Improving the process of in- and outgoing goods at a construction company

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Preface

This thesis would not have been possible without all the support I received during this difficult COVID-19 time.

First of all, I want to thank Agnes Dekker for giving me the opportunity to do my thesis at ADS Groep and guiding me throughout the process while also giving me a lot of freedom to decide my research scope. Throughout this process, I learned not only a lot about myself, but also about the construction sector and how big construction projects are actually executed. I am very grateful for the opportunity I got at ADS Groep to do my thesis, especially considering all the uncertainty surrounding COVID-19.

Furthermore, I want to thank my supervisor from the University of Twente, Patricia Rogetzer, for her continued guidance throughout the process of writing this thesis and helping me greatly in structuring my research. Her detailed feedback helped me a lot in improving not only the quality of my writing but also the overarching structure of my thesis. I also want to explicitly thank her for the attention there was to the mental health aspect during this time.

On a more personal note, I want to thank my housemates for supporting me throughout the process of writing this thesis. I want to thank Joël Ledelay for always being there for me whenever I needed it the most, and for teaching me some very helpful shortcuts in Microsoft Word. I also want to thank Niels Top for providing me a place to study whenever I needed a change of scenery, with the wonderful thesis writing sessions we had a few times over the last couple of months.

I hope you enjoy reading my bachelor thesis!

Willemien Hoogenraad

Enschede, March 2021

Glossary

Term	Explanation	Dutch translations
ADS Groep	Name of the company, used to be ''Aan de Stegge Groep'' until 2018.	Groep means Group.
Water	Department of ADS that is responsible for water projects. Consists of project teams, the engineering department and work preparators/controllers.	
Toelevering Water	Department of ADS Groep that is responsible for production in the production halls, and supplying materials to the construction site.	Toelevering means supply in Dutch, so literally ''Supply Water''.
Projects for Water	Water mostly does project in purifying drinking water or sewage water. These projects usually involve a lot of pipes, and other materials that require welding in the production halls by Toelevering Water.	
Construction site	As the focus is on water related projects only, this is the construction site for water projects such as drinking water purification installations.	

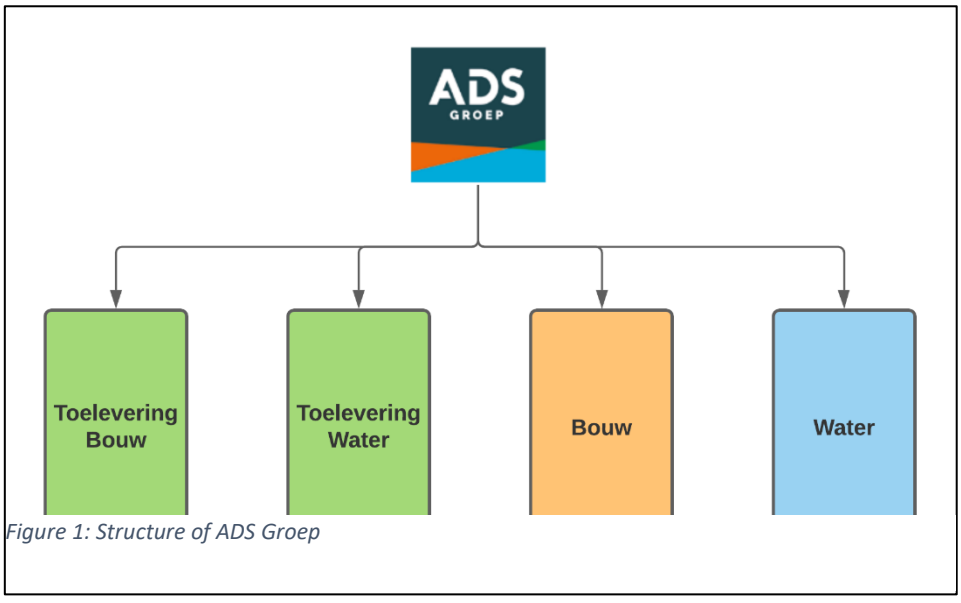

Figure 1: Structure of ADS Groep

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Abbreviation	Full term
ASVB	Aan de Stegge Verenigde Bedrijven
BPM	Business Process Modelling
BPMN	Business Process Model and Notation
CAD	Computer-aided design
CEO	Chief Executive Officer
EPC	Event-driven Process Chain
KPI	Key Performance Indicator
PID	Piping and Instrumentation Diagram
UML	Unified Modelling Language

Contents

1. Introduction

ADS Groep is a construction company that was founded in 1947 by H.J. aan de Stegge. Since then, the company has undergone quite a lot of changes to grow from a small family firm to the firm it is today. In 2018, Aan de Stegge Groep became ADS Group and had a big cultural change due to the influence of the newly-appointed chief executive officer (CEO). ADS Groep is active as an architectural, civil engineering and mechanical engineering contractor company in the construction sector. Since 2018, ADS Groep B.V. is part of Aan de Stegge Verenigde Bedrijven (ASVB). ASVB is a network of 22 innovative businesses in the construction sector and real estate sector with total earnings of about € 742 million.

ADS Groep is divided into four departments since October 2020: Bouw, Water, Toelevering Bouw and Toelevering Water. My research is only focused on the Water side of the company, with Toelevering Water in particular which is the supply side of materials for the Water projects. ADS Groep mostly does assignments in water purification for both drinking water and sewage water. This is done for the semi-public sector, as the assignments are usually done for semi-government companies such as local municipalities or Vitens, which is the largest drinking water company in the Netherlands. Toelevering Water consists of production halls where most of the materials to be used at the construction are made, but some materials that are ordered from external parties get delivered directly to the construction site. The Water department consists of project managers, engineers, work planners, and people that work at the construction site. One of the biggest strengths of ADS Groep is that they can do everything needed to bring a construction project to fruition by themselves, in-house, which is unique for the construction sector and brings them a competitive advantage.

1.1 Research motivation

Ever since ADS Group made the clear division between the four departments, every department got their own financial goals for the coming few years. Right now, the financial aims for Toelevering Water for the coming years in terms of revenue are depicted in Table 1.

2020	€ 3.5 million
2021	€ 5 million
2022	€ 7 million
2023	€ 10 million

Table 1: Financial aims for the coming years for Toelevering Water

As can be seen, Toelevering Water wants to grow exponentially in the coming years. Right now, about 95% of the assignments come internally from projects of the Water department. In order to grow, more external projects are needed and further efficiency in the production process is required in order to have more capacity for production. However, right now only 5% of the assignments are from external clients and not everything at Toelevering Water goes smoothly. The main motivation of this research is to further optimize part of the processes happening at Toelevering Water so that the financial goals for the coming years can be reached.

1.2 Situation at ADS Groep

A normal project within ADS Groep happens according to the following steps, as can be seen in Figure 2:

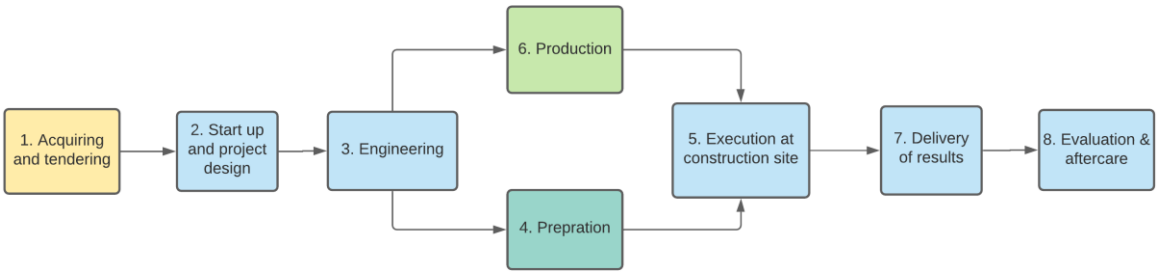

Figure 2: The flow of a project within ADS Groep

The process starts when the Calculation Department tries to acquire a project and ultimately succeed. Then, the Water Department takes over and set up the project itself. It is later handed over to the Engineering Department, which is a department within the Water Department of ADS Groep. Once the Engineering process is done and all the technical drawings are finished, production can take place in combination with preparation. Preparation is shared between both the Water and Toelevering Water department, while production is only Toelevering Water. In preparation, materials are ordered for the production hall and transport is arranged for the materials from the production hall to the construction site. In production, the products needed on the construction site are created according to the technical drawings previously created by the Engineering Department. Once production is done and transport is arranged, the goods are shipped to the construction site.

Right now, it happens very often that the materials that arrive at the construction site are too late, are incomplete, do not fit into the other parts of the construction or a combination of these three. This causes a lot of failure costs, as it is not easy to correct these problems at the end of the entire project cycle. For example, if the materials do not fit at the construction site as imagined on the technical drawing, it could be due to a mistake in production, a mistake in the technical drawing or a mistake from the supplier. Furthermore, the employees at the construction site cannot continue their work if the materials are not there or cannot be used. This causes a lot of unforeseen extra costs and frustration amongst the employees. All in all, the availability of materials at the construction site is not at the level ADS Groep wishes it to be.

As a lot of prior steps happen before *5. Execution at the construction site*, the problem is complex and not easy to solve as multiple different departments are involved. For this research, the focus is on the Toelevering Water department, so the supply side for the Water department. That is the reason why a closer look is taken at the processes in *4. Preparation and 6. Production,* as these two are part of Toelevering Water. For *4. Preparation*, there are both Work Preparators in the project team from Water and work preparators from the Toelevering Water department involved in the process. The most important difference between these two functions is that the work preparators from Toelevering Water typically order the materials needed for production in the hall, while the Work Preparators from Water arrange the transport to the construction site. Based on interviews with employees from Water and Toelevering Water from every part of the process, the following problem cluster was determined:

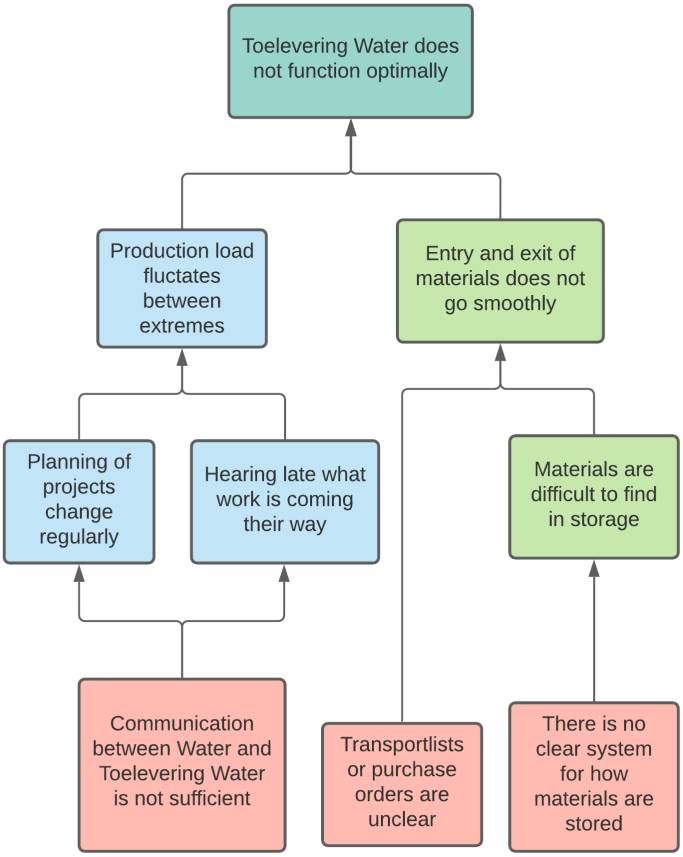

Figure 3: Problem cluster for the department Toelevering Water

As can be seen from the problem cluster in Figure 3, three core problems arise. In order to make my research feasible in the available time, it was decided to focus on the problem that the entry and exit of materials does not go smoothly as this problem is very prevalent: it happens weekly that the trucks that arrive at the construction site are incomplete. This is due to two core problems: *transport lists or purchase orders are unclear* and *there is no clear system for how materials are stored*. This has a direct influence on the availability of materials at the construction site.

1.2.1 Communication between Water and Toelevering Water is not sufficient

Ever since October 2020, Water and Toelevering Water are officially two different departments. The communication between these two departments is currently not as professional as wished. For example, Water does not let Toelevering Water know when they need materials as early as they would do with external parties involved in a project. Ideally, the communication between the departments would be similar to how the communication is between external parties: informing each other of changes on time and having clear ground rules. For example, Toelevering Water gets informed of a change of schedule one week beforehand, even though this change was already determined two weeks beforehand. The information flow between the two departments should be better in regards to informing each other about changes in deadlines and other work activities. That would improve the flow of the process for the entirety of ADS Groep.

1.2.2 Transport lists or purchase orders are not uniform

Sometimes materials arrive at the production hall, but it is unclear which project and technical drawing the incoming materials belong to. Ideally, all the materials belonging to one project are stored in the same place, but this is not possible to execute if it is unclear to what project it belongs. Then, the material is just placed somewhere in storage which greatly increases the chances of it getting lost. This also makes it difficult to find the material to load it on the truck as the material is not clearly labelled and the transport lists are based on technical drawings for each project. The purchase order forms remain on the materials to identify them and are used to find the right materials later when loading the truck when the materials have to go to the construction site.

It happens weekly that the trucks which arrive at the construction site are incomplete, with transport lists being a part of the problem. Ideally, a transport list contains a clear checklist with components from each technical drawing that need to be loaded on the truck, and is sent to the production halls about a week prior to the transport date. However, sometimes people in the production hall do not get a proper list or only receive it a few days beforehand when the work for that week has already been planned. This adds extra time pressure to loading the truck, which increases the possibilities of forgetting to load parts.

Right now, there is not a single employee whose tasks consist solely of being completely responsible for the in- and outcoming goods. After the economic crisis in 2008, this position disappeared as its own full-time function. This means that the welding specialists in the hall have to load the truck as an extra task for the day, while they are sometimes already under a lot of pressure due to the big fluctuations in work load. All in all, this results in some materials being forgotten when loading, and no one feeling particularly responsible for loading it perfectly and informing the construction team if the batch is not complete.

1.2.3 There is no clear system for how materials are stored

For multiple processes within Toelevering Water, it is convenient if the materials can be found easily, not only for loading the truck, but also for finding the right material when welding procedures are planned, and placing it in the correct place after the procedure. Ideally, all the materials belonging to one project are stored in the same place, and it is documented where the materials are. However, making designated shelves for projects does not work well, as the amount of material can differ greatly per project. There is simply not enough space in the indoor hall to keep all the materials together at one place. Usually, the materials that get lost are the small parts, as the big pipes are usually fairly easy to find. Unfortunately, these parts are also the materials that are usually missing when shipments to the construction site happen. For some projects that regard sewage treatment constructions, there can be a lots of small parts involved in one project. As there are usually multiple projects going on at the same time, and when there is no designated storage space for one project, the small parts easily get lost.

1.3 Research questions

The main research question is as follows:

- **What can be done at Toelevering Water in order to optimise their process of in- and outgoing goods to increase the availability of materials at the construction site?**

The main focus will be on improving the process of in- and outgoing goods as the availability of materials at the construction site should be higher in order to decrease failure costs so that the financial goals for the coming years can be reached.

The main question can be split in the following sub questions:

1. **What does the current process from ordering materials to up to the construction site look like?**

a. How can processes be mapped in a clear way to have a good overview?
b. What does the current process of incoming goods look like in terms of communication between different parties and the flow of goods?
c. What does the current process of out-going goods look like in terms of communication between different parties and the flow of goods?

2. **What are the main causes for the in- and outgoing goods process not going smoothly?**

a. How can the main causes be visualised?
b. What are the main problems that were identified?

3. **What solutions can be used to improve the process of incoming and outgoing goods at ADS Groep?**

1.4 Research Design and Deliverables

For the design of the research, the Managerial Problem Solving Method (MPSM) is used (Van Winden & Heerkens, 2017), which is displayed in Figure 4. Step 1 *Problem Identification* and Step 2 *Solution Planning* are part of this introduction. Steps 3 to 5 were executed while doing this research. Step 6 *Solution Implementation* and Step 7 *Solution Evaluation* is the responsibility of the company after the solutions are generated, and is therefore not part of the scope . As can be seen in Table 2, research questions 1 and 2 concern Step 3 *Problem analysis*, while question 3 concerns both Step 4 *Solution generation* and Step 5 *Solution choice*.

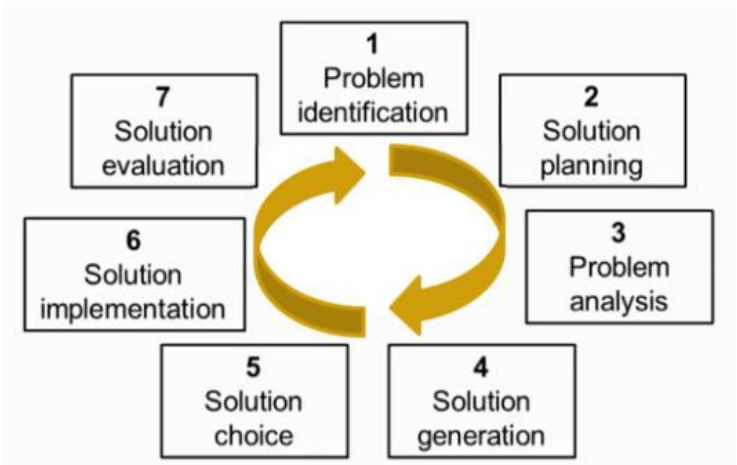

Figure 4: Managerial Problem Solving Cycle

Step of MPSM	Question
Step 3: Problem analysis	1 & 2
Step 4: Solution generation	3
Step 5: Solution choice	3

Table 2: Division of questions

In this part of the thesis, the deliverables of the research will be specified. For every research question, it is specified what will be delivered, and what analysis and research will be done to deliver that result.

What does the current process from ordering materials to up to the construction site look like?

- *How can processes be mapped in a clear way to have a good overview?*

For this question, a literature study is done in order to determine what would be the best method to model the processes. After a comparison of the available methods with their respective pros and cons, a method will be chosen that will be used in later questions to do the actual modelling. There are several methods to do this, such as Business Process Modelling (BPM), Event-driven Process Chain (EPC) or Unified Modelling Language (UML).

- *What does the current process of incoming goods look like in terms of communication between different parties and the flow of goods?*

Based on the first sub-question, the process of incoming goods from ordering up to being stored in the production hall will be modelled. More specifically, the communication between the parties will be modelled, so the information flow, and the flow of the goods. This information will be acquired by observations on the production floor for a while, and interviewing several employees involved with all parts of the process.

- *What does the current process of out-going goods look like in terms of communication between different parties and the flow of goods?*

Based on the first sub-question, the process of outgoing goods from the production hall up to the construction site will be modelled. More specifically, the communication between the parties will be modelled, and the flow of the goods. This information will be acquired by making observations by being on the production floor for a while, interviewing employees and asking them how the process looks like from their perspective.

What are the main causes for the in- and outgoing goods process not going smoothly?

- *How can the main causes be visualised?*

A literature study will be done to determine a suitable way to visualise the causes. One way to give a clear overview of this would be to make use of an Ishikawa diagram to determine the different kinds of causes such as materials, methods, people and more. In an Ishikawa fishbone diagram, causes can be clustered, for example transportation would be a category, and within the categories there can be specific elements of the main causes. This information will be acquired by interviewing employees, and studying data from previous projects, for example the evaluation forms and checking how many of the transports were too late or incomplete.

- *What are the main problems that were identified?*

This will be a list of the main problems that were identified, sorted into the different categories that are used to then visualise the main problems in the Ishikawa diagram. This will be done separately for the process of incoming goods, and the process of outgoing goods. Based on literature research and the current situation at ADS Groep, the importance of solving these problems is described in detail.

What solutions can be used to improve the process of incoming and outgoing goods at ADS Groep?
In this chapter of the thesis, solutions are listed for most of the problems. For some of the solutions, the changes in the way of working are visualised in a BPM diagram. For other solutions, practical examples are given in the form of tables or other visualisations. Once again, this is done separately for the process of incoming goods, and the process of outgoing goods.

2. As-is Situation

Introduction

Right now, ADS Groep is in the process of documenting all their processes, but it is not fully complete yet. Documenting these processes is important in order to obtain uniformity in the way of working, and a standardization of the processes. However, as of right now, the different parties involved in the process of incoming and outgoing goods have their own way of looking at these processes. Based on the interviews that were conducted, they often do not know exactly what the process entails for other parties that are involved. Thus, there is no clear overview of the processes themselves. Currently, both the process of incoming and outgoing goods are not happening optimally, and there is no clear standard of the process to rely on. In order to be able to optimise this process, it is necessary to first have a clear overview of what this process actually contains. First, the method used to model these processes will be determined through a literature study. After determining the stakeholders involved in the process, both the process of incoming goods and outgoing goods will be modelled separately, and explained accordingly.

2.1 How can processes be mapped in a clear way to have a good overview?

The purpose of this research question is to decide on what method to use to model the processes, through researching the advantages and disadvantages different available methods have. Based on this, the most appropriate method for modelling the specific process of incoming and outgoing goods will be chosen.

2.1.1 Theoretical framework

As stated before, it is necessary to first know what the process looks like before being able to optimise it. Processes that involve multiple stakeholders within a company, or stakeholders outside a company in the case of bigger supply chains, can be very complex. With globalization connecting many markets worldwide, coordination and cooperation becomes even more crucial with buyers and sellers located all over the world (Mattsson, 2003). Creating models of a process can provide a good basis for communication, coordination, documentation and implementation for the execution of a process in a supply chain (Bae & Seo, 2007). This is the core of Business Process Modelling (BPM), which allows companies to further optimise their processes by creating an overview that is easy to understand by all parties involved. This can entail more than just business processes themselves. For example, the organisational structure of a company also has an influence on how the processes are structured (Van Looy & Devos, 2018). Therefore, the scope of what is modelled may differ greatly depending on the goal of the BPM itself.

When it comes to modelling business processes, there are several notations that can be used. While many of these can be valuable tools, each technique has their own strengths and weaknesses. In recent years, Business Process Model and Notation (BPMN) has become the most commonly used tool, as it received strong support from both users and researchers (Imgrund et al., 2019). Simply put, BPMN is similar to a flowchart but has more elements that indicate interactions between different parties involved in the process (Carchiolo et al., 2020). One big advantage of BPMN is that it shows exactly in what phase the process is currently in due to its flowchart nature, and what action needs

be taken in order to proceed to the next step. Thus, bottlenecks can be determined relatively easy for specific phases of the process, and the information acquired through it can be used to calculate Key Performance Indicators (KPIs) (Carchiolo et al, 2020). Nonetheless, BPMN also has some limitations. For example, relationships between data objects cannot be modelled properly in BPMN.

However, Unified Modelling Language (UML) can model relationships between data objects. UML is most frequently used in software domains, and is useful when creating a model of the data structure and data entities within a system (Barcelona et al., 2018). While it can be used to model a business process, it is usually only usable for structuring data entities within a system. Another method that can be used is Event-driven Process Chains (EPC), which was the standard notation to go to before BPMN was introduced. Still, it is used quite frequently as this almost the only notation that is supported by enterprise resource planning (ERP) systems, which might be an important reason for companies to keep using it (Imgrund et al., 2019). EPC has a clear focus on business processes, and is quite similar to BPMN as it has many of the same patterns, such as parallel splits and merges of workflows. However, BPMN has more options available for modelling than EPC, thus making BPMN suitable for more processes than EPC (Imgrund et al., 2019). Regardless, EPC still has a wide range of applications and is frequently used by companies, as it is supported by ERP systems as well which is its biggest advantage compared to BPMN.

Applying this to the processes at ADS Groep B.V., BPMN would be the most suitable method. BPMN can easily be used to create an ''as-is'' process model that the stakeholders involved can easily understand (Venkatraman & Venkatraman, 2019). It has more functionalities than EPC, especially when it comes to lower-level process modelling. While BPMN is more difficult to connect with an ERP system, this is not needed in order to reach the goal of making the process clear for all stakeholders involved. Therefore, BPMN is the best choice in this case. Furthermore, it is useful for identifying bottlenecks and their respective key performance indicator (KPIs), which is important for this research. A summary of the pros and cons to each method mentioned in this framework can be found in Table 3: Summary of modelling languagesTable 3.

	BPMN	**EPC**	**UML**
Advantage(s)	-Easy to understand due to flowchart nature -Easy to have an overview of what phase the process is in -More modelling options than EPC	-Compatible with almost all ERP systems -Easy to understand due to flowchart nature	-Very suitable for modelling relationships between data objects in a system
Disadvantage(s)	-Not compatible with all ERP systems	-Less modelling options than BPMN	-Not suitable for modelling entire business processes

Table 3: Summary of modelling languages

2.2 Incoming goods process

In this part of the thesis, the process of incoming goods at the production hall will be explained in detail in order to get a full understanding of the process. The process will be explained step by step. There are two models: one for how the goods are ordered, and one for how the goods arrive at the production hall after being ordered. Important to note is that purchases are done on project basis, so everything on one purchasing form belongs to the same project.

The following stakeholders are directly involved in the process and therefore get a separate lane in the BPM model:

- Engineering Department
- Work Preparation
- Production

The full BPM models for incoming goods can be found in Appendix A and Appendix B

2.2.1 Initial design and feasibility

The process starts at the Engineering Department as can be seen in Figure 5, where they make the initial design for the technical drawings for the project. It can differ greatly per project how long this phase takes. Some clients already know exactly what they want, and already have a well-thought out plan of what they want to have made. In some cases, these plans are so complete that engineering only has to change some details of the plans.

However, there are also clients who do not have such specific plans at the beginning, but only a Piping and Instrumentation diagram (PID) as an idea of what they want. In this case, the Engineering department has a lot more freedom to make a design within the project specific boundaries. This takes a lot more time. Creating the definitive design happens only after the client has given permission for the initial design.

Ever since the autumn of 2020, due to restructuring the processes internally at ADS Groep, Work Preparation from Toelevering Water is more involved in the Engineering process as well. For example, one employee from Work Preparation joins the weekly Engineering meetings in which the designs are discussed. Before that, the Work Preparator only saw the technical drawings after they were already definitive and approved by the client. This mean that the material list was already definitive. If it then turned out the intended materials could not be ordered or made in the production hall, the final design would need to be changed. Changing the final design costs a lot of time, as the client has to approve of a new version as well, so the process would start basically all over again. Right now, the Work Preparator is also involved in the initial design and can already give feedback then on whether the materials can be ordered or if the technical drawings can be made in the production hall before the design is definitive.

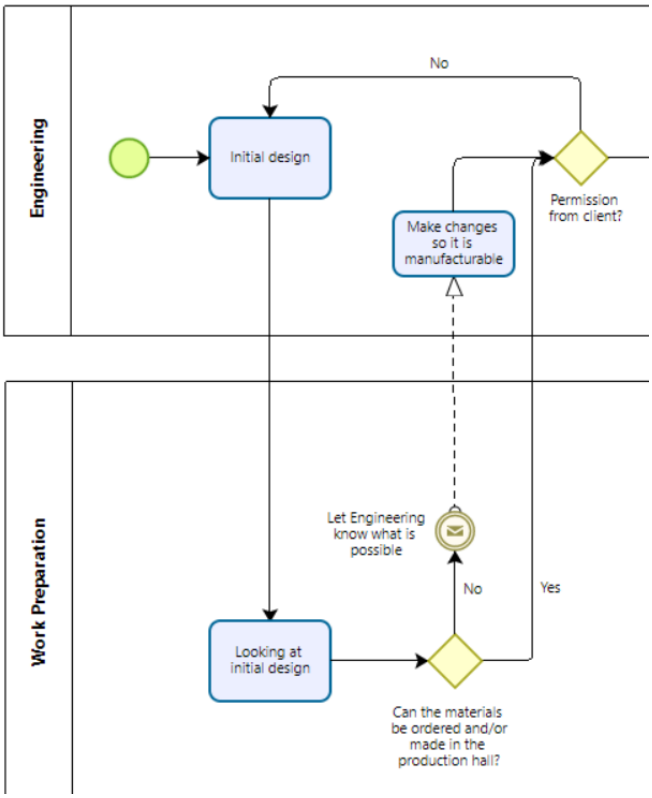

Figure 5: Initial design and feasibility

2.2.2 Definitive design and beginning stages of purchasing process

Once permission has been received from the client for the initial design, Engineering starts working on the definitive design. This contains working out the technical drawings, and making the design complete. When there is permission from the client for the definitive design, the final technical drawings are sent to Work Preparation. After this, the Engineering department starts working on the executive design. For the executive design, extensive 2D technical drawings are made for the production, which is very labour-intensive. Therefore, it is very important that these executive drawings are only made when the design is final, so that this work does not have to be done again. After completing the executive design, the Engineering department is done with their part of the project.

When the definitive design is done, the Work Preparator at Toelevering Water receives the final technical drawings from Engineering. For most projects that have a lifetime of a year or more, they receive the material lists occasionally before the definitive design, so that the parts that have a lead time of a few months or more can be ordered earlier. Based on the technical drawings, all materials that are needed are put into one list. In this list, the materials are sorted by its kind, so for instance stainless steel components go with stainless steel components, and regular steel with regular steel. This list is then used to create another list of what will be ordered at every supplier. ADS Groep works together with many regular suppliers, which results in loyalty discount when large amounts are bought. In total there are a lot of suppliers, because they have regular suppliers for every different kind of material. For example, for stainless steel they have three to four regular suppliers, for steel three suppliers and more regular suppliers for standard products such as plates and pipes. For expensive products, the materials are requested more suppliers to negotiate a good price. After requesting the materials at the suppliers, the Work Preparator gets an estimate of the costs per supplier. This form is sent by e-mail by the supplier and contains the material names, quantities and

the resulting price. The offer is checked whether it contain exactly the materials that were requested. For example, the quantities on the estimate might be different than requested, or a different width is used for the steel plates. This estimate is put in a separate folder for all the offers per project.

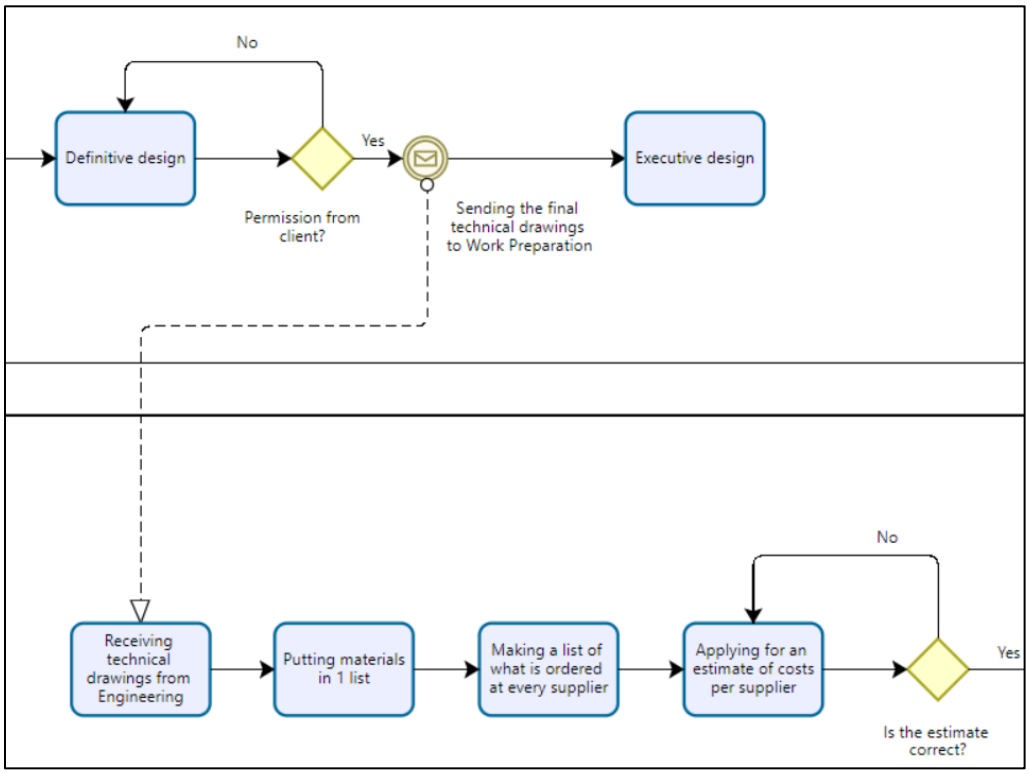

Figure 6: Definitive design and applying for an estimate

If the estimate is correct, the Work Preparator negotiates with the suppliers, which usually happens over the phone. For example, extra discounts may be given based on the loyalty to a particular supplier and the volume of the order. Sometimes, the price gets lowered when the Work Preparator shows the supplier that the material was a lot cheaper last year when the same parts got ordered. Usually, the price does go down quite a bit after these negotiations. After the negotiations, the supplier sends a new offer to the Work Preparator. After this, it is time to select a supplier. It is dependent on the project itself how the trade-off between costs and responsiveness is made. Some projects of ADS Groep only have a lifetime of a few weeks. In this case, responsiveness is very important because there is no room for delay as the planning is tight. Generally, for these projects, there is also less time to negotiate with suppliers, as materials need to arrive at the production hall as fast as possible. A short lead time in this case is very important. Generally, buying more expensive materials is cheaper than exceeding the project deadline and having to pay penalties because of this. While costs are still an important factor in deciding the supplier, the lead time is even more important in this case. The costs will be generally higher as the lead time needs to be very short.

2.2.3 Choosing a supplier and authorisation

In some projects, suppliers must have certain certificates in order to meet the requests of the client. This happens especially in drinking water purification projects, as the guidelines can be quite strict.

Ultimately, the costs are the biggest factor in choosing a supplier. However, for very short projects that only have a lifetime of a few weeks, lead time becomes exponentially more important. In those cases, the price of materials will generally be more expensive as the lead time has to be short in order to meet the project deadlines. Generally, buying more expensive materials is cheaper than

exceeding the project deadline and having to pay fees because of this. After choosing a supplier and checking that everything is within budget regarding costs and lead times, a purchasing request is made. This can be seen in Figure 7.

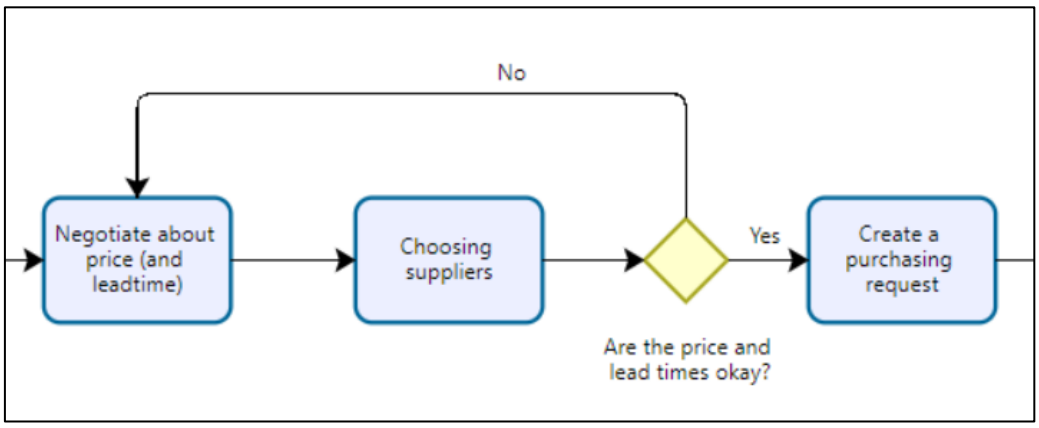

Figure 7: Choosing a supplier

Before the order can be placed, the request must be approved. Depending on the costs, the Work Preparator can verify the purchase themselves, or they have to get approval from a superior. Using these official forms, Table 4 gives an overview of who gives authorisation.

Costs	Authorisation
< € 10.000	Work Preparator
€ 10.000 - € 100.000	Project Leader
€ 100.000 - € 500.000	Company manager
> € 500.000	CEO

Table 4: Authorisation of purchasing requests

This was modelled into the BPM model as can be seen in Figure 8 below.

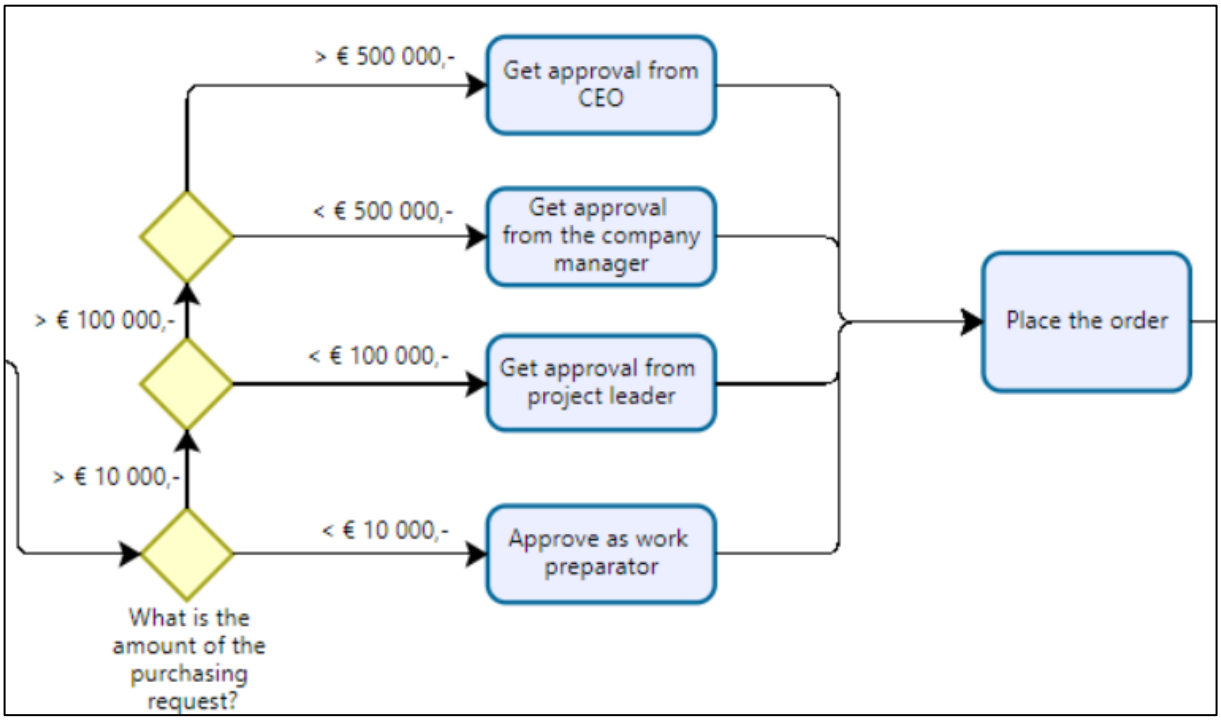

Figure 8: Authorisation of purchase request

After the purchase request has been approved of, the order is placed. Thereafter, an order confirmation is received. This order confirmation is then checked whether the delivery date is realistic and within project deadlines, after which the order is complete. Sometimes, there can be small writing errors that can result in getting the wrong product delivered. It is important to contact the supplier as soon as possible when mistakes like this are found, because then the shipment can still be changed. When the order is confirmed, the order is registered in the system and has its own purchasing form and corresponding number. This also includes an indication of the delivery date. If the delivery date changes later on, it is not updated in the system but instead reported orally. The purchasing form and the purchasing number also gets sent to the supplier, as this is number is put on the waybill in order to be able to trace back to what project the delivery is for. If all parts of a technical drawing has been ordered, the purchasing form joins the technical drawings in physical folder. This is the end of the purchasing process. The full BPMN diagram of this can be found in Appendix A.

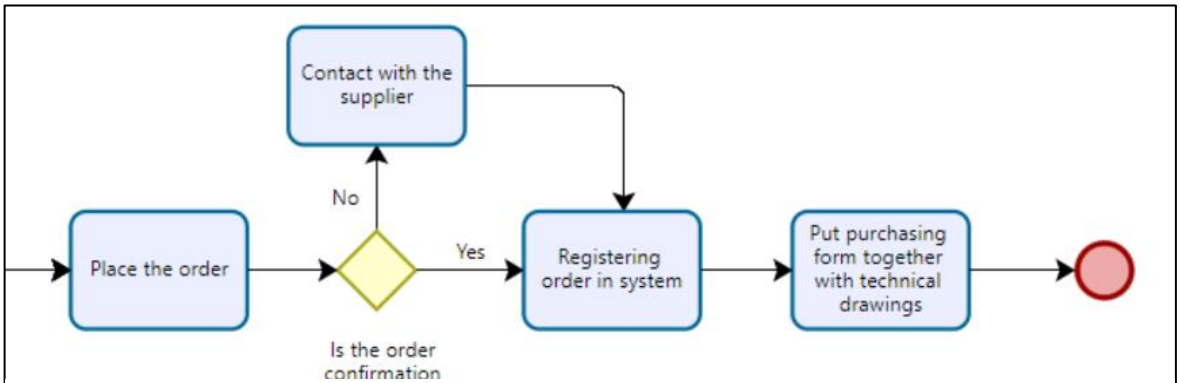

Figure 9: End of the process

2.2.3 Receiving ordered goods in the production hall

This process starts whenever a truck arrives at the production hall with ordered goods. The trucks get unloaded immediately either by the truck driver or someone from the hall, as it is generally custom to let the truck driver continue with his work as soon as possible. When the material is unloaded and put in the hall for incoming goods, the waybill containing information on what should have been delivered gets checked by one of the people responsible for incoming goods. This piece of paper is usually attached to one of the boxes in the delivery. With a pen, all the content of the waybill gets checked in terms of material sort, quantity and size manually by ticking off the products received from the purchasing order. If the material delivered is not the same as the waybill states, the incompleteness is reported to the Work Preparator, usually by visiting their office and explaining the situation.

After checking the waybill, it is time to check the purchasing form. The waybill includes a purchasing number of ADS, which is used to find the purchasing order in the system and print the purchasing order.

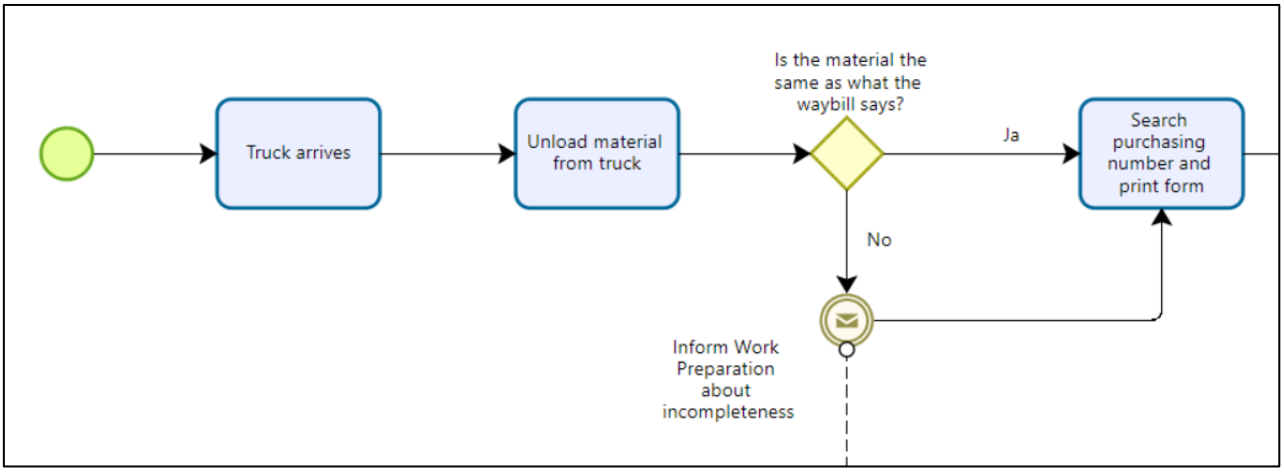

Figure 10: Arrival of incoming goods at the production hall

Then, the second check happens. The content of the purchasing order and waybill are compared by one the people responsible for incoming goods, whether they contain the exact same elements. If this is not the case, the Work Preparator gets informed about this. Using the purchasing number, it is then registered in the system whether the purchase order is complete or not. It happens quite often that something was ordered in one purchase order, but not delivered with all the other products it was ordered with. Usually, that material comes a few days later through a subsequent delivery.

2.3.4 Storing the material

After registering the completeness of the order, the order is stored, ideally inside in the production hall. However, there is not always space to store it inside. The people responsible for incoming goods at the production halls do not know exactly when shipments will arrive. When especially large shipments arrive, there might not be enough space to store it inside as they could not prepare space beforehand because they did not know the order was coming. Currently, there is no registration about where the order is stored. According to Wang (2005), making a precise long-term prediction is difficult when the demand is very chaotic. At Toelevering Water, the amount of work and projects going on can differ greatly every week. Therefore, it is difficult to anticipate correctly how much inventory space is needed every week. In order to remain flexible, no fixed inventory management system is used.

The purchase number is written on the boxes of material and usually also the project number, so it can be derived through the purchasing form what material it is. In order to get some sense of structure, colour codes are used for materials belonging to one project as a label. As some people might be colour blind, the project number is also written on the box. The colour codes are thus used as an extra option of easily spotting to what project the material belongs.

However, the project number does not specify to which technical drawing the material belongs to. This is instead decided by the person responsible for doing the preparation work in the hall, who selects the material for each technical drawing and makes them into a complete package per technical drawing.

If the order is incomplete, it is up to the Work Preparator to solve the problem. There could be several reasons as to why the order is incomplete. In most cases, there is a subsequent delivery of

several parts is still outstanding. After the order has been registered, the materials that have arrived at the hall get stored as can be seen in Figure 11. Ideally, the materials get stored inside to protect the material. However, in peak production times it can happen that there is not enough space to store everything inside. In that case, the materials get stored outside, usually with extra wrappings to protect the material from weather conditions.

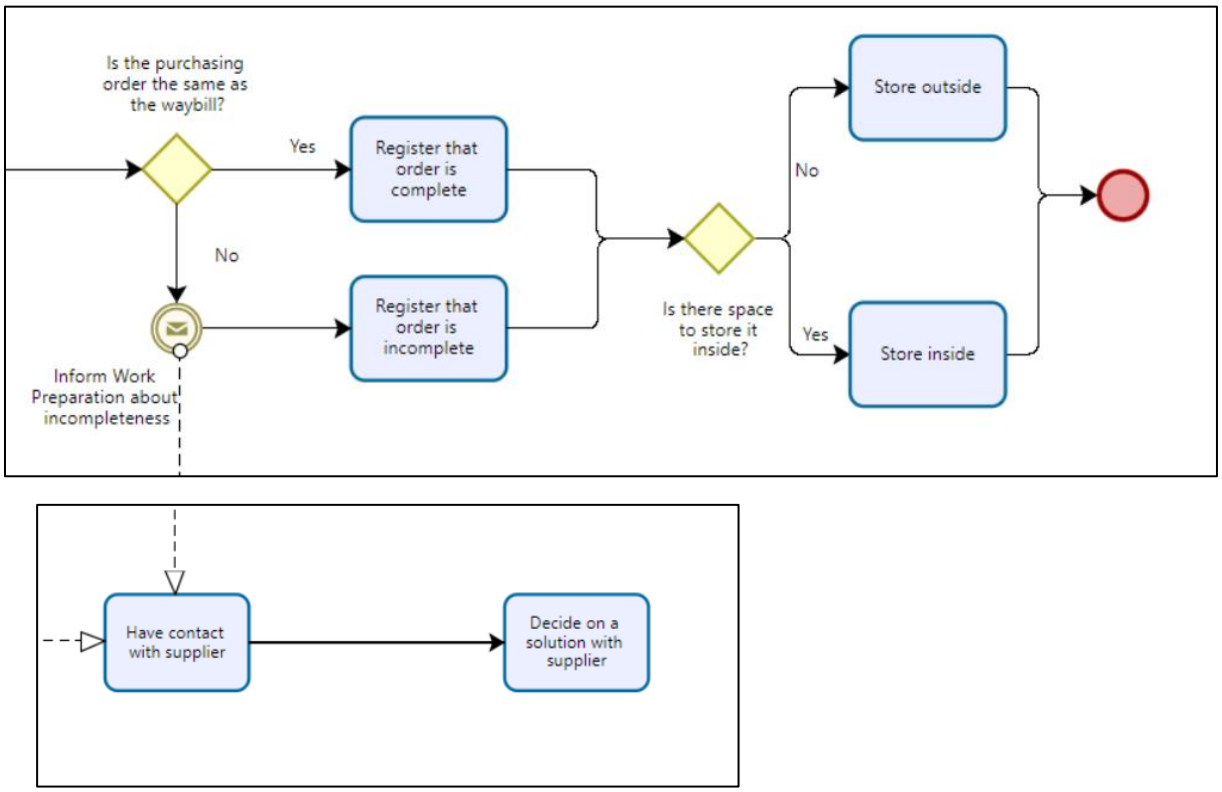

Figure 11: Wrapping up the process

2.3 Outgoing goods process

In this part of the thesis, the process of outgoing goods at the production hall will be explained in detail in order to get a full understanding of the process. The process will be explained step by step in accordance with the BPM models created. There are two models: one for how the transport list is made and the materials are put together, and one for how the goods arrive at the construction site after being ordered. The complete BPM models can be found in Appendix C and Appendix D.

The following stakeholders are directly involved in the process:

- Execution at the construction site
- Work Preparation Project Team
- Work Preparation Toelevering Water
- Transport controller Toelevering Water

There is also a stakeholder Project Team included in the model as a combination of the Project Leader, Work Preparator, and Executor at the construction site and potentially a Work Organisator depending on the size of the project and the requirements of the client. Generally speaking, when the work of a project is too much for one Work Preparator, another Work Preparator gets added to take the position of Work Organisator to divide the work.

2.3.1 Arranging transport

The process starts when the project team has a meeting in which they discuss the materials that are needed on the construction site in order to adhere to the planning. When discussing transport, it is important to decide whether the transport is exclusively carried out for ADS Groep. If it is exclusive, only materials for ADS Groep are transported by the carrier and a precise moment of delivery can be arranged. However, this is more expensive. When the transport is not exclusive, the load will be combined with loads from other companies, and thus cheaper, but an exact moment of delivery cannot be arranged in this case. Once again, there is a trade-off between responsiveness and costs. Most of the transports to the construction site of ADS Groep are booked exclusively. However, if it is only a small batch of materials and the exact moment of delivery is not that important, combined transport can be chosen as well.

In the case of exclusive transport, the exact moment of transport must be clearly defined. In both cases, the executor at the construction site is informed of the planned delivery when transport is arranged, and they can write it down in their planning. After this, the work preparator of the project is tasked with making the transport list that will be sent to the production hall.

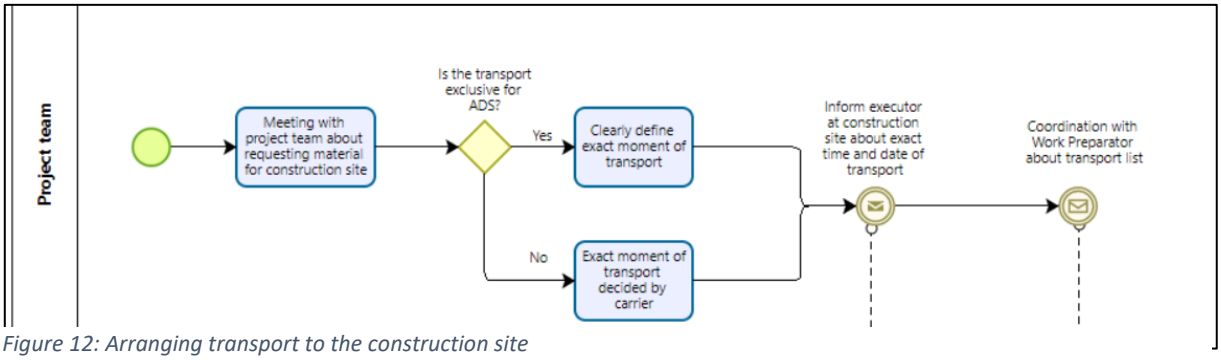

Figure 12: Arranging transport to the construction site

2.3.2 Making the transport list

How the transport list is made, depends how the model was made by the Engineering department. If the parts of the models are made in different programs, it is not possible to automatically generate one list with all the components, as the required components may be divided over the different models. Therefore, it may not be possible for all projects to generate a list of materials from the Engineering file alone. If it possible to generate a list, the list is sent towards the production hall as both a PDF and an Excel file by email. If it is not possible to generate a list, the materials are manually listed in an email, with the technical drawings belonging to the parts mentioned as well. The technical drawings are sent as an attachment to the email as well in this case. In both cases, the project number, delivery address and contact person for the production hall and construction site are included.

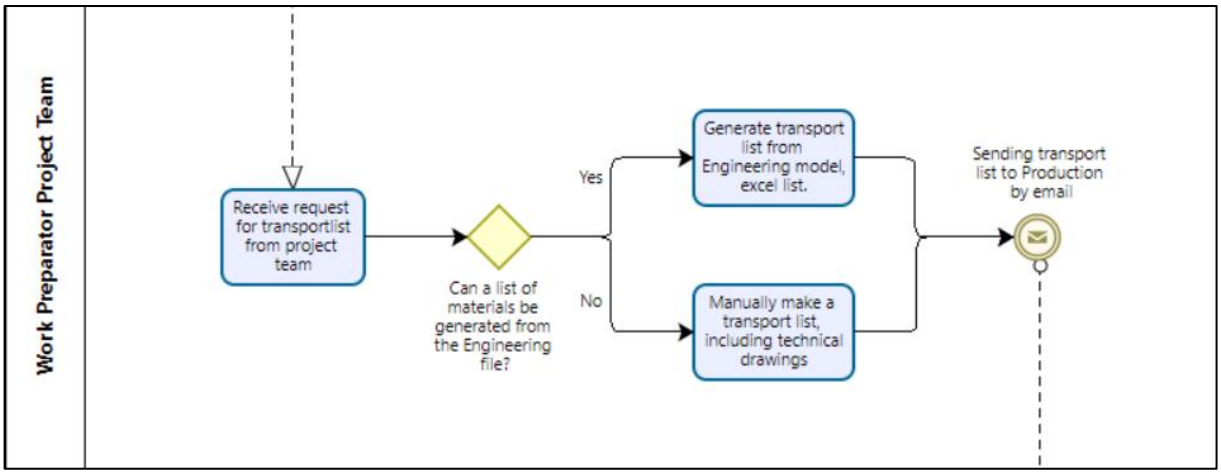

Figure 13: Creating the transport list

2.3.3 Assembling materials in production hall

Once the Transport Controller in the production hall receives the transport list, he searches for all the technical drawings of which components that need to be shipped belong to. This is necessary, as it is only visible on the technical drawings themselves whether fastenings need to be included as well. Fastenings are not mentioned as an element in the list itself, regardless of whether the list is automatically generated through the Engineering file or not. If there are fastenings that belong to a technical drawing, this can be seen in the upper right corner of the drawing.

After the transport list and technical drawings are printed by the transport controller, they systematically go through to the list to check every single material requested. A pile of the materials intended for one shipment is created outside. Every element that is put to the pile, is labelled, which is usually a small piece of paper connected to the material with a metal wire. In some cases, the material may still have a label, but it is not unusual that they fall off at some point during the production process. For example, in the case of pipes, this label contains information about the pipe number, as it is very important in which order the pipes are connected at the construction site. Once the component has been labelled, it gets checked off the list and the transport controller moves on to the next component.

However, it may be the case that a component is not ready for transport yet. If the transport list is only sent one or two days beforehand, in some cases it is impossible to finish it before transport as some material takes around 24 hours for the chemical staining of steel. Depending on whether it is still able to be included in transport or not, it is written down on the list as either missing or included.

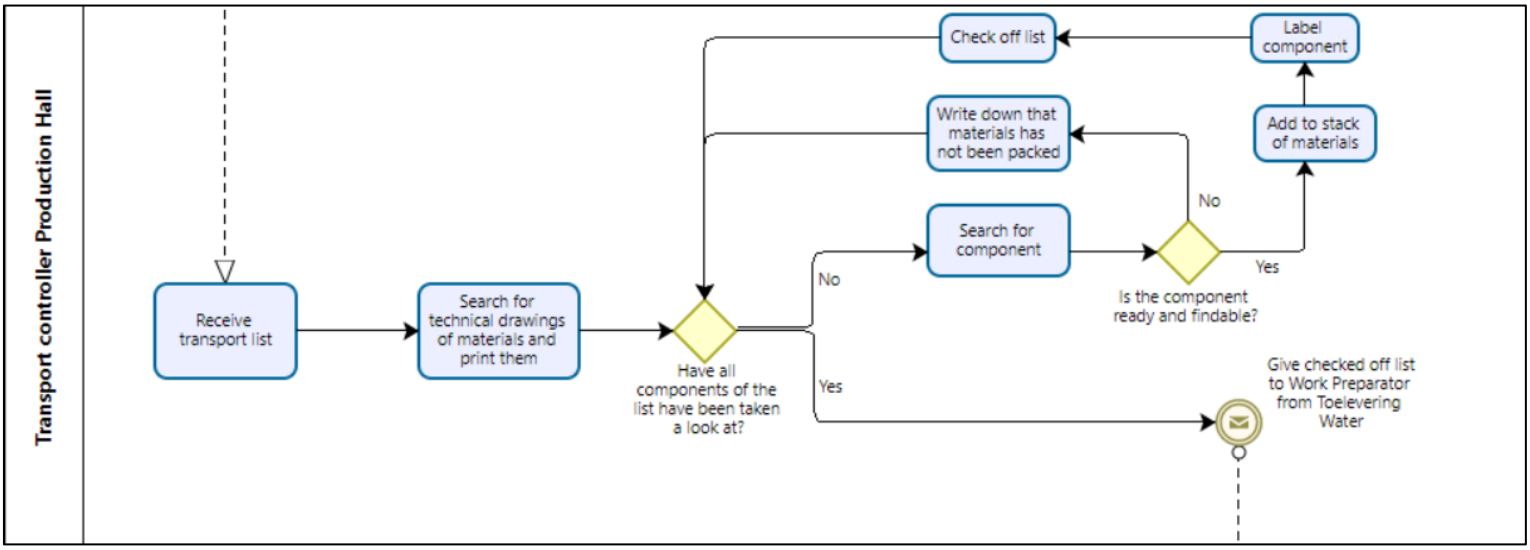

Figure 14: Collecting the materials for shipment

2.3.4 Final list

Once the list has been checked off and the materials are collected, the work preparator of Toelevering Water gets the list from the transport controller. Based on the contents that can be shipped, the final transport list is created. This list is then printed and handed over to the transport controller again. He signs the list, as they were responsible for collecting the materials. Even if the materials are loaded on the truck by a different person that is operating the forklift truck, the list is signed by the person that collected all the materials and checked off the first list. Once the list has been signed, it is put in a protective plastic folder and taped to one of the boxes of the shipment. This is the end of this process.

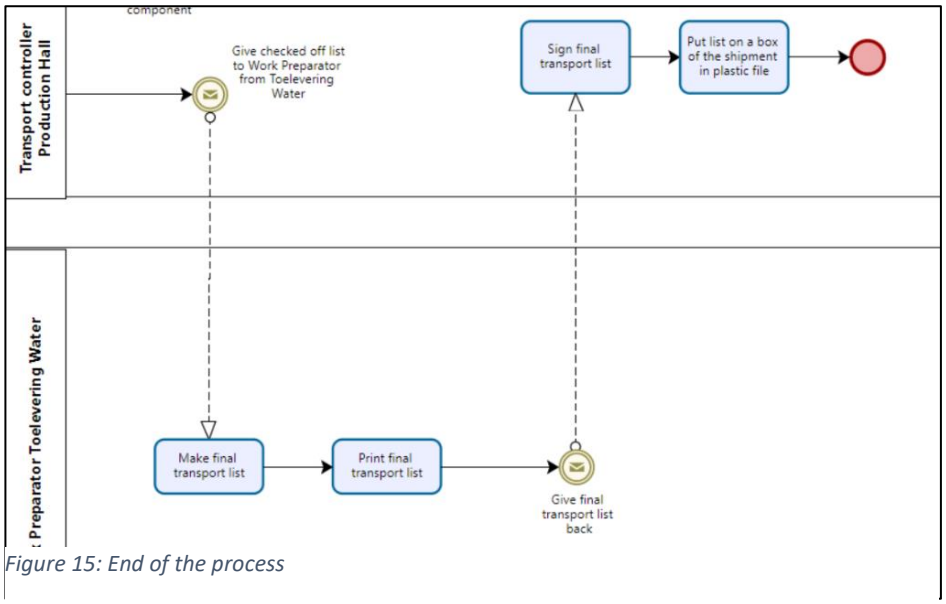

Figure 15: End of the process

2.3.5 Shipment arriving at construction site

The process starts when a truck arrives at the construction site. First, the truck is unloaded and the transport list is searched for. Right now, according to the main executioner at the construction site, the transport list is not there around 90% of the time. If the transport list is there, the load can be checked as to whether it is the same as specified on the list. When there is a list, the materials that are on the construction site can also be registered as they can be identified. If there is no list, it is impossible to register what materials arrived exactly. This can cause the same materials to be requested to the production hall several time. Regardless of whether the transport list is there or not, the material is stored and the work at the construction site continues.

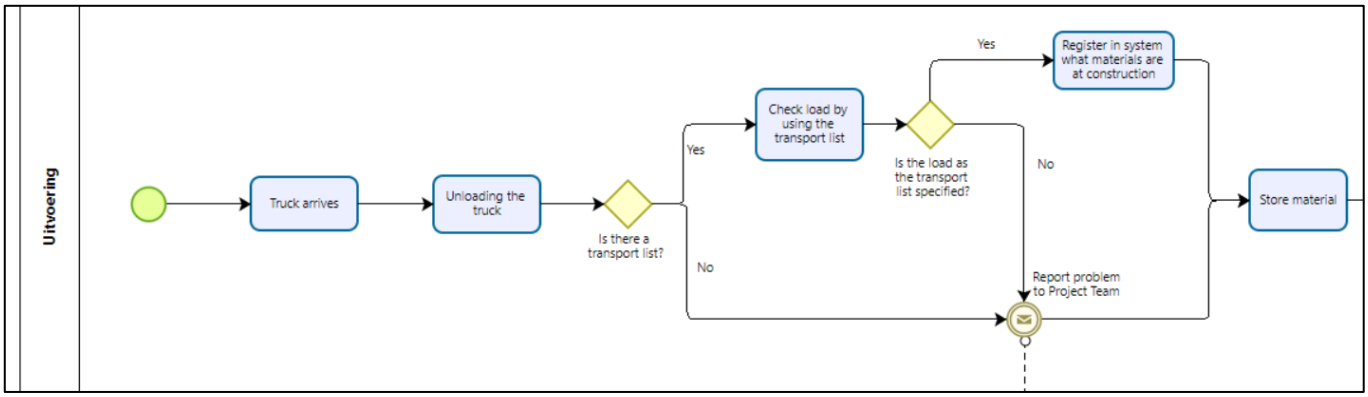

Figure 16: Arrival of goods at the construction site

2.3.6 Missing materials

If the transport list is not there or materials are missing from the transport list, a report is made to the Project Team by the Executioner at the construction site, usually the Project Leader in particular. This is usually done through a phone call.

After receiving the call from the Executioner at the construction site, the person handling the complaint from the Project Team contacts the production hall. It may be the case that some materials were not ready yet, or were forgotten to be packed. In this case, subsequent delivery will usually be arranged to bring the materials to the construction site as quickly as possible. However, it may also be the case that the material cannot be found in the production hall either. While this is rarer, it is very difficult to solve. In the worst case scenario, the product might have to made again from scratch. This takes a lot of time.

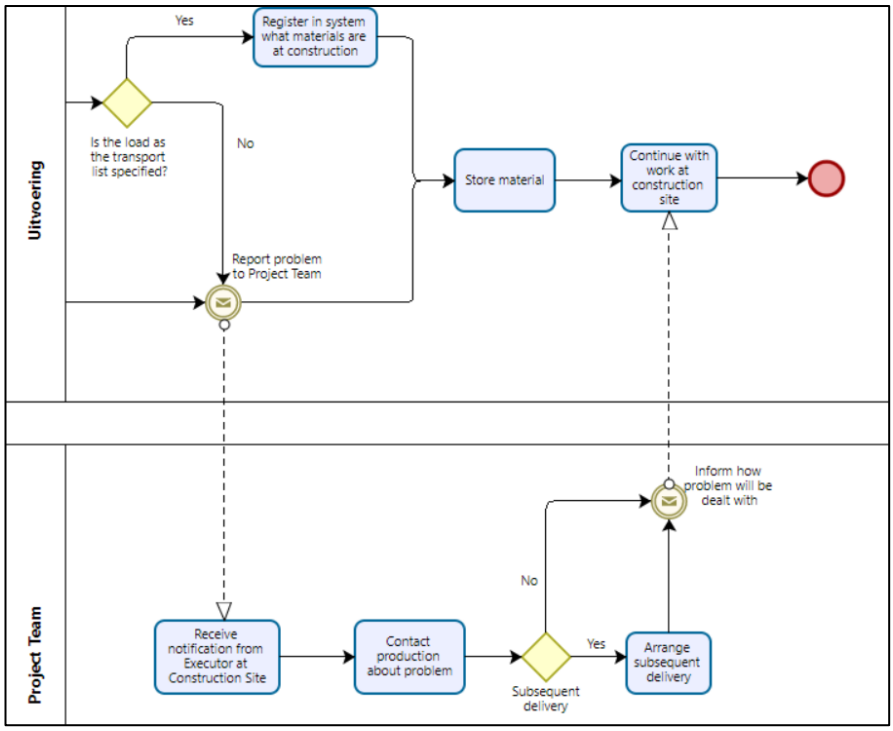

Figure 17: Process when there are missing goods

3. Problem identification

In this part of the thesis, the causes as to why the processes of incoming and outgoing goods do not function optimally will be determined. After discussing the causes, the findings will be presented in an Ishikawa diagram. This will be done for the process of incoming goods and outgoing goods separately.

3.1 How can the main causes be visualised?

In order to have a clear overview of the main causes, it is helpful to use a structured approach and make it visual. One such way of creating an overview of the causes and effect is by making an Ishikawa Diagram. An Ishikawa diagram is constructed like a fishbone, where the head of the fish is the effect of all the causes that make up the bones of the fish (Jalal, Noorzai & Roushan, 2019). It is easy to use as a tool, in order to break down causes that contribute to a problem (Andersen & Fagerhaug, 2000). However, a complete Ishikawa diagram with many branches might look very cluttered, which defeats the purpose of creating clarity. Meanwhile, if it is a very simple diagram, the problem might not be selected properly or further research is needed (Ishikawa, 1982). Therefore, the right balance between branches is needed in order to have a good overview while still containing enough information.

When creating an Ishikawa diagram, first a problem must be selected. This problem is then drawn on the right side of the paper, to create the head of the fishbone diagram, connected to an arrow that points towards it from the left time. Then, the main factors that contribute to the problem, become main branches to the main arrow. For every major branch, smaller factors can be added as an side branches. After writing this down, it is important to critically study whether the diagram contains all the items that may be causing the problem (Ishikawa, 1982).

In the manufacturing industry, the following categories are usually used, also known as the 4 Ms: Material, methods, machines and manpower. However, categories can also be tailored to specifically suit the problem (Moran, Talbot & Benson, 1990). As the two processes that are analysed at ADS Groep are not traditional manufacturing processes, some separate categories are used to fit the situation. For the two processes of ADS Groep that this thesis focuses on, two separate Ishikawa diagrams will be made.

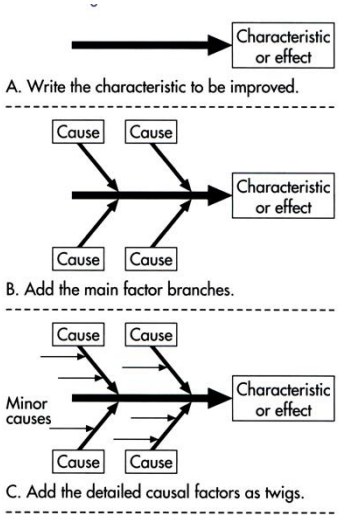

Figure 18: Construction of an Ishikawa diagram

Source: Moran, Talbot & Benson 1990

3.2 Incoming goods

3.2.1 Allocation of incoming goods

Unclear to which technical drawings incoming goods belong to

People receiving the goods in the production hall do not know what technical drawing of a project the materials belongs to when it arrived in the hall. In order to find out to what project it belongs, the purchase number on the shipment is used to find the purchasing form which contains a project number. Some projects have a lifetime of months, sometimes even years and therefore contain more than hundred technical drawings. As the technical drawing number is not included on the purchasing form right now, the incoming materials cannot be directly linked for what part of the project it is exactly needed. The Work Preparator compiles the list of materials based on the technical drawings, but this information is currently not passed on further in the supply chain. Currently the technical drawing number is included 0% of the time, while close to 100% would be desirable.

Importance of solving this issue

ADS Groep produces under a NEN 1090 certificate, which is a standard for constructions made out of steel. In some cases, this is a requirement by the client. NEN 1090 consists out of five different parts, from NEN-EN 1090-1 to NEN-EN-1090-5. NEN 1090-1 describes the requirements for determining the conformity of construction parts made out of aluminium or steel (Piers, n.d.). A part of this certification is being able to fully retrace the goods so that the right materials are used for the construction.

In the current situation, the material for the goods to be produced is selected by the person who does the preparation work in the production hall. Based on the technical drawings, he selects what he perceives to be the right ones for the technical drawing, but there is no way to verify whether the materials selected by this person are the materials that were intended for the production as there is no technical drawing number written on the materials. Because of this, the people in the production have to decide for themselves what material they use for what technical drawing exactly. This means other materials than originally intended could end up being used for a technical drawing, as there is no way to derive whether the material used is the material meant for a specific technical drawing. As a result, the calculations made by the Engineering department for a construction might not be correct anymore, as different materials could be used while the calculations are made with other materials in mind. In the worst case scenario, this could be potentially be dangerous to how well the construction is made, and could cause legal issues as well.

Thus, how the process is currently set up, it does not fully meet the NEN 1090-1 requirements. If ADS Groep loses their NEN 1090 certification, they might lose clients. The Work Preparator uses the technical drawings as a basis to make a material list of what needs to be ordered. The information does exist of what material does belong to what technical drawing. However, it is currently not conveyed downwards in the process chain. Thus, the information gets lost along the process. Information sharing in supply chains is , however, desirable, as it improves coordination between different processes in the supply chain and allows for a smooth flow of materials (Li & Lin, 2006). Information sharing is associated with a shorter cycle order time and less costs (Lin, Huang & Lin, 2002). In the case of ADS Groep, a shorter cycle order time is desirable with around 80% of their projects having a relatively short lifespan of 2 weeks to a few months. Therefore, in order to improve the process, it must be known for the incoming materials to which technical drawing it belongs.

3.2.1 Transport

Unknown estimated time of the arrival of shipments

The people responsible for receiving the goods currently have no idea when shipments arrive. As there is only very limited storage space inside the production hall, the inventory is usually rearranged and moved around in order to create space to store the new materials. This is especially a problem for big shipments which make up around 10% of all shipments, as there is no space prepared to store it. It can also disrupt the flow of work. If it is very busy in the production hall, and there are unexpectedly a lot of goods arriving, it can be very stressful for the people involved who have to handle that on top of the work that needs to be done in the hall. This means that the goods get registered later, while you want to check the goods as quick as possible. This is especially important when a shipment is incomplete while the materials is needed very soon, as the supplier needs to be contacted as quickly as possible.

Importance of solving this issue

As mentioned earlier in the thesis, there are peak moments of how busy it is at the production hall. Especially when it is a very busy cycle in the production hall and the person responsible for incoming goods has no time to spare, it is important to know when and which goods will be delivered so it can be taken into account with the week planning. Firstly, if the people responsible for incoming goods at the production hall know that a large shipment is coming, they can already designate space in the storage before the load arrives and possibly rearrange the inventory so the material can be stored immediately. Secondly, the people responsible for incoming goods know what day the truck will arrive, so they can calculate the time needed for it into their planning.

3.2.2 Stock

Leftover materials in different shapes and sizes from projects on stock

Materials in stock is a combination of standard materials that have standard sizes and serve as safety what is called ‘’safety stock’’ at the company ADS Groep, and the material leftover from projects. When materials are left over from projects, they get added to the stock. Generally, this should not happen as purchasing happens on a project basis, and exactly enough material gets ordered. In some cases, materials leftover from projects remain unused for a very long time due to it having very specific sizes, while taking up some of the limited inventory space that is inside. For example, standard sizes for plates of steel used at ADS Groep are 6 meters long. However, for a specific projects it might have been 3,5 meters long and cannot easily be used as it is too small to get something useful out of it. Therefore, some of materials leftover from projects cannot be reused and are considered scrap materials in the production hall.

Despite that, they do not always get thrown away immediately, but get moved outside instead. There is a large pile of materials outside that have been lying there for years. This is not beneficial to the quality of the material.

Difficult to structure inventory

It is very difficult to get structure in storage due to diversity of projects and materials. As Toelevering Water works on projects in the water purification and sewage water treatment sector, there is a big variety in materials. For example, there are very big pipes, but also small boxes containing fastenings.

As there is little space to store indoors and materials can differ greatly in size, it is simply impossible to store all the material belonging to one project in the same place. Instead, the materials are grouped with materials of similar sizes. For example, there is a storage cabinet that contains boxes of fastenings belonging to different projects.

No overview of the safety stock in the production hall

In the case of ADS Groep, since everything is ordered on a project basis, the safety stock consists of materials that have standard sizes that can be easily used in case some of the ordered material is missing or has a late subsequent delivery. Right now, the people working in the hall have no overview of what standard materials are actually on stock. The only way to find out is by looking in the hall in the different cabinets. If the people in the hall find out a specific standard material is low on stock, they inform the Work Preparator who then orders more alongside project-specific purchases, but it can take a few days until the materials arrive. This can cause certain standard materials to be too low on stock when needed for quick production. In order to be prevent stock-outs, an overview of what the safety stock consists of is needed, along with reorder points for each specific material.

Importance of solving these issues

If there is a project that only has a lifetime of a few weeks, the production hall needs to have enough safety stock in order to be able to respond immediately in case the delivery for the project might be incomplete or late due to problems on the side of the supplier, which can happen every now and then. Having safety stock increases the responsiveness of a system and is helpful when dealing with unreliability and fluctuations in demand and supply (Van Kampen, Van Donk & Van der Zee, 2010). However, right now there is no clear overview of the levels of the safety stock, which means there is no guarantee there is always enough on stock if there is an emergency.

Furthermore, there is only very limited space available in the inside hall, and the great diversity in materials makes it hard to structure the inventory. Materials leftover from projects also end up in some of the shelves where the standard materials are stored as well. Generally speaking, there should not be any materials leftover from projects as it is ordered exactly as stated on the technical drawings. Despite this, it occurs every now and then. Materials leftover from projects can have specific sizes that cannot be easily reused. It is important to know what materials are leftover, so the same material is not ordered again while it is still present in the hall, so that the project leftovers disappear from the safety stock cabinets as quickly as possible. There is currently no list of what materials are available in the hall, both in the case of safety stock and materials that are left over from projects.

3.3 Ishikawa diagram for Incoming Goods

Summarising the problems mentioned for incoming goods, we get the following three categories as depicted in Table 5 as causes for the incoming goods process not function optimally.

Allocation of incoming goods	Transport	Stock
• Unclear to which technical drawings incoming goods belong to	• Unknown estimated time of arrival of shipment	• Leftover materials in different shapes and sizes from projects on stock • Difficult to structure inventory • No overview of the safety stock in the production hall

Table 5: Summary of causes for incoming goods

Visualising these causes using an Ishikawa diagram, results in Figure 19:

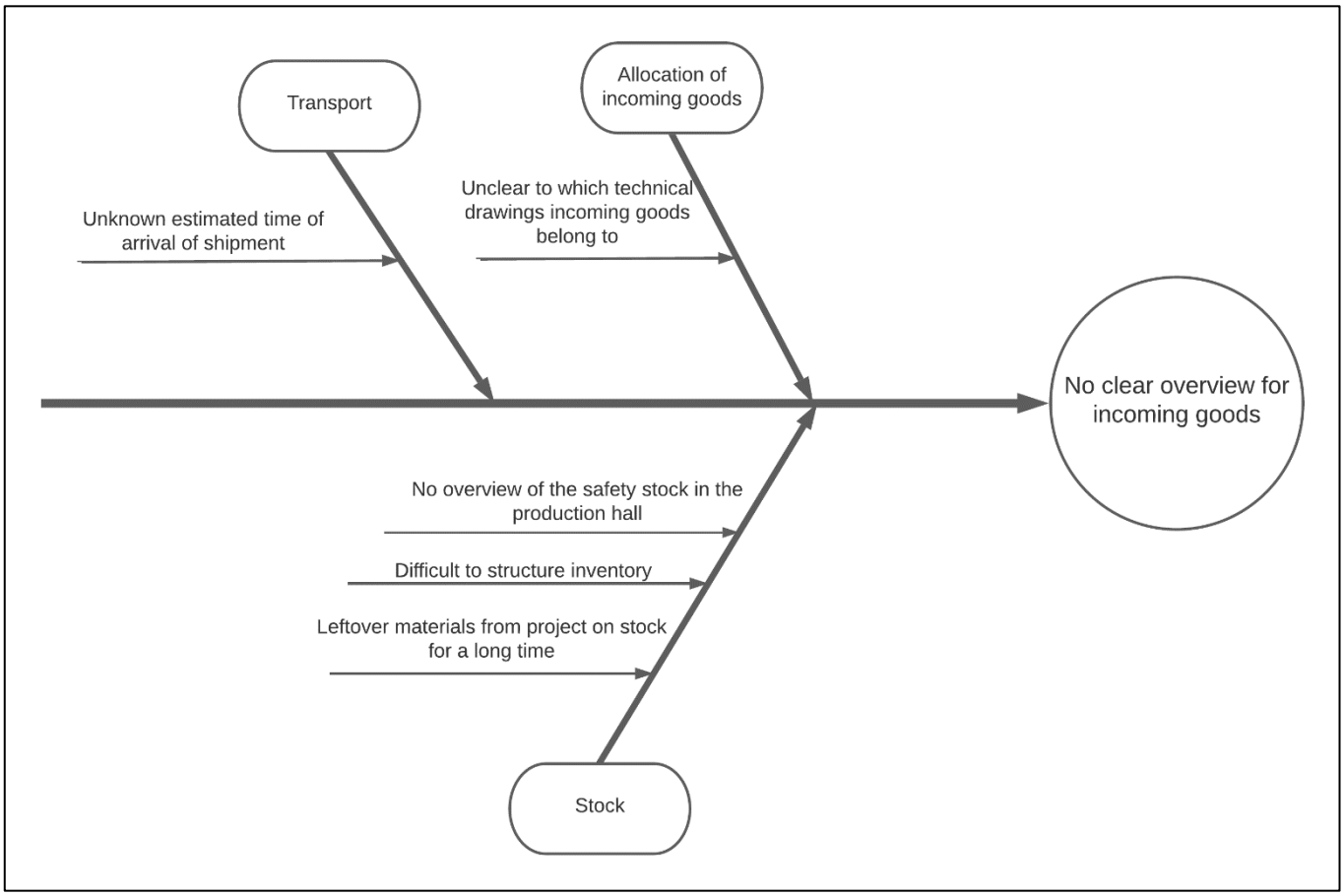

Figure 19: Ishikawa Diagram for the incoming goods process

3.4 Outgoing goods

3.3.1 Transport

Transport list missing very often

The Executioner at the construction site cannot find the transport list 90% of the time. Because of this, it cannot be registered what materials are already available at the construction site. Consequently, the Executioner at the construction site has no idea what materials exactly arrived at the construction site. Generally, the Executioner at the construction site expects the truck driver to give him the transport list. However, the transport list is not always provided to the truck driver by the transport controller in the hall. Usually, the transport controller puts the transport list on a box of the shipment. It might also happen that the paper falls off the box when unloading the truck. It could quite easily get lost before it gets in the hands of the Executioner at the construction site.

When production gets a transport list, it sometimes happens that materials are requested by the Project Team that have already been shipped previously to the construction site. This is probably due to the fact that registration of materials can almost never happen at the construction site due to the Executioner being unable to find the transport list 90% of the time. Because the registration of the materials cannot happen, the Project Team has no clear overview of what materials are actually available at the construction site. To summarise, the absence of the transport list causes a lot problems, which are summarised in Figure 20

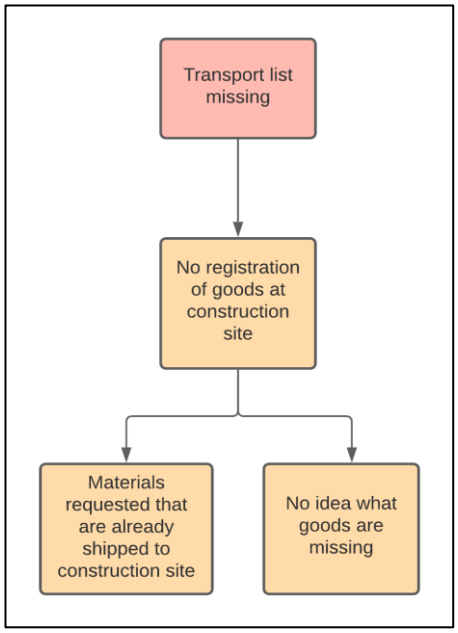

Figure 20: Problem cluster related to ''Transport List missing''

Importance of solving this issue

As can be seen in Figure 20, the fact that the transport list is missing has a big influence on the entire process. Taking all these consequences into account, it is important that the transport list is always available at the construction.

Incomplete shipments, fastenings are missing relatively often

If certain core parts of a shipment are missing, the work at the construction sites cannot continue as planned. In order to meet the deadlines, the planning might be turned around in order to be able to do something else that can be continued without that particular part. However, because of this, the work becomes more difficult than previously intended. Some parts might be very hard to reach if other parts have been welded already. In the worst case scenario, the workers at the construction site cannot continue working, and have to wait until the right materials arrive. This can delay the entire project. In construction projects, delays could potentially cost thousand euros every day the initial deadline is succeeded. Therefore, delays must be avoided at all costs in the construction sector.

The parts that are missing the most, are fastenings. Fastenings are the pieces that connects and secures different parts together, and can generally also be removed again, unlike welding which creates permanent joints. In a big project from last year, out of all the complaints about missing materials from shipments, it was 40% of the time about the fastenings. As fastenings are used to connect different parts of the construction together, they are key components when working at the construction site. One of the reasons why they might be missing relatively often, is that fastenings are not mentioned as a separate entity in the transport list. This means that fastenings are not checked off a list, but instead they are part of a technical drawing. The transport controller does print the technical drawings of the materials that need to be packed, not only to check the measurements and pick the right materials, but also to see whether there are fastenings.

Importance of solving this issue

Fastening are very important materials as they can cause work at the construction site to be delayed exponentially because different parts of the construction cannot be put together. In terms of value, these materials are very cheap, but still very important despite being small.

In inventory management, classification systems such as ABC analysis can be used in order to categorize materials by their value. In ABC analysis, an item is classified as an A item has a high unit cost and makes up about 80% of the worth of the total stock, despite 20% of the materials only being A items (Flores & Clay Whybark, 1986). When talking only about the material in terms of worth in money, fastenings belong in the C category. However, this does not mean that the materials in the C group are not important as well. In manufacturing companies, items that are indispensable to the production process can be found in the C category as well (Kubasakova, Poliokova & Kubanova, 2015). In the case of ADS Groep, fastening do belong to this group. However, not enough attention is paid to them right now.

Transport list is not always a real list that can be checked off

Ideally, a print-out list that can be ticked off with all the parts is created. However, sometimes a list cannot be generated due to difficulties when working with two different Engineering software programs. In that case, the technical drawings that should be included in the shipment gets sent instead. In this case, the fastenings should be included as well. Still, this is not ideal as is not really a list that can be easily ticked off as it is an email without a clear list.

Importance of solving this issue

Not having a list that can be easily ticked off and checked increases the probability of shipments being incomplete, as there is no overview of all the materials in one place. Furthermore, it makes it more difficult in the production hall to properly check whether a shipment is complete. Because of this, collecting the materials happens differently depending on if a transport list can be made, and thus the process is not standardized.

Extra materials shipped that were not requested

Sometimes, materials lie waiting in the hall for a long time, due to it being early in the planning in terms of manufacturing. However, there is little space to store it in the hall. So, sometimes it gets shipped to the construction site when it's ready, even though it is not put as a separate entity on the transport list. This means the shipment is not the same as the transport list specifies.

Importance of solving this issue

If more or less material has been delivered than the transport list specifies, there is no more overview of what materials have actually been shipped. If materials get shipped early despite not being requested, the materials might lie waiting at the construction site for a long time. This is not beneficial for the quality of the material, as it then lies outside and is exposed to rain and dirt.

3.3.2 Material

Materials not finished in production hall before transport deadline

Currently, it happens a few times with every project that the material that is requested for transport to the construction site is not readily produced yet. This happens usually due to a combination of factors. For example, the transport list gets sent only two or even one day beforehand. This means that certain processes cannot take place anymore, with the chemical staining of steel being the prime example as that has a throughput time of at least 24 hours.

Importance of solving the issue

If the material is not finished in the production hall before the transport deadline, the material cannot be included in the shipment. Thus, it contributes to incomplete shipments. In turn, incomplete shipments can cause the work at the construction site to be unable to be continued. Therefore, the probability of the materials not being finished before the production deadline should be minimised as much as possible.

3.3.3 Man

Transport Controller not present day most shipments happen

The current Transport Controller is not present on Fridays, as Friday is his day off. Meanwhile, Friday is the day that most shipments happen. Generally, the Transport Controller tries to get all the materials for one shipment ready before Friday. However, if the transport list arrives only one day beforehand, the Transport Controller does not have enough time to put the shipment together. This means it must be done by someone else in the hall, even though it is not their main responsibility. This may also contribute to incomplete shipments, as the Transport Controller cannot check the loads that were compiled on Friday.

Importance of solving this issue

As mentioned earlier, the current process is very dependent on one person who is not there during the busiest day of the week. This contributes to incomplete shipments, as the final check may not be done by the transport controller.

3.5 Ishikawa diagram for Outgoing Goods

Summarising the problems mentioned for outgoing goods, we get the following three categories as depicted in Table 6 as causes for the outgoing goods process not functioning optimally:

Transport	Material	Man
• Transport list missing very often • Incomplete shipments, fastenings are missing relatively often • Transport list is not always a real list that can be checked off • Extra materials shipped that were not requested	• Materials not finished in production hall before transport deadline	• Transport controller not present on the day that most shipments happen

Table 6: Summary of causes for outgoing goods

Visualising these causes using an Ishikawa diagram, results in Figure 21:

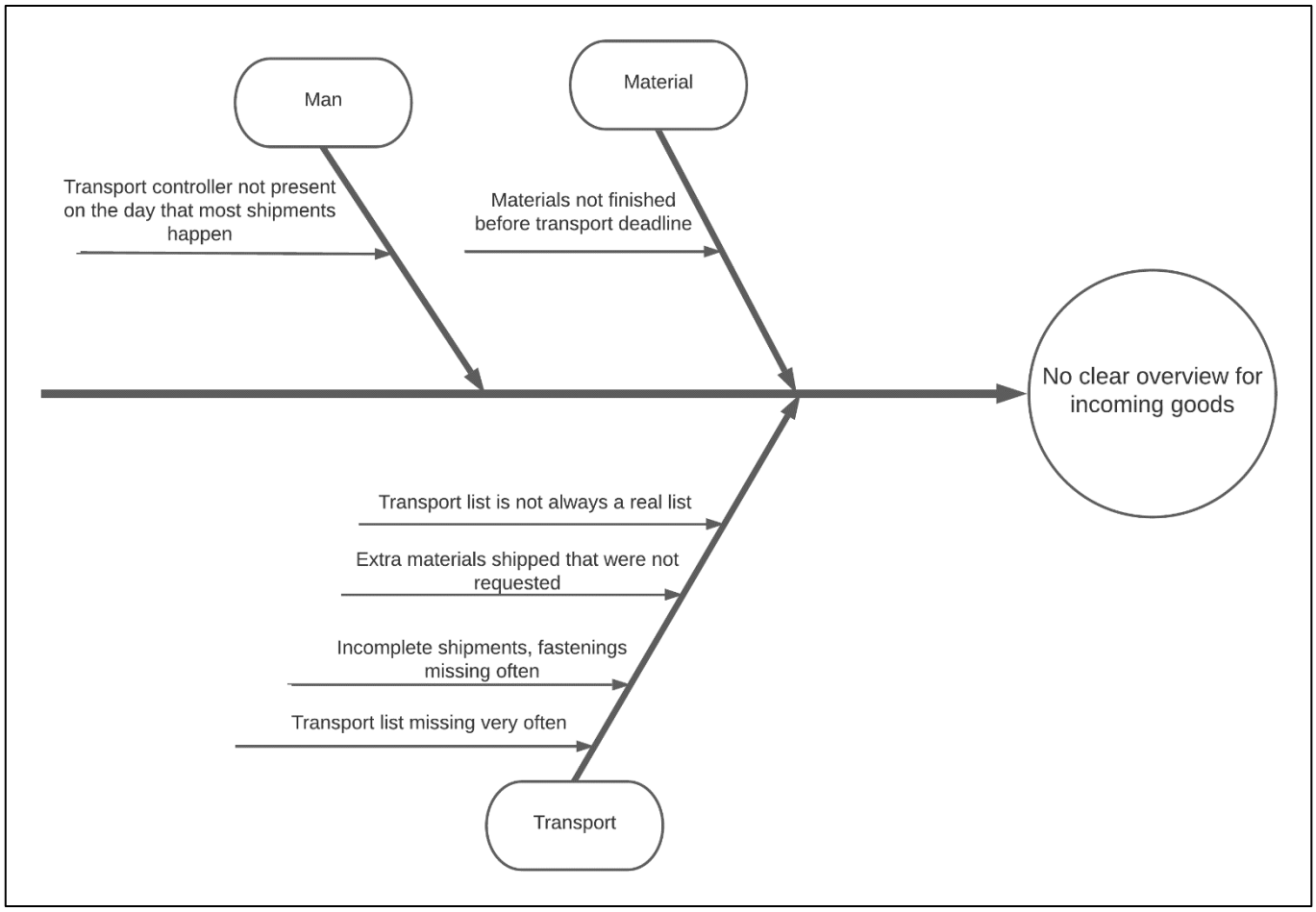

Figure 21: Ishikawa Diagram for the outgoing goods process

4. Solution approaches

In this chapter of the thesis, different solutions will be provided for the problems mentioned in the earlier chapter. This will be done for the incoming goods and outgoing goods process separately.

4.1 Solutions for Incoming Goods

4.1.1 Allocation of incoming goods does not happen in regard to technical drawings

As mentioned previously in this thesis, the people who responsible for receiving goods do not know what exactly the material is for when it arrives. This has several consequences. Most importantly, the requirement for the NEN 1090-1 is not met anymore. Furthermore, it cannot be said with certainty that the incoming materials are being used for the right technical drawing.

Solutions

Orders happen on a project basis, which means that everything in one order belongs to the same project. The materials are ordered based on the technical drawings. On the purchasing form, however, it is not shown what material belongs to what technical drawing. According to the Work Preparator, this is due to there not being enough space on the form itself. For example, if you buy six fastenings but they are for three different technical drawings and write that down as well, a lot more space is needed.

Amount	Description	Technical drawing code
2	Pipe ⌀610 x 6,3 mm	61894-307
1	Pipe ⌀610 x 6,3 mm	61894-234
3	Pipe ⌀610 x 6,3 mm	61894-268

Table 7: Example of list with the same materials, but different quantities belonging to different drawings

Amount	Description	Project number
6	Pipe ⌀610 x 6,3 mm	61894

Table 8: Example of what material list currently looks like after compiling technical drawings

The technical drawing code consists out of two parts. The first numerical part is the project code, which consists out of five numbers. The second part is the number of the technical drawing within a project. There can be over 300 technical drawings within one project at ADS Groep.

Stating on form for which set of technical drawings the purchase form is

As mentioned before, the technical drawings are used to compile the material list. If it takes too much space on the purchase form to write down what belongs to what technical drawing which would look like Table 7, a simple yet effective solution is to include on the form to what set of technical drawings the order belongs. This would mean the purchase order would have to be structured like Table 8, but on the form it states then that it is for technical drawing 307, 234 and 268 of project 61894. Based on that, the person handling incoming goods at the production hall can determine what material will be used for what technical drawing and write it on the material itself. For fastenings, it can be written on the box itself, while for pipes, labels are usually used.

Not everything belonging to one technical drawing might be delivered at the same time. In this case, the person handling incoming goods also has to keep track of what materials of a technical drawing have already arrived and selected for that drawing. It is favourable compared to the current situation where the goods are selected by someone in the hall and turned into packages of all the material belonging to one technical drawing, without knowing for sure the right materials are picked. This way, it is replicable to what set of technical drawings the material belongs to, and the chance of the wrong material being assigned becomes significantly smaller. This new way of working can be seen in Figure 22.

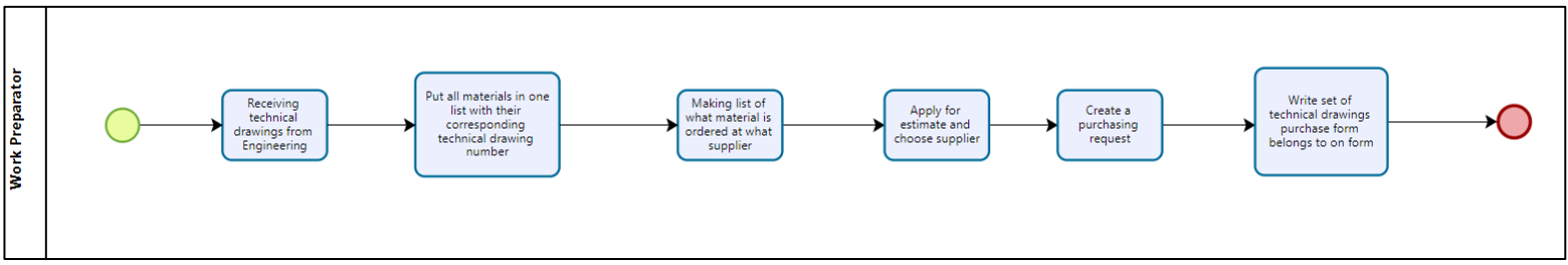

Figure 22: New way of working for Work Preparator

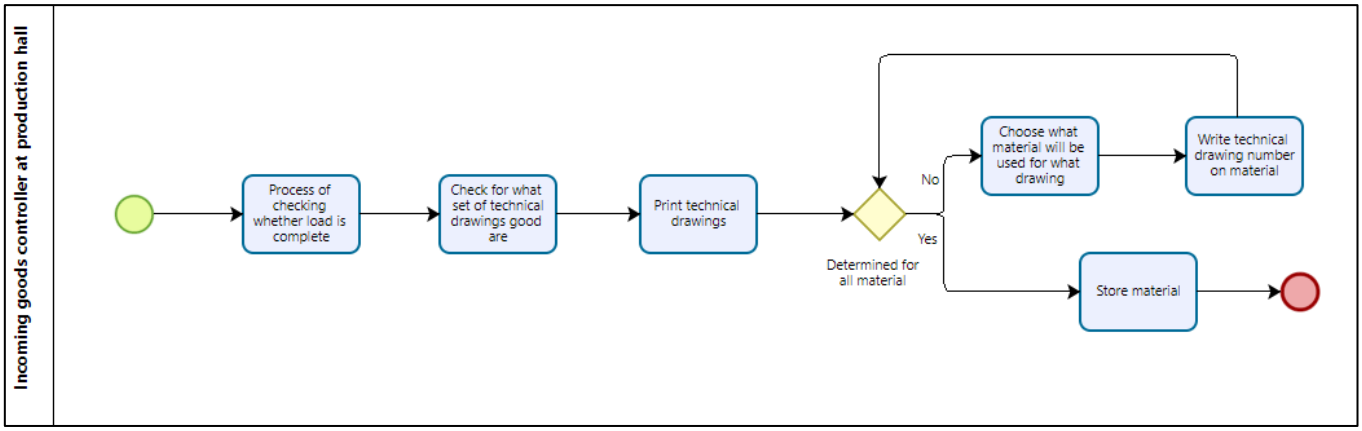

Figure 23: New way of working for incoming goods controller

Generating purchase order from subfiles of each technical drawing

For the supplier, it is not relevant what material is for what technical drawing. The supplier simply wants an overview of all the materials they have to deliver, so it would have to look like in Table 7. However, for internal use, it is very helpful to also have a form which specifies what materials in what quantity are for what specific technical drawing. This could be done by creating sub files to the purchasing order, with every sub file containing the order for one specific technical drawing only. Using the same example again:

Sub file 61894-307

Amount	Description	Technical drawing code
2	Pipe ⌀610 x 6,3 mm	61894-307
1	Lasflens ⌀508 x 26 mm	61894-307

Sub file 61894-234

Amount	Description	Technical drawing code
1	Pipe ⌀610 x 6,3 mm	61894-234
3	Lasflens ⌀610 x 28 mm	61894-234

Sub file 61894-268

Amount	Description	Technical drawing code
3	Pipe ⌀610 x 6,3 mm	61894-268

These three added together would give the following:

Amount	Description	Project code
6	Pipe ⌀610 x 6,3 mm	61894
1	Lasflens ⌀508 x 26 mm	61894
3	Lasflens ⌀610 x 28 mm	61894

Table 9: Compiling the list using this solution approach

Ideally, every sub file is created first, which are then all combined to generate a list like Table 7 for both the supplier and ADS Groep itself to have a general overview. In that case, when looking for the purchase form, the person handling incoming goods can also see the sub files and see how much material is meant for a specific drawing. This can then be written on the label or box of the material, so that the right materials will be used for sure. Having unique labelling helps not only in increasing the traceability of the material, but helps also in coordinating the supply chain to reach further supply chain integration (Pålsson & Johansson, 2009).

An advantage of this method is that there will be a clear list for the supplier generated by the sub files, and the sub files can be used to properly assign materials to technical drawings when they reach the production hall. For that, a new tool or system might be needed in order to compile the sub files. However, a tool like this could also be made relatively easy in Excel using Visual Basic for Application (VBA). In this case, you would have different sheets, with every sub file being one sheet, which are then combined by a macro into a list similar to the one in Table 7. In the case of sub files, it can be simplified further by only using the second half of the numerical code as the first half indicates the project, and the project number is already given in the main file. Compiling the list automatically through for example a macro in Excel eliminates unnecessary manual steps, and thus helps in designing a standard procedure for this process which decreases the opportunities for making mistakes (Anupindi et al., 2006).

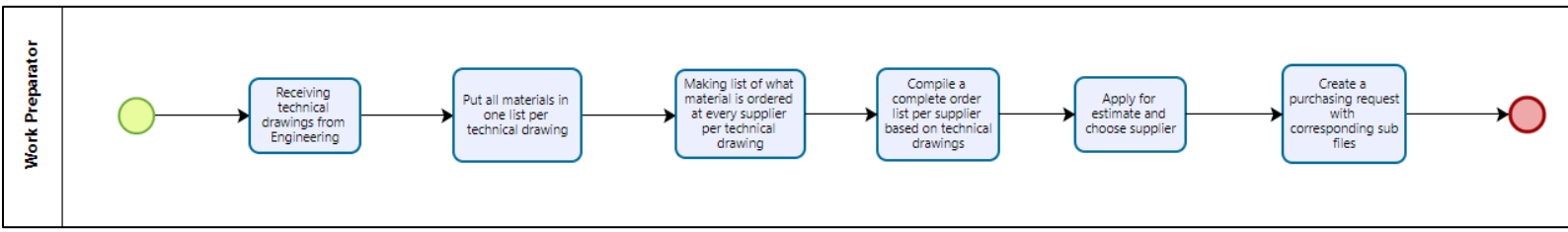

Figure 24: New way of working for Work Preparator

Solving ''No registration of placement of material'' along the way

If the technical drawing number is put on the material, the lack of registration of placement of the material becomes less of a problem as it can be easily seen what material belongs to what technical drawing. This means this process is not dependent on one person anymore, namely the person that stored the materials as they are the only one that knows where what was put. This further standardizes the process, as the way of working is now always the same regardless of who collects the materials to start working with them in the production hall.

Trade-off in this solution

As mentioned before, combining different suborders can be achieved relatively easily in Excel using VBA. Right now, Excel is used within ADS Groep very often for material lists. For example, the transport lists used for outgoing goods are also saved as an Excel file. This means the way of working does not have to change drastically in order to be able to implement this solution. This solution, however, does mean that the Work Preparator has to spend more time in making these lists as the list becomes more complex with an extra label used for the technical drawing numbers. However, it does save work later in the process for the people who are responsible for receiving the incoming goods. Furthermore, the requirements for NEN 1090-1 will be met fully when implementing this solution, thus increasing the amount of potential clients for ADS Groep.

4.1.2 Unknown estimated time arrival for shipments

Right now, the people responsible for receiving the goods in the production hall have no idea when shipments arrive. As there is only very limited storage space inside the production hall, the inventory is usually rearranged and moved around in order to create space to store the new materials. This is especially a problem for big shipments which make up around 10% of all shipments, as there is no space prepared to store it.

Solution: Creating an overview of shipments on a weekly basis

The visualisation of project information is important throughout the process, as it cannot only be used as communication tool, but also be an important bridge between different teams involved in a construction project (Ganah, Anumba & Bouchlaghem, 2001). Furthermore, visual displays of information can also help employees in adapting to changes in the process, and create a sense of involvement and ownership within a project (Stentoft Arlbjørn, 2011). In the case of ADS Groep, the Work Preparator does have the information of when materials will be delivered, while the people in the production hall do not. This information is currently not passed on in the company.

That is why there needs to be an overview of what shipments are coming every week. This overview should be easy to maintain and be updated by the Work Preparator. For example, it could be an Excel file that is updated daily by the Work Preparator, which the people in the hall can access easily through a tablet or computer to directly have an overview of what is happening. To make it more visual, it might be wise to use a whiteboard for this in the production hall as well, so no digital tools are needed to check it. However, it could also be an overview on a big screen in the production hall, which displays the Excel file in a PowerPoint. This big screen in the hall could be used further to serve as a form of dashboard, portraying information of what is happening, which facilitates not only in the flow of information throughout the organization, but also encourages employees to be actively involved in the process (Koçoğlu, İmamoğlu, İnce & Keskin, 2011). The overview of incoming shipments should be weekly and specify what is coming on what day. Updating this overview table daily should not take more than a few minutes. Someone in the hall should be responsible for

checking the Excel file daily and checking whether the information on the whiteboard or PowerPoint presentation is up to date.

The load size should also be indicated, so the people responsible for incoming goods know how much storage space is roughly needed. In order to determine what exactly a small, medium or large load is, the Work Preparator and people responsible for incoming goods in the production hall should determine a definition in consultation with each other. As orders are on a project basis, what project it is for could be included as well. This could either be done through using the project code, or the colour code for a project. This overview of shipments can also be extended to the transport for outgoing goods, so it is clear when the trucks are coming for outgoing goods as well as the current Transport Controller usually does not know when trucks are coming. An example of how this overview will look like can be found in Table 10.

Week 15	Logistics provides	Load size	Project number
Monday	• Truck DHL	• Medium	• 61894
Tuesday	-	-	-
Wednesday	-	-	-
Thursday	• Truck Post NL • Truck DHL	• Small • Large	• 61902 • 61894
Friday	-	-	-

Table 10: Example of an overview of incoming trucks on a given week

Trade-off in this solution

In order to make this solution work, the Work Preparator needs to register a new delivery whenever a purchase order has been made. Furthermore, regular checking is required to check if the overview is up to date. This does result in more work for the Work Preparator. However, having such an overview available in the production hall, will not only be beneficial for the people responsible for incoming goods, but also increase the engagement of employees in the hall as they then are more aware of what is going in that part of the process. Thus, while this solution requires more careful registration, it does improve not only clarity for the people responsible for receiving incoming goods in the production hall but also keeps employees engaged with what is happening in the production hall.

4.1.3 No overview of standard materials on stock

Having safety stock increases the responsiveness of a system and is helpful when dealing with unreliability in demand and supply (Van Kampen, Van Donk & Van der Zee, 2010). In the case of ADS Groep, since everything is ordered on a project basis, the safety stock consists out of materials that have standard sizes that can be easily used in case some of the ordered material is missing or has a late subsequent delivery. Right now, the people working in the hall have no overview of what standard materials are actually on stock. This can cause certain standard materials to be too low on stock when needed for quick production. In order to be prevent stock-outs, an overview of what the safety stock consists of is needed, along with reorder points for each specific material.

Solutions:

By sharing inventory information with several partners in the supply chain, going out of stock can be avoided and allows for more accurate forecasts to be made (Lotfi, Mukhtar, Sahran & Zadeh, 2013). In order to be able to share inventory information within ADS Groep, there needs to be a list

concerning all the standard materials on stock that make up the safety stock that can be accessed by both the Work Preparator and the people working in the production hall. It is also useful to have a list of the project specific materials that are leftover, that can be checked before ordering by the Work Preparator so there will be no duplicate materials. This could be a simple Excel file that is accessible by both the Work Preparator and the people in the production hall. If someone in the production hall takes some material from the safety stock, this should be administered immediately in the list in Excel using a tablet or computer. This also saves a lot of walking around for the people in the hall as they do not need to walk to the office to tell the Work Preparator, because the Work Preparator can easily see in the Excel file what the current stock levels are and what needs to be ordered. For every piece of safety stock material, it should be determined what the stock levels should ideally be, and at what quantity it should be reordered, taking the lead time into account so a stockout does not happen. For example, for most standard sized plates of stainless steel, having two of standard size with different widths would be enough for the production hall.

It might be the case that it is too big of an immediate digitalisation step for people working in the production hall. Another option is that there whiteboard used only for writing down what materials have been taken from the safety stock. While this could also be done on a piece of paper, it could get fairly easily get lost in the hall, and then it becomes rather hard to keep track of the stock. One small whiteboard should be sufficient in the case ADS Groep, as not much gets taken from the safety stock as usually all the materials are ordered for one project specifically. Every few days, the Work Preparator should take this whiteboard, register what has been taken, clean the whiteboard and put it in the designated place.

The Work Preparator should check daily what the stock levels of the safety stock is, and when ordering new materials for projects specifically, it should be checked whether that material is already in stock or not. In order to be able to determine whether something needs to be ordered or not, it should be determined by the Work Preparator how much of what component is needed. Using this as a basis, colour coding can be used in the Excel to give a good overview.

Before this solution can be used, an inventory model should be set up and all the current stock should be counted and registered. Once every few months, for example when it is relatively quiet in the production hall, the stock should be counted again whether the list is still up to date. However, having a clear overview of the safety stock will help in ensuring the production hall can handle unexpected situations better in peak production times. It is also helps in structuring the inventory, by knowing exactly how much inventory there is. Proper management of safety stock is crucial in being able to work in a lean and flexible way, while maintaining an inventory that is easy to maintain (Amirjabbari, Bahareh, Bhuiyan & Nadia, 2014). Having a clear overview of the safety stock is necessary in order to be able to manage the safety stock. Thus, having a clear overview of the safety stock is crucial for the survival of ADS Groep, as they market themselves as an organisation that can produce fast and quickly, which is how they acquire many of their assignments.

Material	Amount in inventory	Status	Orders on the way?	Last checked
Plate steel 2000 x 1000 x 20 mm	2		No	02-05-2021
Plate steel 6000 x 1000 x 25 mm	4		No	02-05-2021

Plate steel 6000 x 1000 x 15 mm	0		Yes – 04/05/2021	02-05-2021

Table 9: Example of what an overview of safety stock materials would look like

Trade-off in this solution

Before this solution can be implemented, there is a relatively big one-time investment by creating an overview of materials and determining for each material what the re-order point should be. After this, the overview needs be updated regularly. However, if there are tablets in the hall, the updates for the overview happen automatically as the employees in the production hall can register themselves when they take material from the safety stock. Thus, it is mostly up to the Work Preparator to look at the overview created to determine if some of the material should be ordered again.

Being able to guarantee the presence of the safety stock using this solution, quick production will almost always be possible in the production hall, especially when the shipments for a project might be partially incomplete. This is especially important for projects that have a short life cycle, where the project deadline could be exceeded due to incomplete shipments from suppliers. Exceeding deadlines for construction projects can be very expensive. For some projects, this may result in a fine of €1000 per day the original deadline was succeeded. Maintaining safety stock will generally be a lot cheaper than having to deal with fines like this, especially considering most materials only need to have a quantity of two.

4.2 Solutions for Outgoing Goods

4.2.1 Transport list is missing very often

According to the Executioner at the Construction site, the transport list is missing around 90% of the time. This is one of the core problems. Because there is no transport list, registration of goods at the construction site cannot take place. Because of this, the Executioner at the Construction site does not know what goods are missing from the shipment, and materials might be requested by the project team while they have already been shipped.

Right now, the list is put on the box of the shipment and easily gets lost. It should be made impossible for the list to get lost, as it is a key component in transportation. Furthermore, the problem of the missing transport list has many consequences in the entire process, which can be seen in Figure 25

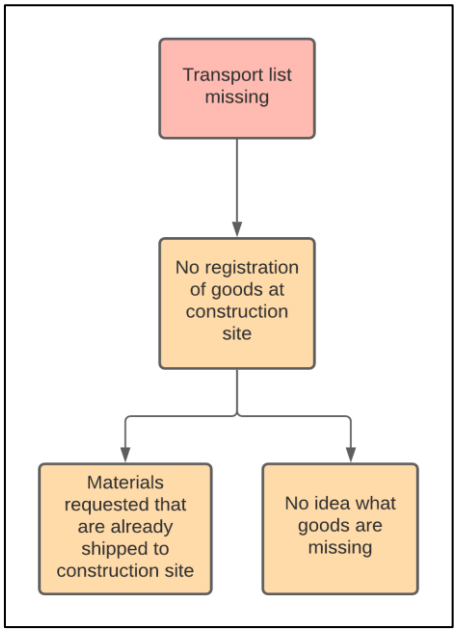

Figure 25: Problem cluster related to "Transport List missing"

Solutions

Simply put, it should be impossible for the transport list to get lost and it should always be digitally accessible at the construction site as well, even if the piece of paper did get lost somewhere. After the final list is made by a Work Preparator of Toelevering Water, the list should be uploaded to a digital system, for example the hard drive used for a specific project under transportation. It might be useful to sort the transport lists belonging to one project on a weekly basis, so it is easy for the Executioner at the Construction site to find it online. If the transport list is physically missing from the

shipment, it could easily be found online and printed so the registration of goods can still take place. The changes in the way of working for the Work Preparator and Transport Controller can be found in Figure 27.

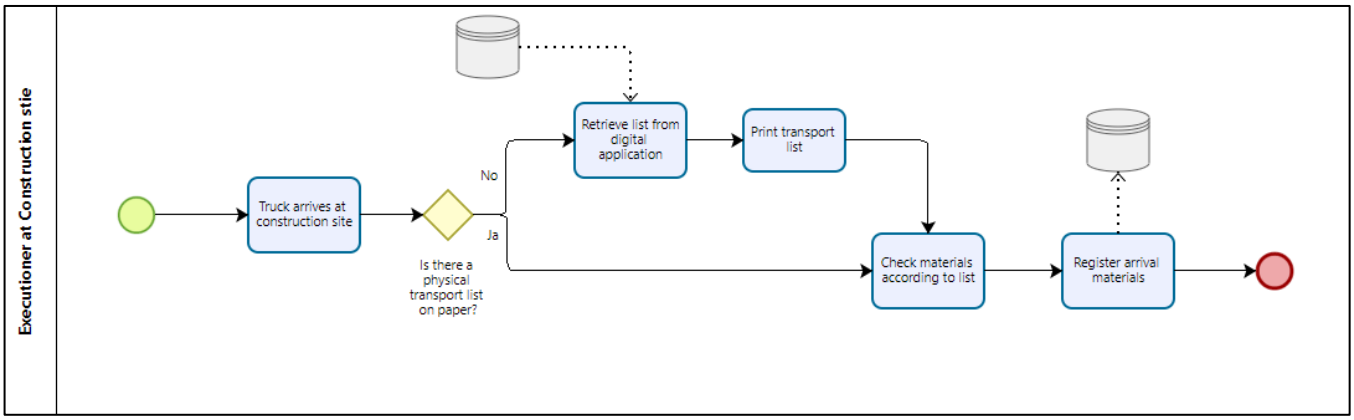

Figure 26: Retrieving the Transport list by the Executioner at the construction site

Furthermore, receiving a copy physically is still beneficial for the Executioner at the construction site so no extensive digital searching is required. Instead of just putting the list on a box, the list should be given to the truck driver as it is common in most industries that during transportation, the truck driver has the transport list in his possession and hands it over when delivering the goods.

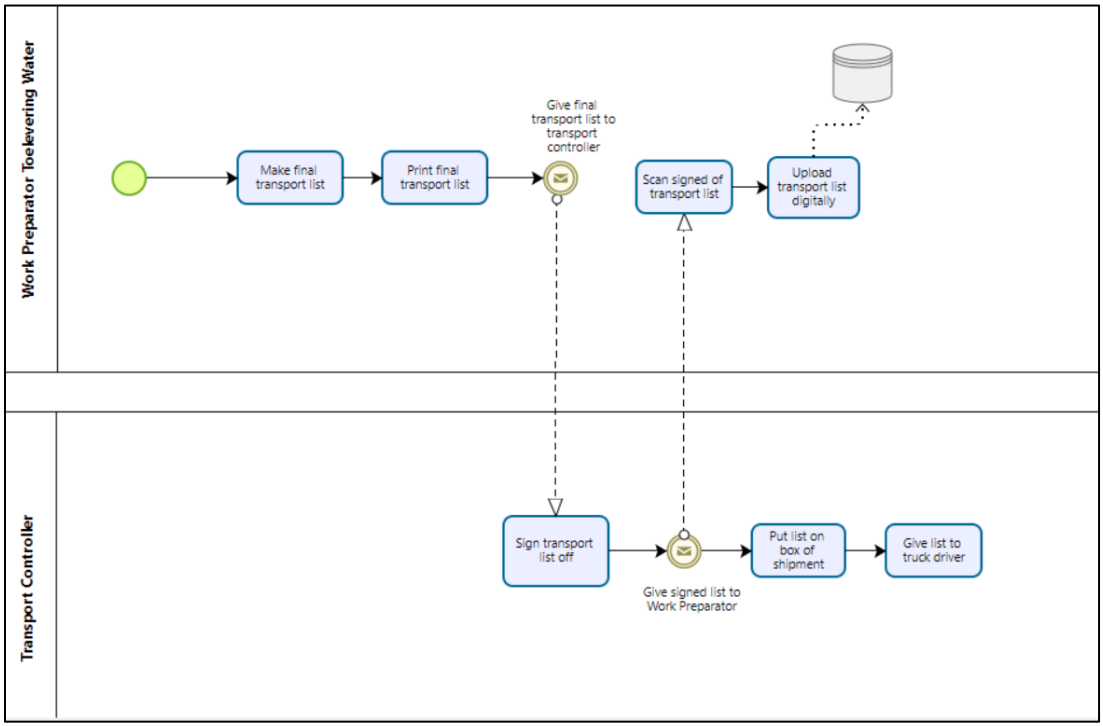

Figure 27: Changes for the Work Preparator and Transport Controller

Trade-off for this solution

As the transport lists are already made on a computer, it is only a small effort to upload them digitally to a cloud service as well. When the work cannot be continued at the construction site because of problems caused by the absence of the transport list, this costs a lot of money as three to

five employees cannot do their work. Moreover, this also has a negative effect on the morale at the construction site. Therefore, applying this relatively small change saves both money and frustration.

4.2.2 Transport list is not always a real list that can be checked off

Not having a list that can be easily ticked off and checked increases the probability of shipments being incomplete, as there is no overview of all the materials in one place. Furthermore, it makes it more difficult in the production hall to properly check whether a shipment is complete if there is no list that can be easily checked off.

Solution:

Process standardization turns out to be profitable in many cases, as the uniformity of processes makes it clear what the output of a process will be and the uniformity of the processes forms a good basis for communication and coordination between business partners (Ramakumar & Cooper, 2004). This can also be applied to the situation at ADS Groep. It is important that the transport list is structured the same way every time, so that the process can happen the same way every time according to the standard process determined and can easily be taken over by someone else in the production hall if needed because the way of working is clear.

The transport list is not always a real list as it cannot always be generated by the Engineering file. This can be because different parts of the Engineering model were made in different computer-aided design (CAD) software programs and are not compatible. In order to solve this problem, agreements must be made with the Engineering department when setting up a project about how they will deliver the engineering files, and how they can be used to generate a transport list from the model. In many cases, it is possible to make the model in such a way that it is possible to generate a transport list out of it. However, in some cases it might be easier for the Engineers themselves to create the models in more than one program, which could potentially cause problems later on when the Work Preparator wants to generate a transport list. Therefore, clear agreements must be made about how the model is made before it is actually made, and whether it can be used to generate a transport list should be discussed as well. It is very helpful to put these agreements on paper in an official documents, so that there is something to rely on when problems arise later on.

Trade-off for this solution

When applying this solution, another element to be discussed at the start of a project is added. Furthermore, right now there is no data on how often the transport list cannot be generated due to compatibility issues in the software programs used by Engineering. Thus, it is hard to say how often this problem occurs right now. However, with the consequences of having a hard to use transport list being severe, the possibility of a shipment being incomplete should be minimised as much as possible. Therefore, while the effectivity of this solution is relatively unknown, it is still worth investing in taking the negative effects a hard to use transport list has into account.

4.2.3 Fastenings are missing relatively often

Despite their small monetary value, fastenings are very important materials and their presence is necessary for many steps at the construction site. Without them, different parts of the construction cannot be connected. Right now, not enough attention is paid to them on the transport list, as they are not put as a separate entity to be ticked off on the transport list.

Solution:

Fastenings should be more prominent on the transport list. Right now, they are not listed as a separate entity of the transport list, but are included as a part of the technical drawing. This means the transport controller has to check all the technical drawings again to see if they contain fastenings. Including them as a separate part to the transport list makes it easier to spot if the fastenings are forgotten in the shipment, because then they also need to be ticked off separately. This way, fastenings are treated with the attention they deserve, as the work at the construction site can often not go on if they are not present.

Trade-off in this solution

Implementing this solution means there are new elements that need to be added to the transport list, and thus creating a bit of extra work for the Work Preparator. However, that means the transport controller only has to look at one document, namely the transport list, to have a complete overview of everything that needs to be shipped. This eliminates the step of having to print all the technical drawings, which means the process is simplified further and the possibilities of making mistakes will be reduced.

4.2.4 Materials not finished in production hall before transport deadline

If the material is not finished in the production hall before the transport deadline, the material cannot be included in the shipment. Thus, it contributes to incomplete shipments. In turn, incomplete shipments can cause the work at the construction site to be unable to be continued. Therefore, the probability of the materials not being finished before the production deadline should be minimised as much as possible.

Solution

When materials are unfinished before the transport deadline, it is usually due to two main causes. Firstly, if the list gets sent only one or two days beforehand, there is not enough time in the production hall to finish everything up. Secondly, some employees in the production hall put the materials on ''100% manufacture ready'' while the chemical pickling of steel has not happened yet. This chemical staining process takes at least a day, ranging from 24 up to 48 hours. This in combination with a delayed transport list, causes incomplete shipments.

If the transport list is sent earlier, there is still time to adapt the planning in order to meet the deadline. Usually, the chemical pickling of steel is the bottleneck in terms of time when meeting the deadline. A buffer in the form of extra time can protect the production against variations in its environment (Hopp & Spearman, 2008). In the case of a time buffer, the buffer itself would be any time between the arrival and the time where the demand is satisfied (Spearman, 2014). Looking back to the case at ADS Groep, the arrival would be the moment the production hall receives the transport list, and the exit would be the moment the truck departs from the production hall. The buffer should be large enough to accommodate the chemical staining process that can take from 24 up to 48 hours. Therefore, the transport list should be sent at least 3 days beforehand.

Furthermore, the definition of ''100% manufacture ready'' needs to be standardized. Right now, some employees set materials on this status while the chemical staining process has not happened yet, while others do not. Fully manufacture ready should mean that the material is ready for shipment. Therefore, the definition used for 100% manufacture ready should include the chemical staining process.

Trade-off of this solution

In order to implement this solution, the transport list needs to be sent earlier to the production hall so that they have enough time to anticipate and execute the chemical pickling of steel process. However, in some cases it might be difficult to send the transport list at least 3 days beforehand. Still, having the 3 days as a standard will help in many of the cases, along with having a clear definition on what 100% manufacture ready should mean.

4.2.5 Transport Controller not present at day of shipment

The current Transport Controller is not present on Fridays, while Friday is the day that most shipments happen. This is problem, because the shipments of Friday are not handled according to the standard procedure as someone else from the hall needs to step in. Right now, the process is very dependent that on one person and it is not clear who takes over when the Transport Controller is not present.

Solutions

As the current Transport Controller is retiring in a few weeks, it is a good opportunity to select a new Transport Controller that should be available all days of the week. There should also be a person appointed who takes over when the main Transport Controller is not present. It would also be helpful if the extra person checks the pile of materials once it has been assembled, to see if it matches everything on the transport list. This does not cost a lot of time, and some small mistakes are easier to spot by someone not fully engrossed in the task at hand. To summarise, the process of checking the shipments should not be dependent on one person.

Trade-off in this solution

Having more employees involved as a Transport Controller will cost some money. However, incomplete shipments also cost a lot. For example, if an extra truck needs to be arranged to send the missing part of the shipment, this could easily cost more than €600. Furthermore, the extra person only has to check the final pile of materials most of the time, and be ready to take over if the main Transport Controller happens to be absent. Therefore, the costs are relatively low, while allowing the two-eyes principle to be used and reduce the amount of incomplete shipments.

5. Conclusions

5.1 Summary

This thesis started off by introducing the current situation at ADS Groep B.V., and determining the scope of this thesis. With the focus on the process of incoming goods and the process of outgoing goods, the as-is situations for both these processes were determined. After the process was mapped, the main causes for the process not functioning optimally were determined, and then visualised in an Ishikawa diagram. The categories used in the Ishikawa diagram were used to structure and generate solutions, as some of the solutions solve more than one problem that was present in the current situation.

The solutions for ADS Groep were presented to both the Process Coordinator and the CEO of Toelevering Water, as well as the Head of Production and a prominent Work Preparator involved in process optimisation at ADS Groep. Several decisions were made in order to implement some of the solutions that were presented in this thesis.

For the transport list, there are several elements that are going to be changed. First of all, it will become part of the standard procedure that the transport list will also be uploaded and thus can be retrieved online as well. This will improve the availability of the transport list, as it will then still be retrievable even if the physical copy gets lost in the shipment itself. This means that the registration of goods can always happen. Furthermore, fastenings will become a separate entity on the transport list, as they recognized at the company not enough attention is paid to them currently despite their importance. With fastenings missing relatively often in the current situation, this change will also decrease the amount of incomplete shipments in the future.

New investments will be made for tablets and eventually for a screen in the hall to display some kind of dashboard. Firstly, tablets will be used to do registration of incoming goods at the beginning of the production hall. This will not only result in less walking around the hall and thus a faster process, but also decrease the amount of paper used as the purchase forms do not need to be printed anymore. Furthermore, the tablets will also be used to help in monitoring the safety stock, where the people in the production hall can insert in the tablet what material they have taken from the safety stock, which immediately updates the overview for the Work Preparator who is responsible for reordering materials if necessary. The tablets will be put at fixed places in the hall where they are needed to do registration.

In the future, there will be investments for a big screen in the hall that will be used as some sort of dashboard to encourage involvement and engagement of the employees in the production hall. This will most likely be a screen that shows a loop through different PowerPoint slides. One of these slides would be an overview of when incoming goods are coming, and another of the transport date for outgoing goods.

5.2 Future research

For future research, the structure of inventory system used in the production hall could be researched further. This was out of the scope for this research, as it solely focused on the processes itself and not the structure of the inventory. Furthermore, right now there is not any data available on the inventory levels at the production hall. However, with the limited space available inside the hall and the increase in turnover in the coming few years, it might be wise to evaluate how the space is currently used, and make some changed to further optimise the production hall. A good example of this would be the registration of goods by making use of a system such as numbered shelves, so that the material is easy to find. This goes hand in hand with the investments that are currently being

made with tablets, as the ease of registration using tablets would allow for such changes to be possible.

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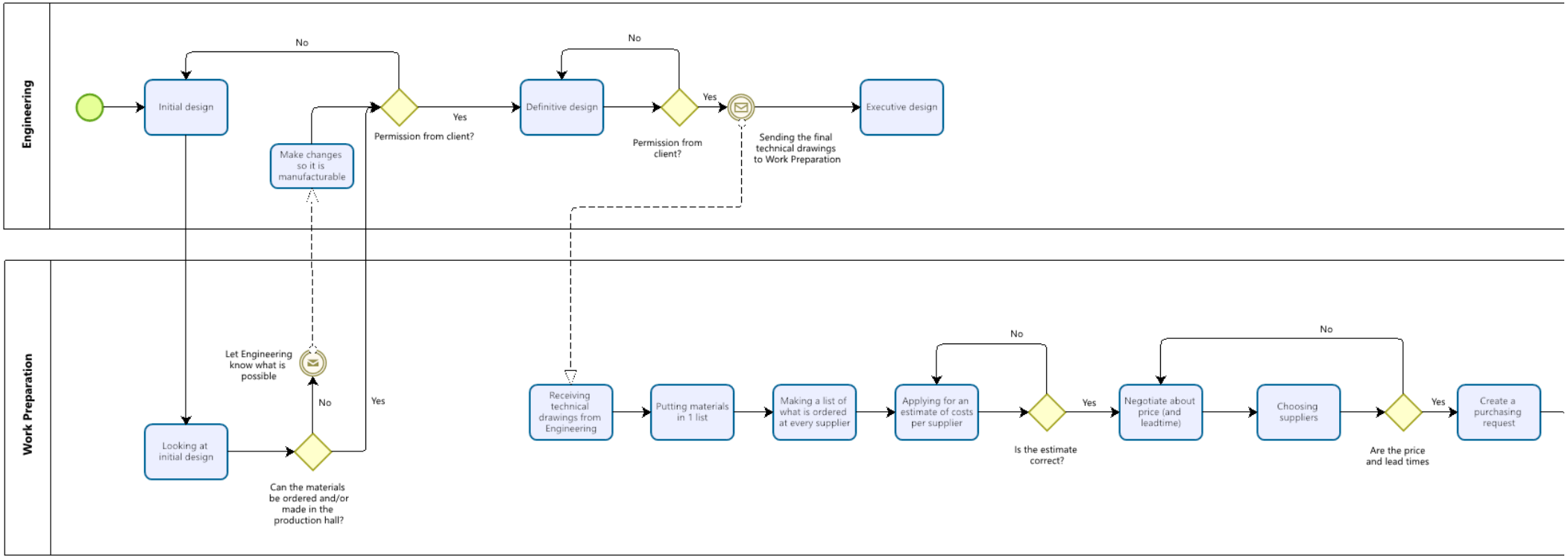
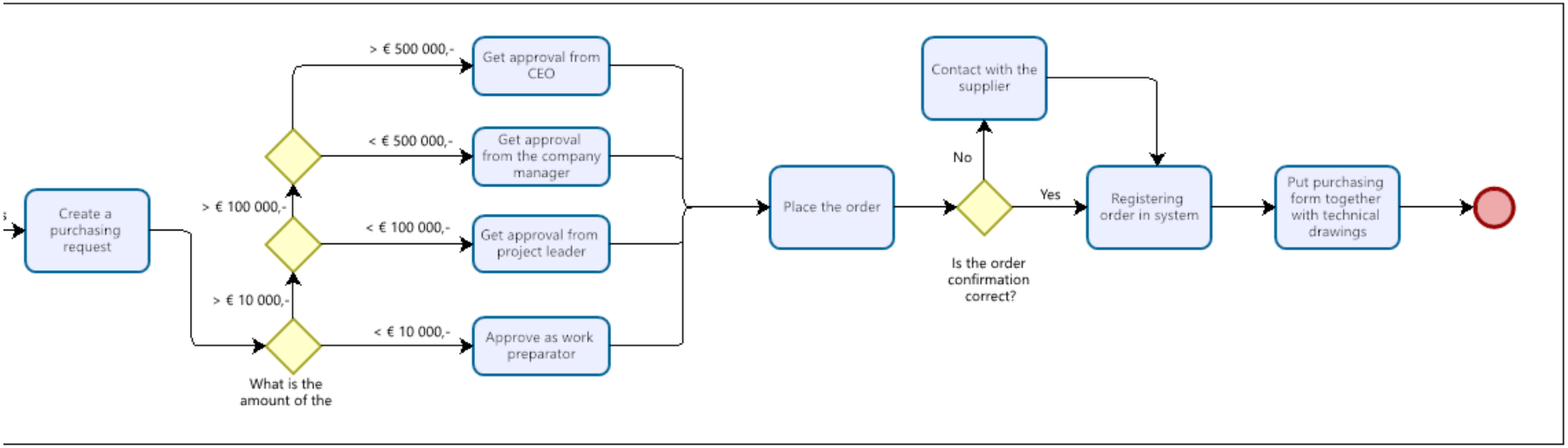
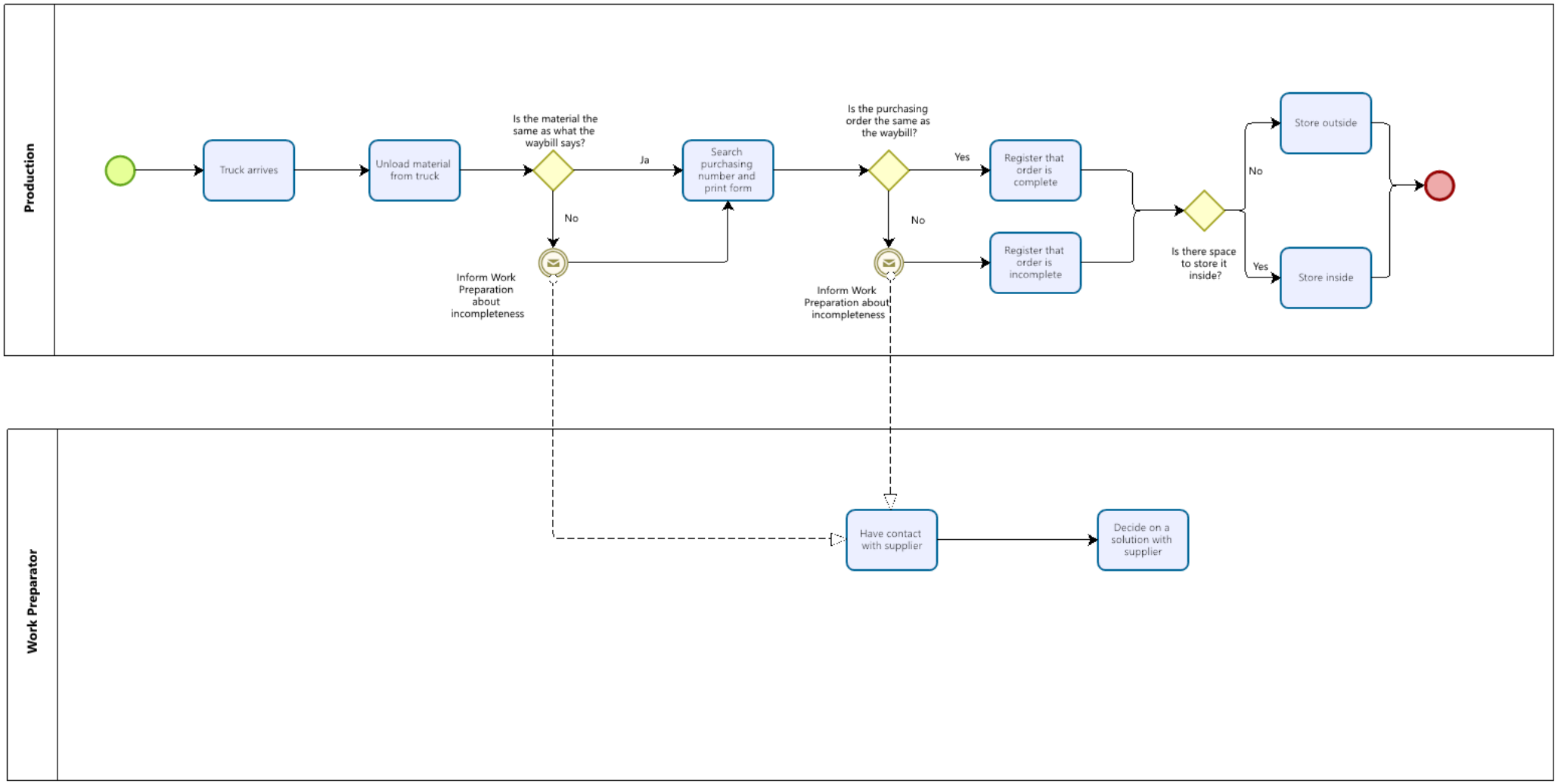
Appendix A Incoming Goods: Ordering process

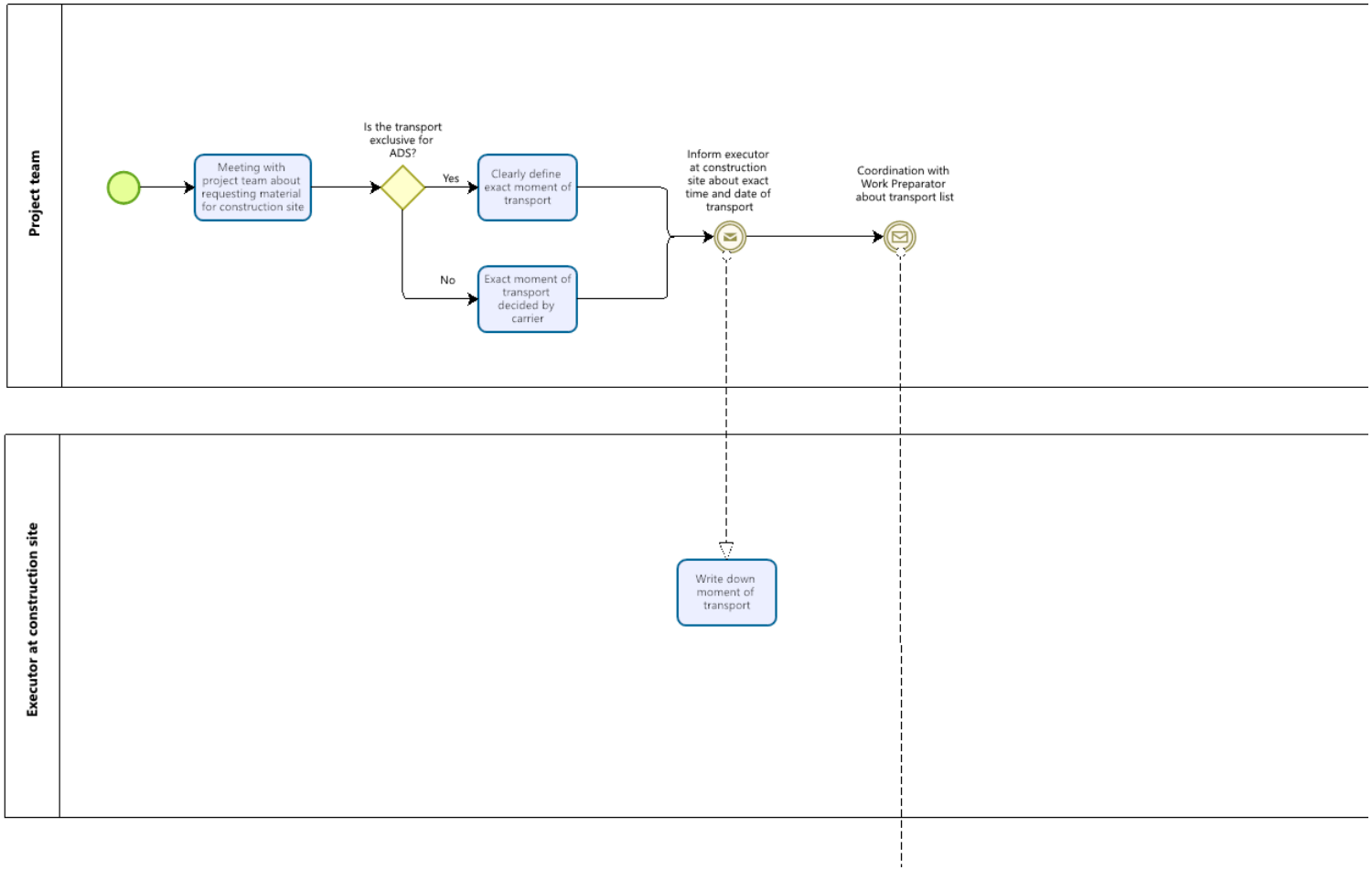


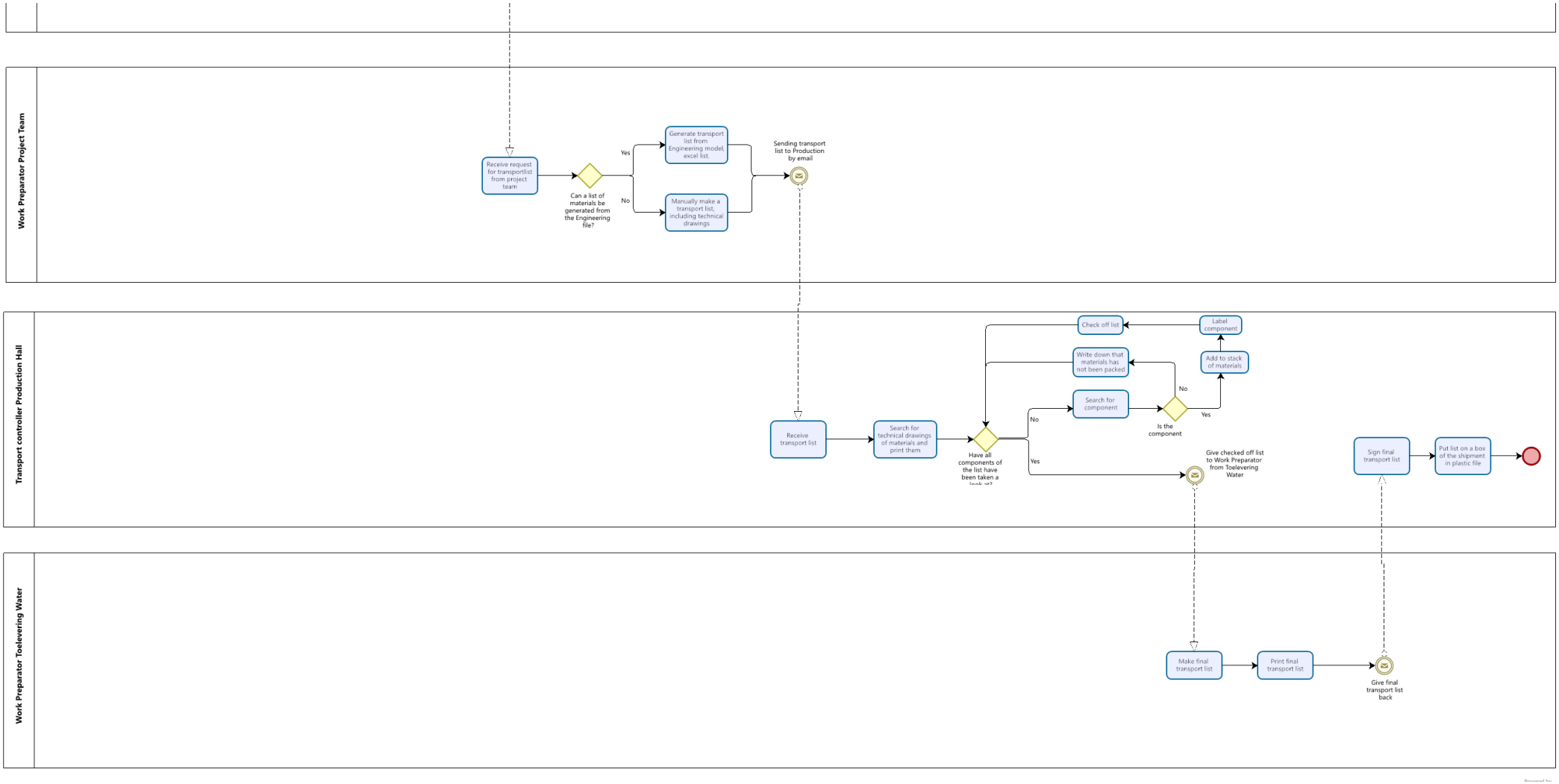

Create a purchasing request
What is the amount of the
> € 500 000,-
< € 500 000,-
> € 100 000,-
< € 100 000,-
> € 10 000,-
< € 10 000,-
Get approval from CEO
Get approval from the company manager
Get approval from project leader
Approve as work preparator
Place the order
Contact with the supplier
No
Yes
Is the order confirmation correct?
Registering order in system
Put purchasing form together with technical drawings

Appendix B Incoming goods: Receiving goods in the production hall



Appendix C Outgoing goods: Process before truck departs from production hall




Work Preparator Project Team
Receive request for transportlist from project team
Can a list of materials be generated from the Engineering file?
Yes
No
Generate transport list from Engineering model, excel list
Manually make a transport list, including technical drawings
Sending transport list to Production by email
Transport controller Production Hall
Receive transport list
Search for technical drawings of materials and print them
Have all components of the list have been taken a
No
Yes
Search for component
Is the component
No
Yes
Check off list
Label component
Write down that materials has not been packed
Add to stack of materials
Give checked off list to Work Preparator from Toelevering Water
Sign final transport list
Put list on a box of the shipment in plastic file
Work Preparator Toelevering Water
Make final transport list
Print final transport list
Give final transport list back

Appendix D Outgoing goods: Arrival of truck at construction site