an implementation plan for the solutions found for the bottlenecks described in chapter 4. Section 5.1 generally describes the approach. Section 5.2, 5.3 and 5.4 describe the improvement steps together with their benefits and investments. Section 5.5 gives a conclusion to the research question: which improvements steps should Kolb take to improve the picklist process?

5.1. Approach

For every bottleneck described in section 4.1, a solution is identified with help of simplification, integration or automation. Section 4.2 identified the best approach to use when finding a solution. The following approaches are taken into account when generating a solution to the bottlenecks:

- Manual processing of a paper picklist – automation
- Lack of experience and data for the purchasing department to order chemicals – integration and automation
- Incorrect determination of the shipping date - automation

The improvement plan exists of the following three steps:

- **Step 1:** Implement a digital picklist and hand scanner
- **Step 2:** Conduct data analysis and implement an inventory policy for chemicals division
- **Step 3:** Implement Available-To-Promise (ATP) and Capable-To-Promise (CTP) in Navision

The next sections explain the improvement step together with an approach to implement the solution and their benefits and investments. The improvement steps do not have to be executed in the given order. One improvement step is not needed to implement the other.

5.2. Step 1: Implement a digital picklist and hand scanner

This improvement step helps to solve the bottleneck: manual processing of a paper picklist. Section 4.2.1 explains how this improvement step is found.

5.2.1. Description

Where a paper picklist is processed manually, a digital picklist can be processed with a mobile device. A mobile device can be a mobile phone, a tablet or a hand scanner. The mobile device should be able to get a connection with the ERP-system Navision. There exist multiple suppliers with mobile device integration for Navision. These integrations are called Warehouse Management Systems (hereinafter referred to as WMS). Examples of suppliers are Tasklet Factory, MobileNAV and Insight Works.

Kolb has two logistics employee and one logistics manager. The CEO of Kolb stated that one logistics employee picks and packs orders and the other logistics employee does other tasks at the logistical centre. Therefore, one mobile device is needed at the beginning. It is also useful that the logistics manager has excess to the WMS software on his computer, so he can keep track of orders and can make changes if needed. Therefore, the cost analysis is based on one hand scanner and 2 WMS licenses.

According to the CEO of Kolb, it takes 6 to 8 months to fully integrate the digital picklist. To cover this period, two short-term improvements can be implemented. The first one is that the AB only print express picklists. It is not needed that the AB prints every picklist separately and the logistics manager walks to the printer for every picklist. One solution is to only print express picklists by the AB. The picklists that need to be processed at a specific day can be printed in the morning by the logistics manager. This will also eliminate the steps of the tray and order folder.

The second short-term improvement step is to adjust the picklist. Currently, the logistics employee puts the dimensions of the package on the picklist. This sometimes leads to unreadable hand-written information. By adjusting the picklist format this is not needed anymore. Kolb mainly uses standard packages to ship their products. Kolb can create a checklist on the picklist format with all standard packages and can add one blank line where the logistics manager can put its dimensions when this differs from the standard. The logistics employee then only has to mark the package format he used.

Table 11 shows the process steps that can be eliminated by the short-term solutions

TABLE 11: PROCESS STEPS THAT CAN BE ELIMINATED BY IMPLEMENTING THE SHORT-TERM SOLUTIONS

Process step	Total processing time per week (minutes)	Part of total processing time
Receive picklist (incl. walking to the printer)	5	1%
Check on duplicates	5	1%
Removal of duplicates	1	0%
Bring picklist immediately to the employee	10	2%
Put picklist in the tray	23	4%
Get picklists out of tray	1	0%
Put picklists in folder	23	4%
Check order folder	1	0%
Put information on picklist	55	9%
Total	**124**	**21%**

One step needs to be added to the process and that is that the logistics manager prints all picklists every morning and brings them to the logistics employee. This step will approximately take 60 seconds per picklist, this equals on average 55 minutes per week. Also, the right package dimension needs to be marked. This will also take approximately 30 seconds per picklist, this equals 28 minutes per week. The time and cost of adjusting the picklist format are negligible to the total processing time of the picklist.

So in total, the two short-term improvements will decrease the total processing time with 124 minutes per week. The total processing time will increase 83 minutes per week by adding the two extra steps. Overall, the processing time will decrease by 40 minutes per week (7%) by implementing the two short-term solutions.

5.2.2. Benefits and investments

Benefits

Concluded from the elimination phase is that all four activity types contain necessary but non-value-added steps caused by the bottleneck: use of a paper picklist. Therefore, every process step which remains after implementing the short-term solutions is examined on what happens with each process step when implementing a digital picklist in combination with a mobile device. Three actions can happen to the process steps:

- **Elimination (indicated by E) –** the process step becomes obsolete after implementing a mobile device solution and can be eliminated

- **Maintaining (indicated by M) –** the process step is not affected by a mobile device solution and needs to be maintained
- **Replacement (indicated by R) –** the process step is still needed when implementing a mobile device but is changed

The effect on every process steps mentioned in Table 3 is estimated by myself based on information found about the functionalities on the websites of the WMS suppliers MobileNAV, Tasklet Factory and Insight Works. Also, several video's from the WMS providers are analysed where the different steps of a mobile WMS are explained. Besides, MobileNAV offers a demo application for mobile phone and laptops. This one is also tested by myself, to get an insight into the process using a WMS mobile device.

Table 12 shows the action per process step when implementing a digital picklist and mobile device.

TABLE 12: ACTION PER PROCESS STEP WHEN IMPLEMENTING DIGITAL PICKLIST AND HAND SCANNER

Process step	Total processing time per week (minutes)	Action	Remark
Check shipment day	14	M	
New shipment day discussion	30	M	
Check type of packaging	9	M	
Change type of packaging	0	M	
Check raw material Navision + order raw material + order assembly product	102	M	Maintains when implementing a digital picklist. However, it is eliminated by the solution Kolb already implemented (section 4.1.1).
Check chemicals Navision	15	M	
Order chemicals	151	M	
Check spare part Navision	15	M	Maintains when implementing a digital picklist. However, it is eliminated by the solution Kolb already implemented (section 4.1.1)
Check spare part warehouse	30	M	Maintains when implementing a digital picklist. However, it is eliminated by the solution Kolb already implemented (section 1.2.3).
Check spare part machine department + changing spare part	6	M	Maintains when implementing a digital picklist. However, it is eliminated by the solution Kolb already implemented (section 1.2.3).
Order spare part	4	M	Maintains when implementing a digital picklist. However, it is eliminated by the solution Kolb already implemented (section 4.1.1).
Check modification	8	M	
Bring spare part to electrical or mechanical department	45	M	
Print picklists and bring them to the employee	54	E	
Mark the corresponding package dimension	27	R	Replaced by: add package information to picklist
Put sticker on package	5	R	Replaced by: print sticker + put on package
Scan picklist to AB	55	E	

In total, 142 minutes per week is saved by process steps that are eliminated after implementing a digital picklist. Some process steps need to be replaced and some are added due to the digital picklist. Table 13 shows the new estimated processing times per processing step for the replacement steps presented in Table 12 and the extra steps. This is estimated in the same way as the actions. So, with information on the websites of three providers, video's of the three providers and a demo version of MobileNAV.

TABLE 13: NEW ESTIMATED PROCESSING TIMES FOR REPLACEMENT STEPS

New process steps	Estimated processing time (seconds)	Occurrence (per week)	Total estimated processing time per week (minutes)
Release picklist on mobile device	5	55	5
Check mobile device and select picklist	5	55	5
Add package information to picklist	60	55	55
Register picklist	2	55	2
Print sticker + put on package	15	55	14
Total			**80**

In total, the processing time for the replacing and extra activities leads to an increase of 80 minutes per week for the total processing time. Together with the elimination steps, a total savings of 62 minutes per week is reached by implementing a digital picklist.

In total, a mobile device decreases the total processing time with 62 minutes per week, this equals 10%. Together with the short-term solutions, the total processing time decreases with 102 minutes per week (17%). According to the CEO of Kolb, a logistics employee cost on average €22 per hour. So, implementing a mobile device will save €37 per week. Based on 262 work-days per year, the savings per year equals €2,043 (Rekenkeizer, n.d.).

Investments

The CEO of Kolb already requested an offer at their consultant for the WMS software MobileNAV. The investment of implementing a digital picklist and hand scanner is based on that offer. Appendix D: investment costs solutions Table D16 and Table D17 show the investment costs for MobileNAV per type of license. In total, the one-time investment cost for MobileNAV for two licences equals €14,724. The yearly cost equals €1,824.80 for two users.

For a mobile device, the Intermec CN51 hand scanner from Honeywell is recommended by MobileNAV (MobileNAV, n.d.). The internet prices vary between €1,000 net and €2,000. Therefore, the average investment cost of €1,500 is used as an indication of the investment cost of a mobile device.

The total one-time investment for one hand scanner and two WMS software licenses equals €16,224. With the savings of €2,043 per year, the pay-back period of this solution for only the picklist process is almost 8 years.

The pay-back period is unacceptable for Kolb. Normally Kolb allows a 3 to 4 years pay-back period of IT investments. However, the picklist process is not the only process benefiting from WMS software.

With a WMS software also the incoming goods, stock counts and more processes can be executed digitally. It also saves time for entering the data at the AB. The AB normally puts the data from the scanned picklist into Navision, this cost roughly estimated 1 minute per picklist for 55 picklists per week. This is almost one hour per week. It also saves a lot of paper. Kolb prints on average 1 normal picklist and 2 changing picklists per sales order. With 11 sales orders per day, this is a total of 33 papers per day. This leads to 8646 printed A4 papers per year. Kolb already makes use of recycled paper, but saving 8646 A4 papers per year is even better in terms of sustainability.

Due to the time constraints of this research, not all benefiting processes can be researched. Therefore the pay-back period cannot be calculated exactly. Therefore, the advice is to implement the two short-term solutions and analyse the total benefit of WMS software for all processes at Kolb.

5.3. Step 2: Conduct data analysis and an implement inventory policy for chemicals division

This improvement step helps to solve the bottleneck: lack of experience and data for the purchasing department to order chemicals. Section 4.2.2 explains how this improvement step is found.

5.3.1. Description

How do we know when and how much to reorder from a specific product? This can be determined by transforming historical data from Navision about the sales of chemicals into inventory policies. An inventory policy determines when to reorder and how much to reorder based on historical data (Axsäter, 2006). The two most common inventory policies are (Axsäter, 2006):

- Continuous review
  With a continuous review the inventory is continuously tracked to determine when an order needs to be placed. When the inventory position drops below the reorder point (s), an order with a fixed lot size (Q) is placed. This is called an (s,Q) system (Silver et al., 2016). Another continuous review system is the (s,S) system. When inventory drops below the reorder point (s), an order with a variable lot size is placed to raise the inventory to the order-up-to-level (S). With this policy, the time between orders fluctuates since the demand is variable. Continuous review is mostly used for high-value articles.
- Periodic review
  With a periodic review the inventory position is checked at regular periodic intervals (R) and products are ordered to raise the inventory position to a set threshold (S). This is called an (R,S) system (Silver et al., 2016). Another periodic review system is (R,s,S) (Silver et al., 2016). The inventory position is checked at regular periodic intervals (R), when it is at or below the reorder point (s) an order is placed to raise the inventory position to the order-up-to-level (S). The (R,s,S) system also exists with a fixed lot size (Q), this is called an (R,s,Q) system. One disadvantage of this policy is that higher safety stock is required but it is easier to implement since inventory is not tracked continuously. Periodic review is mostly used for low-value articles.

Figure 18 shows a rule of thumb for selecting an appropriate inventory policy. The inventory policies are based on the type of review and type of item. The item type is based on the ABC- classification. According to this classification, there exist three category types (Kheybari et al., 2019):

- Item A – 10-20% of the inventory that includes 60-80% of the total value, these items need tight control
- Item B – 20-25% of the inventory that includes 30% of the total value, these items need less control

- **Item C** – 50-60% of the inventory that includes 5-15% of the total value, these items need very low control

	Continuous Review	*Periodic Review*
A items	(s, S)	(R, s, S)
B items	(s, Q)	(R, S)

FIGURE 18: RULE OF THUMB FOR SELECTING AN INVENTORY POLICY (SILVER ET AL., 2016)

Due to the time restrictions of this bachelor thesis, it is not possible to analyse and implement the right inventory policy by myself. According to the CEO of Kolb, there is an employee of Kolb at the purchasing department who can conduct data analysis and implement the inventory policy. This is preferred over an external person. An employee of Kolb knows the processes so it is easier and faster to conduct data analysis, whereas with an external person the processes need to be analysed to know what is going on.

First research needs to be done on which order policy is most suitable for the chemical division of Kolb. When this order policy is established historical data about the sales and purchases of chemicals needs to be gathered from Navision. With this data, the right lot size and order frequencies per chemical can be determined based on the chosen order policy. This information can be added to the ERP-system or a tool can be made, for example in Excel. This tool should be able to generate a list of which chemicals to order together with their quantities, to guarantee a three day delivery time.

To check if the order policies are a representation of reality they can be assessed by the logistics manager of Kolb. He orders the chemicals for several years and with his experience, he can assess the outcomes of the ordering policy. He can also give valuable information about exceptions.

5.3.2. Benefits and investments

Benefits

The following process steps are eliminated when an order policy for the chemicals is analysed and eventually implemented at Kolb:

- Order chemicals (151 minutes per week)
- Check chemicals Navision (15 minutes per week)

In total the picklist process decreases with 166 minutes per week, this equals 26%. The savings only apply to the picklist process. When all necessary information is added to the ERP-system and the purchasing department order the chemicals, the workload of the purchasing department will increase.

According to the CEO of Kolb, a logistics employee cost on average €22 per hour. Implementing this solution will save €61 per week. Based on 262 work-days per year, the savings per year equals €3,197 (Rekenkeizer, n.d.).

Investments

The CEO of Kolb estimated how much time the data analysis and implementation of an inventory policy cost. The estimation is 300 hours. According to the CEO of Kolb, a purchasing employee cost on average €28 per hour. So conducting the data analysis and implementing the inventory policy has a one-time cost of approximately €8,400. This leads to a pay-back period of 2.6 years. This pay-back period is accepted by the CEO of Kolb.

5.4. Step 3: Implement Available-To-Promise (ATP) and Capable-To-Promise (CTP) in Navision

This improvement step helps to solve the bottleneck: incorrect determination of the shipping date. Section 4.2.3 explains how this improvement step is found.

5.4.1. Description

ATP and CTP are concepts used at the *calculate order promising date functionality* in Navision. This functionality calculates shipments and delivery dates based on the known and expected availability dates of the products in Navision (Microsoft, 2017). There exist two ways of calculating the order promising date (Microsoft, 2017):

- Requested delivery date by the customer
  When a customer asks for a specific delivery date, Navision checks if this delivery date can be met. If it cannot be met, it calculates the earliest possible shipping date. If the ordered items are on stock, it can immediately be picked and the sales process can continue. If the products are out of stock, Navision gives an out-of-stock warning.
- No requested delivery date by the customer
  When the customer does not ask for a specific delivery date, the earliest possible shipment day is calculated.

To calculate the delivery date Navision makes use of two fundamental concepts (Microsoft, 2017):

- Available-to-promise (ATP)
  ATP checks the availability of products, taking into account the planned production, purchase, transfers and sales returns. So, ATP calculates a delivery date based on available products in inventory or on planned receipts.
- Capable-to-promise (CTP)
  CTP calculates the earliest delivery date for products that are not available at this moment but are available when they are to be produced, purchased or transferred. It is based on a what-if scenario.

The order promising date functionality is a standard functionality of Navision. For the standard products, this will immediately work. However, in the case of Kolb, a connection with an ERP planning software is needed to automatically retrieve end dates of the assemblies and modified articles. At this moment Microsoft Excel is used for production planning. With a connection with an ERP planning software, this end date can be automatically received from the planning software. Kolb already analysed a suitable ERP software for planning and decided to integrate the software DimeScheduler for their project planning. DimeScheduler is a resource planning and scheduling tool which can be integrated with Navision (Bertier, n.d.). This ERP planning software needs to be implemented first.

After implementing the ERP planning software, the order promising date functionality of Navision needs to be set up. Kolb only has to set up the functionality, no further integration needs to be done since it is an already integrated solution at Navision.

5.4.2. Benefits and investments

Benefits

When implanting the order promising date functionality two steps are eliminated in the picklist process:

- Check shipment day (14 minutes per week)
  - Calculating the shipping date is part of the job of the AB and checking is not needed anymore
- New shipment day discussion (30 minutes per week)
  - When the calculated shipping date deviates from the requested delivery date, the AB can discuss a new delivery date with the customer, the logistics manager is not needed anymore for this.

This leads to a total decrease of 44 minutes per week which equals 7% of the total processing time. According to the CEO of Kolb, a logistics employee cost on average €22 per hour. So, implementing a mobile device will save €16 per week. Based on 262 work-days per year, the savings per year equals €831 (Rekenkeizer, n.d.).

Investments

The investment is negligible for Kolb. The ATP and CTP functionality is already integrated at Navision, only set up is needed. This can be done by an employee of Kolb and will not take longer than 2 working days. Therefore, the cost for set up is negligible.

The investment of an ERP planning software tool is not applicable for this solution, since it will be purchased for project planning and not specifically for using the ATP and CTP functionality. This means, that the ATP and CTP functionality only can be used after implementing the tool for project planning. This is planned after two other projects at Kolb are finished.

5.5. Conclusion

This chapter explains the improvement steps for the bottlenecks found at chapter 4. The following research question is answered:

- Which improvements steps should Kolb take to improve the picklist process?
  - What are the improvements steps to solve the bottlenecks?
  - How can the improvement steps be implemented at Kolb?
  - What are the investment costs of the improvement steps?
  - What is the impact of the solutions on the total processing time?

The following improvements steps solve the bottlenecks of the picklist process:

Implement a digital picklist and hand scanner

A digital picklist allows to collect and process information about the picklist with a mobile device such as a hand scanner. The mobile device needs an integration with the ERP-system of Kolb. This integration is called Warehouse Management System. For Kolb 2 WMS software licenses are recommended. One for the logistics employee and one for the logistics manager. Implementation cost approximately 6-8 months. To cover the implementation time, two short-term investments can be implemented:

- Logistics manager prints picklist each morning, AB only sends express picklists
- Add checklist with standard packages on the picklist

These two short-term solutions decrease the total processing time with 40 minutes per week (7%). After implementation of the two short-term solutions, a digital picklist will further decrease the processing time with 62 minutes per week (10%). By implementing the short-term solutions and a digital picklist, the processing time will decrease with 102 minutes per week (17%). In total this will save €2,043 per year.

The one-time investment for this solution equals €16,224 and the yearly costs are €1,824.80. This leads to a pay-back period of almost 8 years. This is too high and not accepted by Kolb. However, this pay-back period is only calculated with the benefits of the picklist process. More processes will benefit from the WMS software and it will most likely be profitable. Therefore, I would recommend to implement the short-term solutions and analyse the total benefit of a WMS software.

Conduct data analysis and implement an inventory policy for the chemicals division

After conducting data analysis and implementation of an inventory policy, the purchasing department can purchase the chemicals. An order policy tells when and how much to reorder of a specific product. The data analysis and order policy can be executed by a specified purchasing employee of Kolb. First research needs to be done about which order policy is suitable for Kolb. Then, data analysis needs to be executed on historical sales and purchasing data. With this data, the right information can be added to the order policy. This improvement step leads to a decrease of 166 minutes per week for the picklist process (26%). This will save €3,197 pear year. Conducting data analysis and implementing an order policy approximately takes 300 hours. Based on the hourly wage of the purchasing employee this cost €8,400. This leads to a pay-back period of 2.6 years, which is accepted by Kolb.

Implement Available-To-Promise (ATP) and Capable-To-Promise (CTP) in Navision

ATP and CTP is a standard functionality of Navision. For the standard products of Kolb, this already works. However, for the assemblies and modification articles, the end dates are needed. These end dates can automatically be retrieved from an ERP software planning tool. Currently, Kolb is using Excel for its project planning. However, they are planning to implement an ERP software planning tool for project planning. Therefore, no investment is needed for this solution. ATP and CTP only need to be set up by an employee of Kolb. However, these costs are negligible. Implementing this solution leads to a processing time decrease of 44 minutes per week (7%). This will save €831 per year.

6. Conclusion & discussion

Section 6.1 provides a conclusion to the main research question and research questions per chapter. Section 6.2 provides a discussion.

6.1. Conclusion

The following main research question is answered during this research:

"How can the processing time of the picklist process be reduced by at least 50% and be structured efficiently such that it can be digitized?"

The processing time of the picklist process can be reduced by implementing the following improvement steps:

Step 1: Implement a digital picklist and hand scanner
Step 2: Conduct data analysis and implement an inventory policy for the chemicals division
Step 3: Implement Available-To-Promise (ATP) and Capable-To-Promise (CTP) in Navision

The first step allows Kolb to collect and process information about the picklist digitally into their ERP-system instead of manually. This will reduce the processing time but also the chance of defects. The implementation of a digital picklist needs to be executed by a consultant. The implementation of a digital picklist for just the picklist process is not profitable and also takes 6 to 8 months. Therefore, Kolb needs to analyse the total benefit of WMS software for all processes at Kolb. In the meantime, two short-term solutions can be implemented as explained in Section 5.3.1.

The second step enables the purchasing department to purchase the chemicals. With the data analysis and implementation of an inventory policy, the purchasing department has enough information about which chemicals to order and how much to insure a three-day delivery date. The data analysis and implementation of an inventory policy can be conducted by a specified purchasing employee of Kolb. Implementation will cost approximately 300 hours with an hourly wage of the purchasing employee of €28.

The last improvement step allows the AB to automatically retrieve the first possible shipment day for sales orders. ATP and CTP is a standard functionality of Navision. However, a connection with an ERP software planning tool is needed to automatically derive end dates from assemblies and modified articles. Kolb already is going to implement an ERP software planning tool for project planning. After implementation, ATP and CTP can be set up by an employee of Kolb. This will take no longer than 2 working days.

Table 14 shows the overall impact of the three improvement steps

TABLE 14: OVERALL IMPACT ON THE THREE IMPROVEMENT STEPS

Improvement step	Impact on the processing time	Savings per year	One-time investment	Yearly cost	Pay-back period
Step 1	-17%	€ 2,043	€ 16,224	€1,824.80	8 years
Step 2	-26%	€ 3,197	€8,400	€0	5,2 months
Step 3	-7%	€831	€0	€0	-

The current picklist of Kolb consists of four activity types: remaining activities (34%), transportation and motion (33%), internal checks (27%) and defects (6%). The CEO and logistics manager of Kolb initially thought that transportation and motion contribute most to the processing time. However, this is not the case. To analyse what the bottlenecks are, all activity types are analysed with a business process improvement method.

Several business process improvements are analysed together with their advantages and disadvantages. The most suitable business process improvement method for the specific situation of Kolb is a systematic business process re-engineering. This method uses the ESIA rule. This rule allows to systematically re-engineer the process to make it as efficient as possible before automation possibilities are analysed. ESIA stands for eliminating non-value-adding activities, simplification and integration of the remaining activities and seek for automation opportunities.

During the value-added analysis at the elimination phase, two non-value-added activities were found. These steps can be eliminated immediately:

- Sign the picklist (1% of total processing time)
- Archive the picklist (1% of total processing time)

It is also found that the process consists of a lot of necessary but non-value-added activities. This are activities that exist because of the current way of working but do not add value to the product and/or service. Four bottlenecks are causing this high amount of necessary but non-value added activities:

- Use of a paper picklist (17% of total processing time)
- Lack of experience about ordering chemicals at the purchasing department (27% of total processing time)
- Incorrect determination of shipping date (7% of total processing time)

These bottlenecks are solved with the following solution generation approach:

- Use of a paper picklist
  A solution to this bottleneck is found with automation. The solution is implementing a digital picklist. This solution is generated after discussions with the CEO and logistics manager of Kolb. After creating the solution, more information is collected at the websites of three different digital picklist software suppliers.
- Lack of experience about ordering chemicals at the purchasing department
  A solution to his bottleneck is found with integration and automation. The solution is to conduct data analysis and implement an inventory policy. This solution is created by knowledge gained during the Bachelor Industrial Engineering and Management. After creating the solution, more information is gathered with help of literature.
- Incorrect determination of shipping date
  A solution to this bottleneck is found with automation. The solution is to implement ATP and CTP. This solution is created with knowledge gained during a visit to the logistical centre of Odin Groep. After creating the solution, more research is executed about ATP and CTP and the opportunities within Navision.

6.2. Discussion

The first limitation of this research is that the outcomes only apply to the situation of Kolb. The theoretical framework is generally applicable and can be used for any business improvement situations.

The second limitation is Covid-19. Due to Covid-19 the initial problem of Kolb could not be researched anymore. Also, the bachelor thesis is executed from home, which made it harder to ask questions but fortunately, the logistics manager and CEO were always available for questions by e-mail. Only the case study is executed at Kolb.

A third limitation is the time limit of 10 weeks. The processing times of the picklist process are estimated based on experience. Due to the time limit, no valid experiment could be executed to measure the processing times. This can influence the findings of this research. When the time estimates are estimated too low in comparison with reality, it can be that the pay-back period of a digital picklist and hand scanner is lower and more appealing to Kolb.

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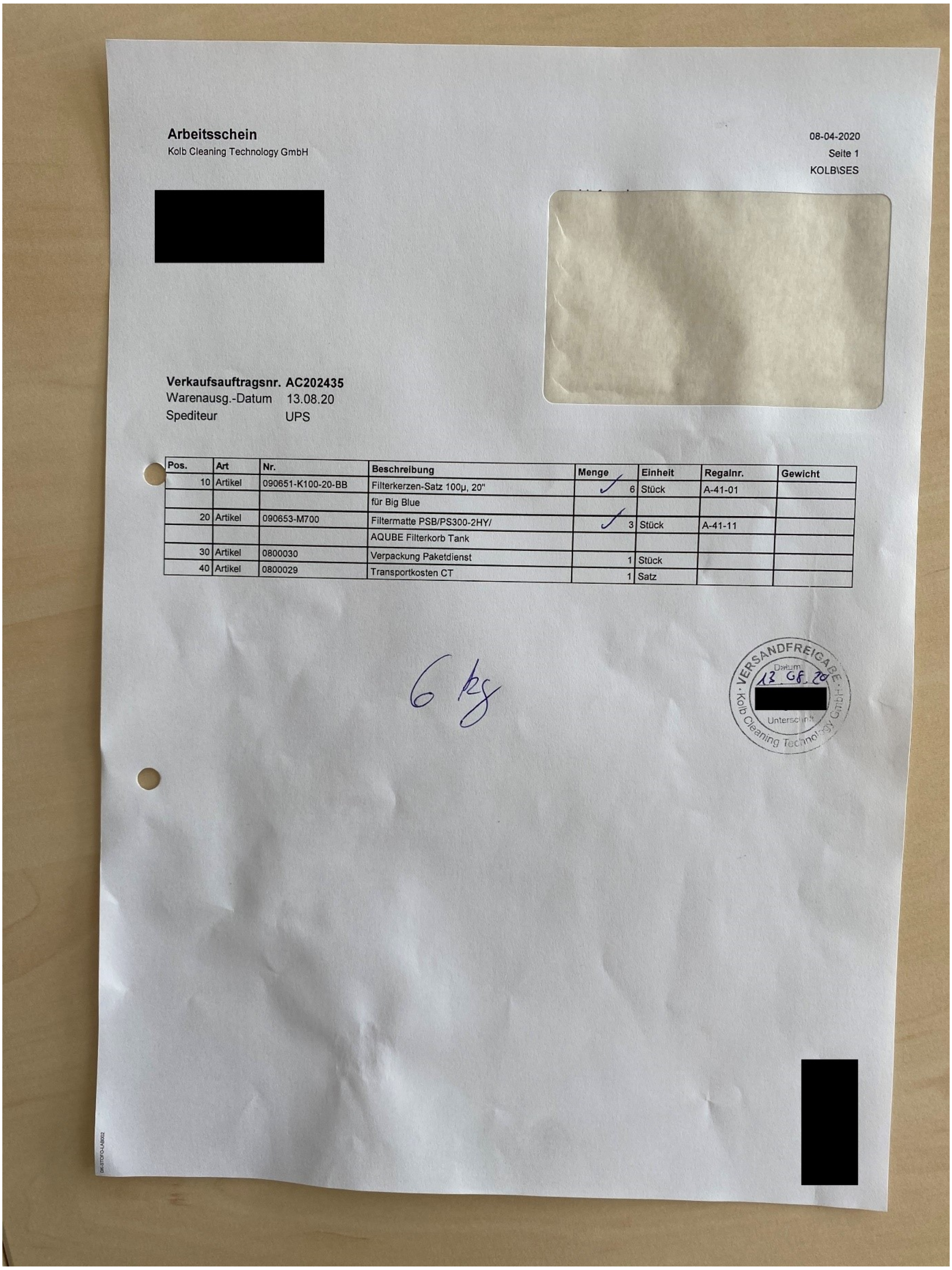
Appendix A: examples types of picklists



Arbeitsschein
Kolb Cleaning Technology GmbH

08-04-2020
Seite 1
KOLB\SES

[redacted]

Verkaufsauftragsnr. AC202435
Warenausg.-Datum 13.08.20
Spediteur UPS

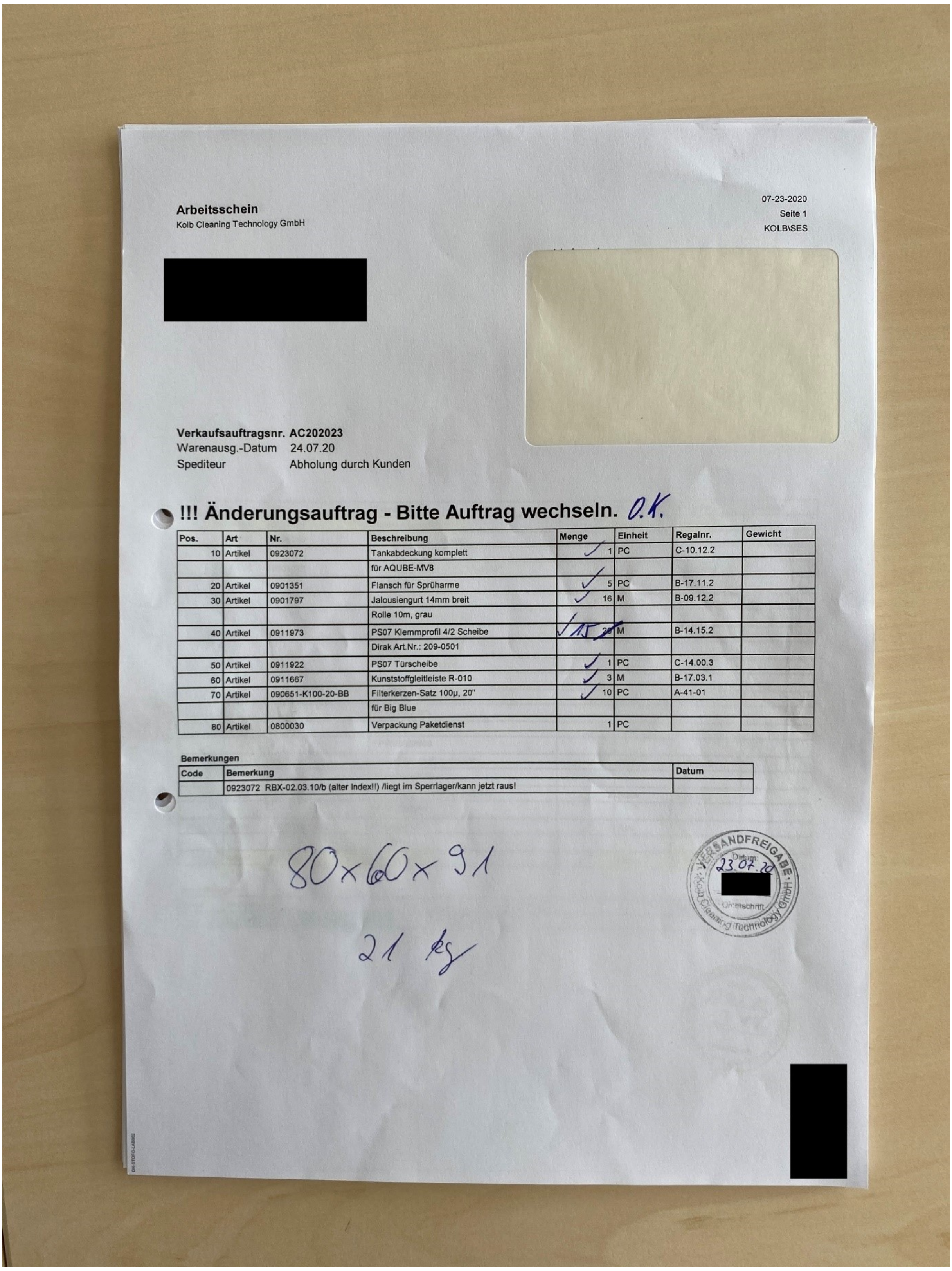
Pos.	Art	Nr.	Beschreibung	Menge	Einheit	Regalnr.	Gewicht
10	Artikel	090651-K100-20-BB	Filterkerzen-Satz 100µ, 20"	6	Stück	A-41-01	
			für Big Blue				
20	Artikel	090653-M700	Filtermatte PSB/PS300-2HY/	3	Stück	A-41-11	
			AQUBE Filterkorb Tank				
30	Artikel	0800030	Verpackung Paketdienst	1	Stück		
40	Artikel	0800029	Transportkosten CT	1	Satz		

6 kg

VERSANDFREIGABE
Datum 13.08.20
[redacted]
Unterschrift
Kolb Cleaning Technology GmbH

[redacted]

FIGURE A1: NORMAL PICKLIST



Arbeitsschein
Kolb Cleaning Technology GmbH

07-23-2020
Seite 1
KOLB\SES

[redacted]

Verkaufsauftragsnr. AC202023
Warenausg.-Datum 24.07.20
Spediteur Abholung durch Kunden

!!! Änderungsauftrag - Bitte Auftrag wechseln. O.K.

Pos.	Art	Nr.	Beschreibung	Menge	Einheit	Regalnr.	Gewicht
10	Artikel	0923072	Tankabdeckung komplett	✓ 1	PC	C-10.12.2	
			für AQUBE-MV8				
20	Artikel	0901351	Flansch für Sprüharme	✓ 5	PC	B-17.11.2	
30	Artikel	0901797	Jalousiengurt 14mm breit	✓ 16	M	B-09.12.2	
			Rolle 10m, grau				
40	Artikel	0911973	PS07 Klemmprofil 4/2 Scheibe	✓ 1,5 ~~25~~	M	B-14.15.2	
			Dirak Art.Nr.: 209-0501				
50	Artikel	0911922	PS07 Türscheibe	✓ 1	PC	C-14.00.3	
60	Artikel	0911667	Kunststoffgleitleiste R-010	✓ 3	M	B-17.03.1	
70	Artikel	090651-K100-20-BB	Filterkerzen-Satz 100µ, 20"	✓ 10	PC	A-41-01	
			für Big Blue				
80	Artikel	0800030	Verpackung Paketdienst	1	PC		

Bemerkungen

Code	Bemerkung	Datum
	0923072 RBX-02.03.10/b (alter Index!!) /liegt im Sperrlager/kann jetzt raus!	

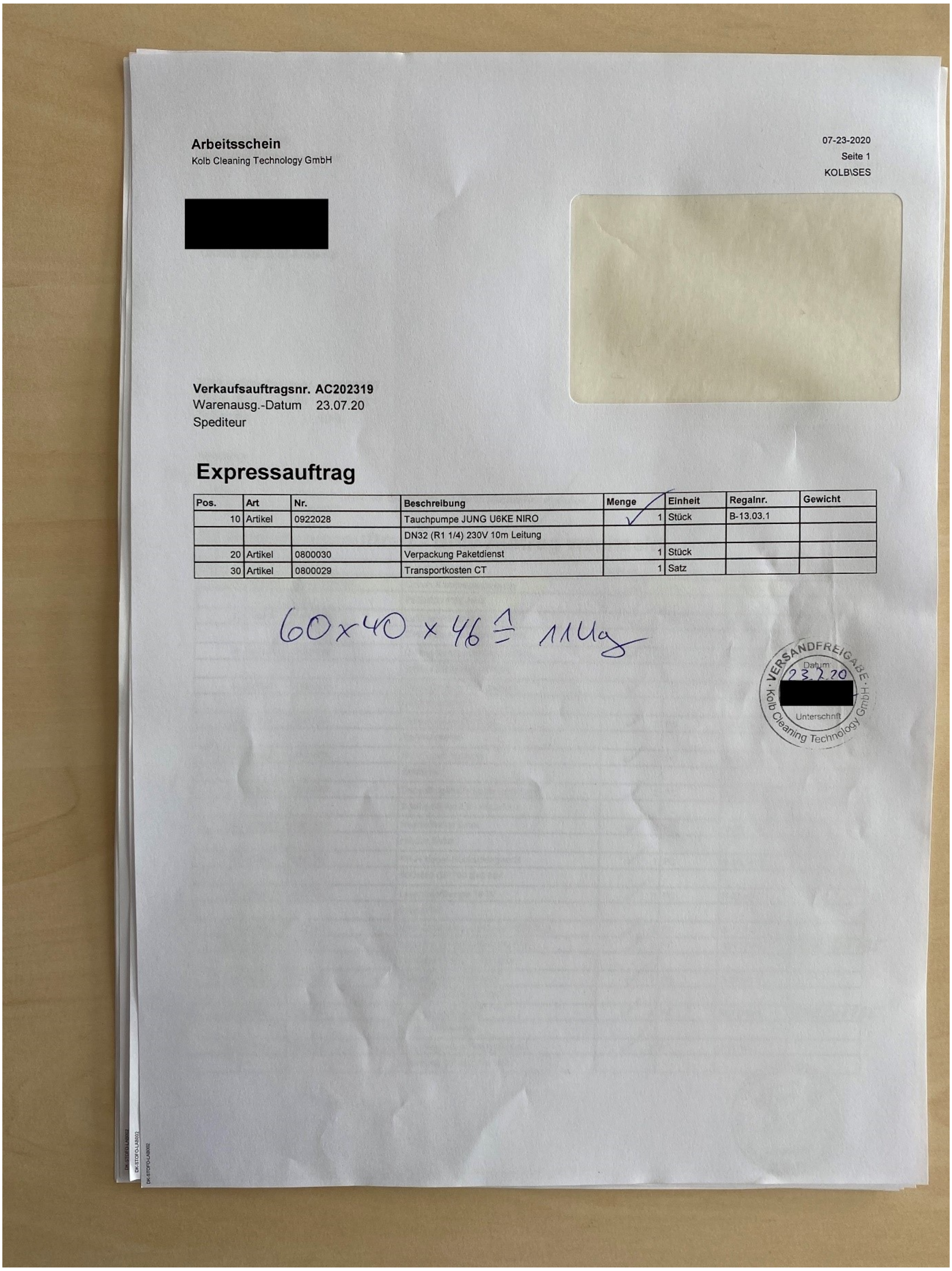
80x60x91

21 kg

VERSANDFREIGABE
Datum: 23.07.20
[redacted]
Unterschrift
Kolb Cleaning Technology GmbH

[redacted]

FIGURE A2: CHANGING PICKLIST



Arbeitsschein
Kolb Cleaning Technology GmbH

07-23-2020
Seite 1
KOLB\SES

[redacted]

Verkaufsauftragsnr. AC202319
Warenausg.-Datum 23.07.20
Spediteur

Expressauftrag

Pos.	Art	Nr.	Beschreibung	Menge	Einheit	Regalnr.	Gewicht
10	Artikel	0922028	Tauchpumpe JUNG U6KE NIRO	1	Stück	B-13.03.1	
			DN32 (R1 1/4) 230V 10m Leitung				
20	Artikel	0800030	Verpackung Paketdienst	1	Stück		
30	Artikel	0800029	Transportkosten CT	1	Satz		

60x40 x 46 ≙ 11kg

VERSANDFREIGABE
Datum 23.7.20
[redacted]
Unterschrift
Kolb Cleaning Technology GmbH

Figure A3: Express Picklist

Appendix B: extra information current situation Kolb

B1: Calculation average amount of processed picklists per day

Based on data from the ERP-system Navision, the average amount of sales orders per month from January 2018 until July 2020 is calculated by dividing the amount of sales orders per month by the number of days from that month. The conclusion is that on average 11 sales orders are processed and picklists are made. Table B15 shows the data.

TABLE B15: DATA ON AVERAGE AMOUNT OF PICKLISTS PER DAY

Date	Amount of sales orders	Days per month	Average per day
01-2018	381	31	12.29032258
02-2018	336	28	12
03-2018	395	31	12.74193548
04-2018	359	30	11.96666667
05-2018	347	31	11.19354839
06-2018	320	30	10.66666667
07-2018	369	31	11.90322581
08-2018	357	31	11.51612903
09-2018	334	30	11.13333333
10-2018	375	31	12.09677419
11-2018	336	30	11.2
12-2018	266	31	8.580645161
01-2019	437	31	14.09677419
02-2019	376	28	13.42857143
03-2019	309	31	9.967741935
04-2019	371	30	12.36666667
05-2019	363	31	11.70967742
06-2019	298	30	9.933333333
07-2019	408	31	13.16129032
08-2019	315	31	10.16129032
09-2019	308	30	10.26666667
10-2019	335	31	10.80645161
11-2019	343	30	11.43333333
12-2019	248	31	8
01-2020	392	31	12.64516129
02-2020	351	29	12.10344828
03-2020	369	31	11.90322581
04-2020	303	30	10.1
05-2020	332	31	10.70967742
06-2020	343	30	11.43333333
07-2020	371	31	11.96774194
Average			**11.40269783**

B2: Turnover by product group

A picklist can contain multiple product groups. Therefore it is necessary to multiply the activities belonging to a specific product group by the percentage of the turnover of that specific product group. Figure B1 shows the turnover by product group from January 2020 until July 2020. SYS includes assembly products such as machines and VBG includes chemicals and spare parts.

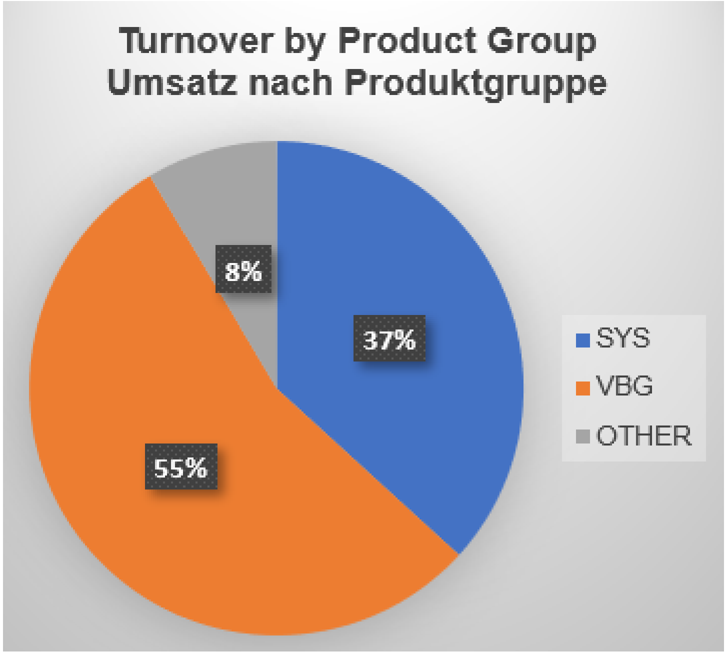
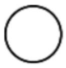


FIGURE B1: TURNOVER BY PRODUCT GROUP JANUARY 2020 UNTIL JULY 2020

Appendix C: explanation symbols process map

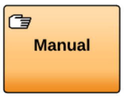
This appendix shows the symbols used for the process maps in Chapter 2.3 (Lucidchart, n.d.).


Start event


Start event triggered by a message


End symbol

A task

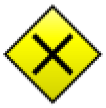


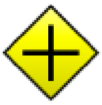
A manual task

A task which is achieved when a message is received from third parties

A task which sends a message to another process or lane

A task that makes use of an automated application or internet


Exclusive gateway, splits the process into one direction based on criteria or specific events


Parallel gateway, represent two or more parallel occurring flows of tasks


Parallel event-based gateway, represents two or more parallel occurring flows of tasks based on criteria or specific events

Represents the sequence of the tasks

Represents a relationship between artefacts


Data storage symbol, shows where the data of the task is stored or collected from

Appendix D: investment costs solutions

TABLE D16: ONE-TIME INVESTMENT COST FOR 2 MOBILENAV LICENSES

License	Price per license	Amount	Total price
oneF!T MobileNAV License for Dynamics NAV	€2,900	2	€5,800
oneF!T MobileNAV User License	€450	2	€900
oneF!T Dynamics Full User CAL License	€2,250	2	€4,500
Microsoft SQL server 2017 User-License Full User CAL	€82	2	€164
Implementation and designing of MobileNAV License	€3,360	1	€3,360
Total			**€ 14,724**

TABLE D17: YEARLY COST FOR 2 MOBILENAV LICENSES

License	Price per license	Amount	Total price
oneF!T MobileNAV License for Dynamics NAV	€464	2	€928
oneF!T MobileNAV User License	€72	2	€144
oneF!T Dynamics Full User CAL License	€360	2	€720
Microsoft SQL server 2017 User-License Full User CAL	€16	2	€32.80
Total			**€1,824.80**