Productivity in the transport hall of HST Groep

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MANAGEMENT SUMMARY

This thesis aims to calculate and map the productivity of employees in the transport hall of HST Groep. A performance dashboard including key performance indicators has been developed.

Problem definition
This research focuses on the evening unloading and loading process that takes place in the transport hall of the Benelux road transport department of HST Groep. This transport hall is extremely tight while the company is growing and expanding fast. Therefore, more pressure is occurring on improving the productivity of the process. However, there is a lack of information since the productivity is unknown. Research is done to calculate and map the productivity in the several segments of the process. Thus, this thesis answers the following main research question:

"What is the productivity in the different segments of the evening unloading and loading process, displayed in a performance dashboard?"

Approach
The Design Science Research Methodology has been used to solve the core problem. First, the current situation is worked out by observation to gain insights into the different segments of the process. Then, literature reviews were done on visualization tools, key performance indicators, and productivity. Lastly, interviews have been conducted to get to understand the user.

Results
The developed performance dashboard of this research shows the team and individual productivity of the overall process and the several segments. The total average team productivity per year is 10.9, 8.5, and 9.5 pallets per employee hour in 2019, 2020, and 2021 respectively. The total average individual productivity per year is 69.7, 54.6, and 58.8 pallets per employee in 2019, 2020, and 2021 respectively. Table 1 summarizes the productivity of the several segments on the 26th of May. We cannot recommend improvements based on the productivity of the different segments since the manager of HST TransMission cannot base decisions on one day.

Table 1: Results productivity segments

	Team productivity (output per employee hour)	**Individual productivity (output per employee)**
Unloading process	26.55	94.46
Loading general cargo process	13.26	44.00
Loading route cargo process	29.70	112.43
Scanning pallets process	188.92	614.00
Fall-out process	87.06	43.53

Conclusion and evaluation
The performance dashboard developed in this research has great added value to providing an insight into the productivity of the evening unloading and loading process in the transport hall. If the data is automatically transferred to the performance dashboard, the manager of HST TransMission can base his decisions on it and evaluate them. However, further research is needed to find out why the productivity acts the way it does and how it could be improved. Causes of the shift in productivity can be found by creating more detailed charts. Besides that, all manual activities should be mapped so that possibilities of automizing and improving the process can be researched.

PREFACE

Dear reader,

This report is the result of my research conducted at HST Groep, located in Enschede. The research investigates improvements by calculating and mapping the productivity of the transport hall. Based on the identified improvements, I made recommendations to increase the productivity. The report fulfils the graduation requirements of the Bachelor's program in Industrial Engineering and Management at the University of Twente.

First of all, I would like to thank my company supervisor, Gijs Boermans, who gave me the chance to develop myself during this research. I am grateful for his contribution to this research. Alongside, I would like to thank all other employees at HST Groep.

Secondly, I would like to thank my first supervisor, Patricia Rogetzer, for the productive meetings and clear feedback. I would also like to thank Dennis Prak for being my second supervisor.

Lastly, I would like to show my gratitude towards my family and friends. A special thanks to my buddy, Rozan Hopman, for all the talks and motivation during these crazy times.

Enjoy reading my Bachelor thesis!

Carmen Cijffers

Enschede, 09/07/2021

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READER'S GUIDE

This thesis creates a performance dashboard displaying productivity key performance indicators. This report is structured in eight chapters, which are shortly discussed below.

Chapter 1: Introduction
The first chapter introduces the company and department at which this research is done. It identifies the core problem and provides a problem-solving approach. Furthermore, it describes the research questions and deliverables of this thesis.

Chapter 2: Current situation in the transport hall
The second chapter determines the current situation in the transport hall of the company. It maps the layout of the transport hall and sketches a timeline. Besides that, it explains the process in detail and links it to the layout.

Chapter 3: Data visualization tools and key performance indicators
The third chapter discusses several visualization tools and chooses the best option for this research. It explains what an effective key performance indicator entails and defines productivity.

Chapter 4: Performance dashboard requirements
The fourth chapter elaborates on the requirements of the performance dashboard. It determines the current possibilities of a performance dashboard within the company. Moreover, it outlines the user-friendliness aspect.

Chapter 5: Design and development performance dashboard
The fifth chapter derives the key performance indicators to be displayed on the performance dashboard. Furthermore, it determines the data required and shows the final data set.

Chapter 6: Demonstration performance dashboard
The sixth chapter demonstrates the performance dashboard created in this research by showing the several pages and the data model. Besides that, it analyses the performance dashboard.

Chapter 7: Improvements layout and process transport hall
The seventh chapter recommends one possible improvement for the layout of the transport hall and one for the design of the evening unloading and loading process.

Chapter 8: Conclusion
The last chapter summarizes the sub-conclusions and creates a final discussion.

LIST OF FIGURES

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LIST OF ABBREVIATIONS

BPM	Business Process Model
BPMN	Business Process Model Notation
DSRM	Design Science Research Methodology
KPI	Key Performance Indicator
UML	Unified Modelling Language
VBA	Visual Basic for Applications

1 INTRODUCTION

This report describes the thesis research performed for the completion of the Bachelor's program in Industrial Engineering and Management at the University of Twente. The goal of this research is to map and calculate the productivity of the process in the transport hall in a performance dashboard. This chapter introduces the research that is carried out at HST Groep. Section 1.1 presents the company and department at which the research is conducted. Section 1.2 discusses the identified problem, including the problem cluster, the action and core problems, and the variables and indicators. Section 1.3 determines the problem-solving approach used in this research. Section 1.4 outlines the research questions of this research. Section 1.5 provides an overview of the deliverables of this research. Section 1.6 presents the structure of this report.

1.1 COMPANY AND DEPARTMENT DESCRIPTION

In 1978, three local transporting companies operating in the Netherlands, Haarman, Smit, and Thijssen, united and HST Groep was born (HSTGroep, n.d.). HST Groep is an all-round logistics service provider located in Enschede, the Netherlands. It is a family-owned business in which the 350 employees are actively engaged. They arrange the complete transportation and logistics process for their customers. Their primary services regard international road transport, sea freight, air freight, and warehousing. HST Groep consists of the departments HST Logistics, HST International, HST TransMission, HST Sea & Airfreight, and HST Service BV. These company branches are all specialists in their discipline.

This report focuses on the Benelux road transport department, HST TransMission. HST Groep owns 180 vehicles consisting of vans, box trucks, and trailer trucks. These vehicles pick up and deliver items, such as pallets and colli, from and to their customers throughout Belgium and the Netherlands. Besides that, items are incorporated in a Dutch franchise network called TransMission. In 2000, the cooperation between HST Groep and TransMission started. TransMission is the biggest partnership of independent transport and distribution companies in the Benelux (TransMission, n.d.). Figure 40 in Appendix A depicts the locations of the depots of the TransMission partners, including the red dot indicating HST Groep. TransMission assigned a number to every depot corresponding to the first two numbers of their zip code. HST Groep is number 75, corresponding to zip code 75XX for Enschede. In addition to the Dutch franchise partners, five independent partners from Belgium and Luxembourg joined the network. All partners together deliver items throughout the Benelux. The partners have a joint transport management system to exchange data regarding shipments, such as the address and time of delivery.

1.2 PROBLEM IDENTIFICATION

Within HST TransMission, this research focuses on the evening unloading and loading process within the transport hall. This transport hall is tight while HST TransMission is growing fast. This causes the employees to perform more actions than initially necessary. For example, the items within the transport hall must be moved more often to create space to reach other items. The lack of knowledge within HST TransMission worsens these space problems causing the management to possibly make wrong decisions. While the transport hall cannot expand, HST TransMission needs a solution to increase the productivity of the process. This means that the transport hall employees must perform fewer actions while spending the same or less time, resulting in a better outcome. The problem we identify is the unknown productivity. This prevents the management from identifying

productivity improvements to the process and the layout of the transport hall. By performing this research, we elaborate on this problem and search for a solution.

1.2.1 Problem cluster and action problems

A problem cluster is a helpful tool to understand and communicate the relationships between the occurring problems (Heerkens & van Winden, 2017, p. 42). Figure 1 shows the problem cluster of the evening unloading and loading process in the transport hall. The arrows represent the relationships between the identified problems from cause to effect.

The dark (blue) boxes in the problem cluster depict two action problems of the TransMission department. The first action problem is the increase in the delivery time of shipments. The deviation of dimensions indirectly causes this because shipments do not fit in the appointed vehicle, or the shipments' distribution is not equal. The second action problem is low labor productivity in the transport hall. A lot of other problems cause this. Firstly, the low labor productivity is due to the deviation of dimensions as an employee loses time by filling out a form. Secondly, it is caused by the customer not making their order final, resulting in a question mark popping up on the screens while scanning. Thirdly, because of the transport hall being tight, items are placed on the paths, in the wrong boxes, and empty vehicles. Therefore, tasks take more time, the transport hall employees must move multiple items to reach other items, and they must move some skipped items to the correct box after the check. All this causes time loss, and thus the labor productivity is low. Lastly, the lack of information causes the labor productivity to decrease. The lack of information regards the unknown productivity of the unloading and loading process. Because of that, the bottlenecks within the process are unknown. This causes not only the worsening of misplacing items as the transport hall is organized inefficiently but also inefficiency within the process. This inefficiency is causing additional actions, such as manually scanning all items in the zip code boxes.

Besides these problems, there are always unforeseen problems, such as a pump truck breaking down. The transport hall employee tells the transport hall manager about the damage. The manager takes a picture and hands over the pump truck to HST Service BV. All this results in a decrease in labor productivity and the loss of capital. Many other factors and unforeseen problems influence the unloading and loading process causing it to be sensitive to delays. However, HST TransMission cannot affect these problems in advance, so they must solve them daily.

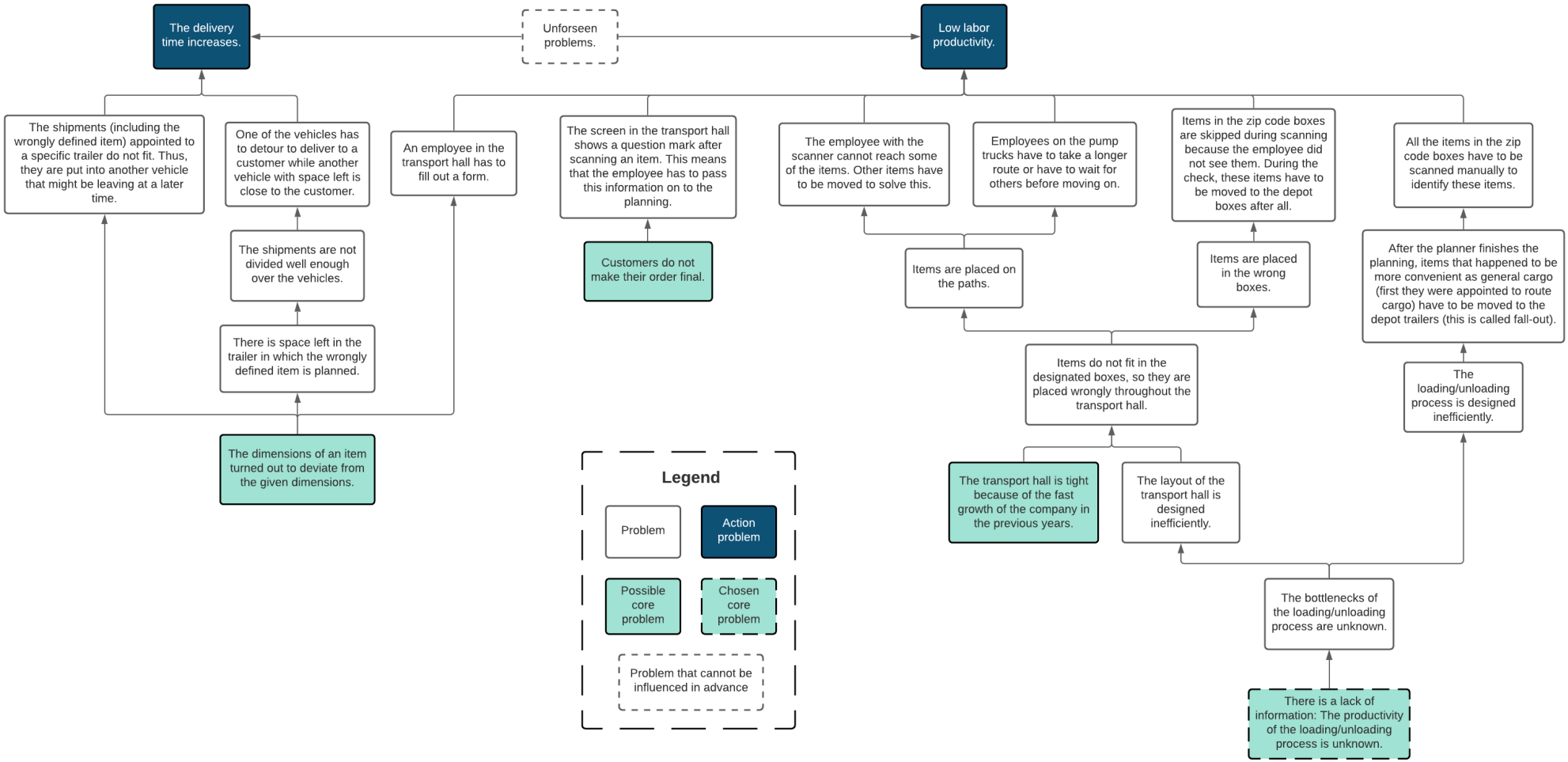
1.2.2 Core problem and motivation

The problems that can be influenced and have no direct cause themselves can be defined as possible core problems (Heerkens & van Winden, 2017, p. 44). The light (blue) boxes in the problem cluster in Figure 1 depict the possible core problems of this research. Based on this, we define the following problems as possible core problems:

- The dimensions of an item turned out to deviate from the given dimensions;
- Customers do not make their order final;
- The transport hall is tight because of the fast growth of the company in the previous years;
- There is a lack of information: The productivity of the unloading and loading process is unknown. An overview is missing because of all the different flows of goods.

Heerkens and van Winden (2017, p. 44) describe that limiting the number of core problems is essential. Thus, we eliminate the first three possible core problems from the list as they are already being tackled or minimized by HST TransMission. The first problem is minimized by addressing a customer if it keeps on giving the wrong dimensions. For the second problem, an employee from planning makes daily calls to the customers who placed an order the day before without making it

Figure 1: Problem cluster



final. Because of this, the customer pays more attention the next time. Besides that, HST TransMission is working on a new software system, which solves this problem as well, according to the manager of HST TransMission. The third problem is more challenging to solve. The different departments of HST Groep are in discussion about moving HST International or the Online department to either another building or a new building. HST TransMission can then take over their part of the transport hall.

HST TransMission is not investigating the last possible core problem yet. However, solving the problem regarding the lack of information is critical to identify bottlenecks. They can only be identified if the productivity in all segments of the process is known. Then, both the unloading and loading process and the transport hall layout can be designed more efficiently. By doing that, HST TransMission might save capital and time. During the first week at HST Groep, it became clear that HST TransMission is growing and expanding faster than they can handle. As a result, more and more pressure is occurring regarding improving the efficiency of the unloading and loading process. Thus, for this research, we select the following core problem:

"There is a lack of information: The productivity of the unloading and loading process is unknown."

1.2.3 Variables and indicators

A measurable variable needs to be defined to make the problem manageable (Heerkens & van Winden, 2017, p.50). By doing this, we can examine the effects of the solution and the extent to which this research reaches its goal. The variable is expressed in a reality and a norm. The reality of a variable reflects on the current situation, whereas the norm of a variable determines the desired situation. The variable's reality is 'Unknown productivity', and the norm is 'Known productivity'. This concept is still broad and hard to measure. Therefore, we identify indicators.

The first indicator is the 'number of bottlenecks of the process known'. This indicator shows how many bottlenecks the implementation of the solution identifies. We elaborate on each bottleneck to identify productivity improvements. The second indicator is the 'number of productivity improvements to the layout of the transport hall', and the third indicator is the 'number of productivity improvements to the design of the process'. The more improvements we identify, the more the solution contributes to making the layout of the transport hall and the design of the process efficient. This research elaborates on the productivity improvements so that the manager of HST TransMission can implement them. The reality value for all three indicators is zero. The norm value of all three indicators is at least one.

1.3 PROBLEM-SOLVING APPROACH

This research develops a performance dashboard including Key Performance Indicators (KPIs) to solve the core problem. A performance dashboard is an information system, existing to support and automate the work performed by other work systems to provide information for decision making (Alter, 1999). Therefore, this research needs a research perspective based on information systems. Design science is an information-based research methodology that creates artefacts for specific information problems (Hevner, March, Park, & Ram, 2004). Thus, the problem-solving approach that best fits this research is the Design Science Research Methodology (DSRM). We describe the six steps of the DSRM, adapted to this research, below (Peffers et al., 2007).

Phase 1: Problem identification

This phase uses the first phase of the managerial problem-solving method. This problem-solving approach uses both creative and systematic methods to solve managerial problems (Heerkens & van

Winden, 2017, p. 17). The first phase provides a straightforward method to identify and motivate action and core problems based on a problem cluster. We develop this problem cluster and the current situation by directly observing the process and conducting semi-structured interviews.

Phase 2: Define objectives
The second phase of the DSRM defines the objectives for the solution to the research problem. It describes the goal and scope of the research. Moreover, it determines the intended deliverables, including the way to achieve them. We derive these objectives from the previous phase.

Phase 3: Design and development
This phase consists of the gained theory and approach to develop the performance dashboard. It conducts literature research and discusses the chosen solution to the main research problem. Based on this, we carry out literature research and a semi-structured interview to develop a performance dashboard prototype.

Phase 4: Demonstration
In this phase, I show the prototype of the performance dashboard to my company supervisor. This includes an explanation and guidelines on how to use the performance dashboard.

Phase 5: Evaluation
This phase aims to determine whether the prototype works, if it contributes to solving the research problem, and if the solution is in line with the defined objectives from phase 2. We evaluate the prototype by discussing it with my company supervisor. Based on his feedback, I can improve the performance dashboard and the measurements of the KPIs.

Phase 6: Communication
This phase reaches its goal by presenting findings at my publicly open colloquium. My company supervisor, teachers of the University of Twente, and fellow students will be present there.

1.4 RESEARCH QUESTIONS

The goal of this research is to solve the core problem of unknown productivity. Therefore, the main research question is the following:

"What is the productivity in the different segments of the evening unloading and loading process, displayed in a performance dashboard?"

The segments are the different components of the process, so the various events and decisions occurring. To answer this research question and to solve the core problem, we determine knowledge questions. Some of the knowledge questions contain one or several sub-questions to make them more accessible (Heerkens & van Winden, 2017, p. 122). We describe the knowledge questions and purpose below.

1. What does the current evening unloading and loading process look like?
   1.1 What does the current layout of the transport hall look like?
   1.2 What are the transport flows of the items in the transport hall?

A visual representation of the current evening unloading and loading process is essential to understand the action and core problems better. Thus, this knowledge question contributes to phase 1 of the DSRM. A better understanding of the different segments of the process results in a more accurate selection of the productivity KPIs. A visual representation of the transport hall's current layout is required to understand the process even better. To link the process and the layout to each other, we identify the different transport flows. We derive these visual representations by

directly observing the process and conducting a semi-structured interview with the transport hall manager.

2. What data visualization tool is used to develop the performance dashboard of this research?
The selection of a user-friendly program is crucial. It saves a lot of time if there are several tutorials available on how to use the program. Besides that, the tool should be able to output an array in different chart and graph types so that the dashboard is attractive and the user can immediately observe the main points. The identification of the required steps is essential. It results in fewer adjustments afterward and a better evaluation. The tool selection depends on literature research. This knowledge question helps in designing the performance dashboard in phase 3 of the DSRM.

3. What are the most important characteristics of an effective KPI?
It is crucial to understand what a KPI should contain and especially for it to be effective. We derive this information from a systematic literature review. This knowledge question improves the design in phase 3 of the DSRM.

4. Which requirements of HST TransMission should be considered when developing the performance dashboard?

4.1 What current possibilities to display a dashboard are there within HST TransMission?

4.2 How can the performance dashboard be made user-friendly?

We should consider the requirements of HST TransMission when developing the performance dashboard. Therefore, we must identify these requirements to keep the problem owner satisfied. We evaluate the current possibilities within HST TransMission to display a performance dashboard. Besides that, the performance dashboard should be user-friendly so that no time is lost during the implementation. I acquired these aspects through semi-structured interviews with the transport hall manager and my company supervisor and performing literature research. This knowledge question improves the development in phase 3 of the DSRM. Phase 4 and 5 check whether this knowledge question is adequately executed by demonstrating the performance dashboard to my company supervisor and the transport hall manager and discussing how to evaluate it.

5. What productivity KPIs fit the unloading and loading process of HST TransMission and should be selected?

5.1 How can the selected productivity KPIs be calculated?

5.2 What data is required from the company to calculate the productivity KPIs?

The dashboard consists of several KPIs to measure the productivity of the unloading and loading process segments. We must identify these KPIs to create the performance dashboard. We can have a clear structure of the dashboard based on the relationships between the KPIs. We need to process a lot of data. Thus, it is crucial to understand how the KPIs are calculated and what data is required. We derive the KPIs, including how to calculate them from literature research and the required data from a semi-structured interview with my company supervisor. This knowledge question contributes to the development of the performance dashboard in phase 3 of the DSRM.

6. What improvements to increase productivity can be suggested to the design of the evening unloading and loading process and the layout of the transport hall from conducting this research?
Based on this research, we can identify possible improvements regarding the design of the evening unloading and loading process and the transport hall layout. We add this knowledge question so that HST TransMission can implement the research into practice. We convert the performance dashboard to legible text, which contributes to the last phase of the DSRM.

1.4.1 Research design

Table 2 shows an overview of the research design. The overview contains the knowledge questions, type of research, research population, subjects, data gathering and processing methods, and activities corresponding to the knowledge questions.

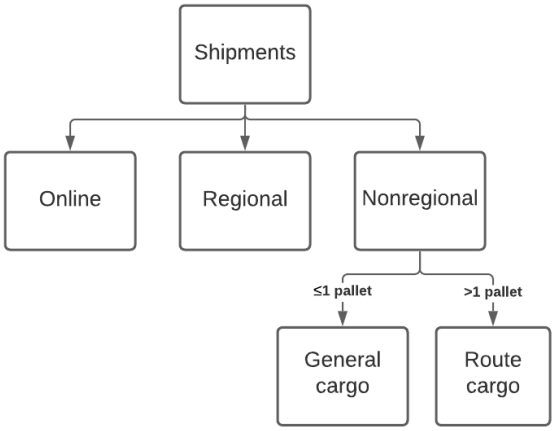
1.4.2 Research scope

As earlier described, this research focuses on the TransMission department of the company. Within this department, this report focuses on the evening unloading and loading process of the vehicles transporting the shipments. HST TransMission distinguishes between different types of shipments. Figure 2 shows these different types: online, regional, and nonregional shipments. The online shipments are out of scope since they do not concern the TransMission department. Regional shipments are out of scope as well since they are not loaded during the evening unloading and loading process. The nonregional shipments are in scope and the focus of this report. There are two types of nonregional shipments: general and route cargo. Chapter 2 explains the difference between them and describes the current situation of the evening unloading and loading process.

During the evening, the nonregional general cargo vehicles drive between depots and HST Groep. After return, the transport hall employees must unload the general cargo vehicles. This process is out of scope since it continues until the following morning. In further research, the productivity of the items out of scope can still be calculated and mapped using the same method as this research.

Within the process, the sorting belt sorts small items such as colli and bundles. The sorting belt is out of scope. Most of the time, the items that go over the sorting belt stand still on a rack. Thus, these items are static compared to the other items in the transport hall. Only the several types of pallets do not fit on the sorting belt, so they are in scope. The other types of transportation units are out of scope.

Figure 2: Types of shipments



1.4.3 Reliability and validity

Reliability is concerned with the accuracy and precision of a measurement procedure and the stability of the research results (Cooper & Schindler, 2014, p. 257; Heerkens & van Winden, 2017, p. 127). In other words, are the research results the same if another researcher conducts the research? In this research, the two main methods of data gathering are interviews and literature research. On the one hand, literature research is reliable because it can be carried out the same by other researchers. On the other hand, interviews are not that reliable because interviewers can interpret the answers differently, so subjectivity is involved. To increase the reliability of an interview, it must be as structured as possible. However, during the interviews, I come up with follow-up questions.

Table 2: Overview research design

Knowledge question	Type of research	Research population	Subjects	Research strategy	Method of data gathering	Method of data processing	Activities
1. What does the current evening unloading and loading process look like?	Descriptive.	Company.	Transport hall manager.	Deep quantitative Contact.	Direct process observation and communication (cross-sectional).	Visual representation and description. Quantitative and qualitative.	Directly observe process. Conduct a semi-structured interview. Overview process. Layout transport hall. Link both.
2. What data visualization tool can be used to develop the performance dashboard of this research?	Descriptive.	Literature.	Specific tool.	Deep qualitative.	Literature study (cross-sectional).	Description of tool. Qualitative.	Research. Choose tool. Literature research. Describe tool.
3. What are the most important characteristics of an effective KPI?	Descriptive.	Literature.	Effective KPI.	Broad qualitative.	Literature study (cross-sectional).	List of KPI characteristics. Qualitative.	Systematic literature review. List characteristics.
4. Which requirements of HST TransMission should be considered when developing the performance dashboard?	Descriptive and explanatory.	Company. Literature.	Problem owner. User-friendly dashboard.	Broad qualitative.	Communication and literature study (cross-sectional).	List of requirements and possibilities, and explanation. Qualitative.	Semi-structured interview with company supervisor. Overview requirements. Overview current possibilities. Literature research on user-friendly. Explanation and overview.
5. What productivity KPIs fit the unloading and loading process of HST TransMission and should be selected?	Explanatory.	Literature. Company.	Productivity KPIs. Problem owner.	Deep qualitative.	Literature study and communication (cross-sectional).	Explanation of KPIs and their equations. Quantitative and qualitative.	Literature research. Semi-structured interview with company supervisor. List KPIs and equations.
6. What improvements to increase productivity can be suggested to the design of the evening unloading and loading process and the layout of the transport hall from conducting this research?	Explanatory.	Company.	Problem owner.	Deep qualitative.	Answers to other questions (cross-sectional).	Description. Qualitative.	Evaluate. Explain improvements.

The reliability of this research can also be threatened by the fact that I am the only researcher. My buddy and university supervisor help me in making decisions. However, I make all the final decisions.

Validity is the extent to which you measure what you intended to measure (Cooper & Schindler, 2014, p. 257; Heerkens & van Winden, 2017, p. 127). In this research, the goal is to calculate and map the productivity with the use of productivity indicators. Thus, the KPIs must actually describe the productivity of the unloading and loading process. There are three types of validity: internal, external, and construct validity.

Internal validity is the extent to which the research design and my measuring instruments have been adequately formulated and constructed (Heerkens & van Winden, 2017, p. 127). The selection of KPIs threatens internal validity. Other KPIs can give different results. We carefully identify them, keeping their goal of mapping productivity in mind.

External validity is the extent to which you can apply your research to other groups than your research population (Heerkens & van Winden, 2017, p. 127). In this research, the main research population is the HST TransMission department of the company. However, this research could also be carried out for other departments because the performance dashboard is fully adapted to the conditions and preferences of HST TransMission. But because of that, the results are not generalized to other companies. However, a researcher could use this research as a guideline. Thus, good communication and documentation are needed to increase external validity.

Construct validity is the extent to which the constructs have been properly operationalized, logically related, and based on scientific knowledge (Heerkens & van Winden, 2017, p. 127). The KPIs in the performance dashboard should clearly show the productivity. To achieve this, we should define and operationalize productivity and the KPIs.

1.4.4 Limitations

To clearly define the research design's imperfections, we identify limitations (Cooper & Schindler, 2014, p. 17). This research design's limitations are the time constraint, data and literature availability, and cost constraint. First, this research has a time constraint because I performed it for the completion of my Bachelor's thesis. The execution time is ten weeks, which means that we set certain parts of the unloading and loading process out of scope. Subsection 1.4.2 describes the scope of this research. The second limitation concerns data availability. It might be possible that we cannot calculate certain KPIs because HST TransMission is missing data. Together with my company supervisor, I tried to gather as much data needed as possible. Third, literature availability is a limitation. We can only derive literature that is available on the databases. The full text of certain articles might not be accessible. However, productivity and KPIs are both much-discussed topics in academic literature. The problem is that researchers disagree about how productivity can be identified and calculated. The last limitation is the cost constraint. In principle, the research should not cost any money. I assume that these limitations do not influence the results significantly.

1.5 Deliverables

The deliverables that result from this research are the following.

- Business Process Models (BPMs) of the current evening unloading and loading process. These models graphically present the steps of the process, including who performs which task. We achieve this by conducting a semi-structured interview with the transport hall manager.

- Floor plan of the layout of the transport hall. This floor plan includes a spaghetti diagram to identify the different transport flows and understand better what happens inside the transport hall (Uriarte, Ng, Zuniga, & Moris, 2017). We achieve this by observing the process.
- A performance dashboard including productivity KPIs of the evening unloading and loading process. We achieve this by gathering data from the transport hall and process it in a visualization tool. We conduct a semi-structured interview with the transport hall manager and problem owner and perform literature research to find the best way to do that.
- Productivity improvements to the unloading and loading process and the layout of the transport hall to increase efficiency. Based on the performance dashboard, we identify bottlenecks within the evening unloading and loading process. The bottlenecks will help to develop improvements.

1.6 STRUCTURE OF THE REPORT

Table 3 shows the structure of the thesis report derived from this research. It links the phases of the DSRM to the chapters of this thesis report and the knowledge questions.

Table 3: Structure of the report

DSRM phase	Chapter	Knowledge questions
1. Problem identification 2. Define objectives	1. Introduction	*1. What does the current evening unloading and loading process look like?* *1.1 What does the current layout of the transport hall look like?* *1.2 What are the transport flows of the items in the transport hall?*
	2. Current situation in the transport hall	
3. Design and development	3. Data visualization tools and key performance indicators	*2. What data visualization tool is used to develop the performance dashboard of this research?*
		3. What are the most important characteristics of an effective KPI?
	4. Performance dashboard requirements	*4. Which requirements of HST TransMission should be considered when developing the performance dashboard?* *4.1 What current possibilities to display a dashboard are there within HST TransMission?* *4.2 How can the performance dashboard be made user-friendly?*
	5. Design and development performance dashboard	*5. What productivity KPIs fit the unloading and loading process of HST TransMission and should be selected?* *5.1 How can the selected productivity KPIs be calculated?* *5.2 What data is required from the company to calculate the productivity KPIs?*
4. Demonstration	6. Demonstration performance dashboard	-
5. Evaluation	7. Productivity improvements layout and process transport hall	*6. What improvements to increase productivity can be suggested to the design of the evening unloading and loading process and the layout of the transport hall from conducting this research?*
	8. Conclusion	-

2 CURRENT SITUATION IN THE TRANSPORT HALL

This chapter maps and describes the current situation of the layout of the transport hall and the design of the evening unloading and loading process of HST TransMission. This is essential for evaluating the solution of this research by comparing the current situation with the new situation. The aim is to answer the first knowledge question and its sub-questions:

1. What does the current evening unloading and loading process look like?
1.1 What does the current layout of the transport hall look like?
1.2 What are the transport flows of the items in the transport hall?

Section 2.1 explains the difference between route cargo and general cargo. Section 2.2 develops a floor plan on the layout of the transport hall. Section 2.3 develops a timeline of the overall unloading and loading process in the transport hall. Section 2.4 maps and describes the evening unloading and loading process by splitting it up into four sub-BPMs. Section 2.5 develops a spaghetti diagram to show examples of the flow of items through the transport hall. Section 2.6 concludes this chapter by answering knowledge question 1.

2.1 ROUTE CARGO VERSUS GENERAL CARGO

As Subsection 1.4.2 describes, HST TransMission distinguishes between three types of shipments: online, regional, and nonregional. The focus of this report is on the nonregional shipments. There are two types of nonregional shipments: general cargo and route cargo. The system automatically appoints a nonregional shipment as 'general cargo' if it meets the following requirements:

- The order consists of one pallet or less.
- There is no time limit for delivery.
- There is no customer priority.

The nonregional shipments that do not meet the requirements are automatically appointed as 'route cargo'. In the case that a shipment is appointed as route cargo, a vehicle of HST TransMission delivers it to the customer. The vehicles with route cargo leave during the night. After delivering the route cargo, the vehicles pick up shipments from customers and return them the following day to HST Groep. Next to the shipments of the regional vehicles, these shipments are the input of the evening unloading and loading process.

In the case that a shipment is appointed as general cargo, a vehicle delivers it to another depot, and HST TransMission outsources the final customer delivery to the partner corresponding to that depot. Vice versa, a partner may outsource their shipments to HST TransMission. During the evening, the vehicles transporting general cargo depart. After delivering the general cargo, the vehicles are loaded at the partner and return to HST Groep during the night. These picked up shipments are mainly regional shipments that are delivered by the regional vehicles in the morning.

2.2 LAYOUT TRANSPORT HALL

This section develops a floor plan of the transport hall of HST TransMission in which the evening unloading and loading process takes place. This floor plan provides a clear overview to keep in mind while mapping the process. After mapping the process, a spaghetti diagram points out the flow of items using this floor plan. Figure 3 shows the floor plan of the transport hall. The office with the planning and customer service is next to the transport hall. Therefore, employees from the office can easily walk to the transport hall to search for items, and the transport hall manager can quickly

walk to the planning. On the other side of the TransMission transport hall is the international transport hall. The TransMission transport hall has 19 dock shelters on both sides, which are all numbered. Dock shelters 1 until 3 are van places. The vans mainly transport regional packages. Dock shelters 4 until 19 are box truck places. The box trucks mainly transport regional and route cargo items. HST TransMission owns and uses more box trucks than dock shelters available for them. Thus, dock shelters 10 until 13 are exchange dock shelters. There are constantly different box trucks placed on those dock shelters. Dock shelters 20 until 38 are trailer truck places, which are all exchange dock shelters. The trailer trucks mainly transport regional and route cargo items.

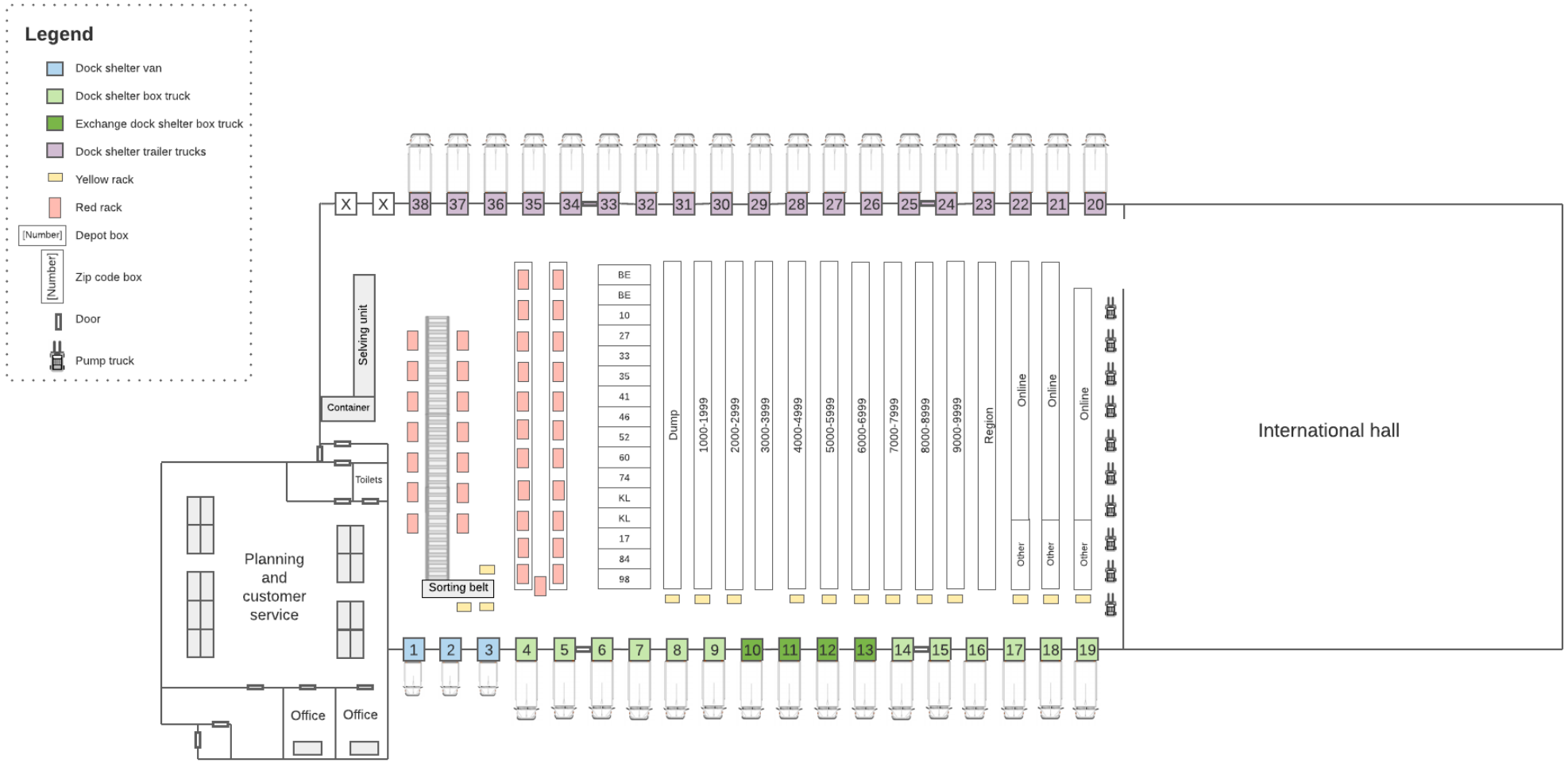
HST TransMission uses the yellow racks to transport packages from and to the customer directly. These are regional or route cargo shipments. However, route cargo shipments consist of items of more than one pallet. Thus, HST TransMission mainly uses the yellow racks for regional packages. Therefore, the yellow racks are mainly used by drivers from the vans and box trucks. When unloading, these yellow racks only contain general cargo and can thus be brought to the sorting belt. Therefore, the van and box truck dock shelters are next to the sorting belt. However, as described in Subsection 1.4.2, the loading process of the regional shipments happens in the morning. So, loading a yellow rack is out of scope.

In addition, HST TransMission uses the red racks to transport packages from and to the depots. These are general cargo shipments. Thus, HST TransMission mainly uses the red racks for general cargo packages. Therefore, the red racks are loaded into trailer trucks. However, as described in Subsection 1.4.2, the unloading process of the general cargo is out of scope.

Several boxes are drawn on the floor throughout the TransMission transport hall: depot boxes, a dump box, zip code boxes, a region box, online boxes, and boxes for other items. All depot boxes are connected to a number corresponding to the several depots of the partners of HST TransMission. These numbers are on the floor as well, next to the depot boxes. The depot boxes serve as an intermediate place for general cargo items before the transport hall employees load them into the correct general cargo vehicle. HST TransMission makes an exception for packages. Packages directly go onto a yellow rack and on the sorting belt. In the dump box, a transport hall employee scans and stickers the general cargo items to immediately see to which depot box the item needs to be moved. The zip code boxes serve as short-term storage of the route cargo items. The transport hall employees load the route cargo items during the evening. The region box serves as short-term storage of the regional item. The transport hall employees load the regional items the following morning. The online boxes are used for online items. Besides that, HST TransMission mainly uses the ‘Others’ boxes for items without a label or a big shipment consisting of multiple pallets intended for one customer.

Without knowing or understanding the process, the transport hall seems tight according to the floor plan. The boxes, especially the depot boxes, are narrow and close to each other. The floor plan displays the space constraint of HST TransMission. It also shows that there is no nonutilized space that could still be used. Something else striking is the number of red racks. It looks like the employees use them for items from the sorting belt. However, less than half of the red racks fit next to the sorting belt. This means that all other red racks are placed somewhere else in the transport hall and take up space.

Figure 3: Floor plan transport hall HST TransMission



2.3 TIMELINE OVERALL UNLOADING AND LOADING PROCESS

This section develops a timeline of the overall unloading and loading process in the TransMission transport hall. This timeline puts the evening unloading and loading process in perspective. Figure 4 shows the timeline. The darkest (blue) boxes correspond to the time between the first vehicle transporting a specific type of shipment departing at HST Groep until the last vehicle transporting the same type arriving at HST Groep. The second darkest boxes correspond to the unloading processes, and the third darkest boxes to the loading processes. The third lightest boxes correspond to the time that the sorting belt is working. Lastly, the second lightest boxes are checks performed by the transport hall manager.

The process starts at around 3:00 p.m. with the arrival of the vehicles transporting regional and route cargo shipments. The employees in the transport hall start unloading the items. As soon as packages are unloaded and moved to the sorting belt, the sorting process starts. The loading process of general cargo starts as soon as possible to make room for other items. When the employees are done with unloading, and while the planner is still planning the shipments, the employees take a break. When the planner is finished, the fall-out starts. This is at around 8:00 p.m. Subsection 2.4.4 discusses the fall-out. The fall-out takes between half an hour and an hour. During the end of the fall-out, the transport hall manager starts performing his first check. After the fall-out, the loading process of the route cargo vehicles starts at around 8:45 p.m. and takes about five hours. The transport hall manager now performs his last check.

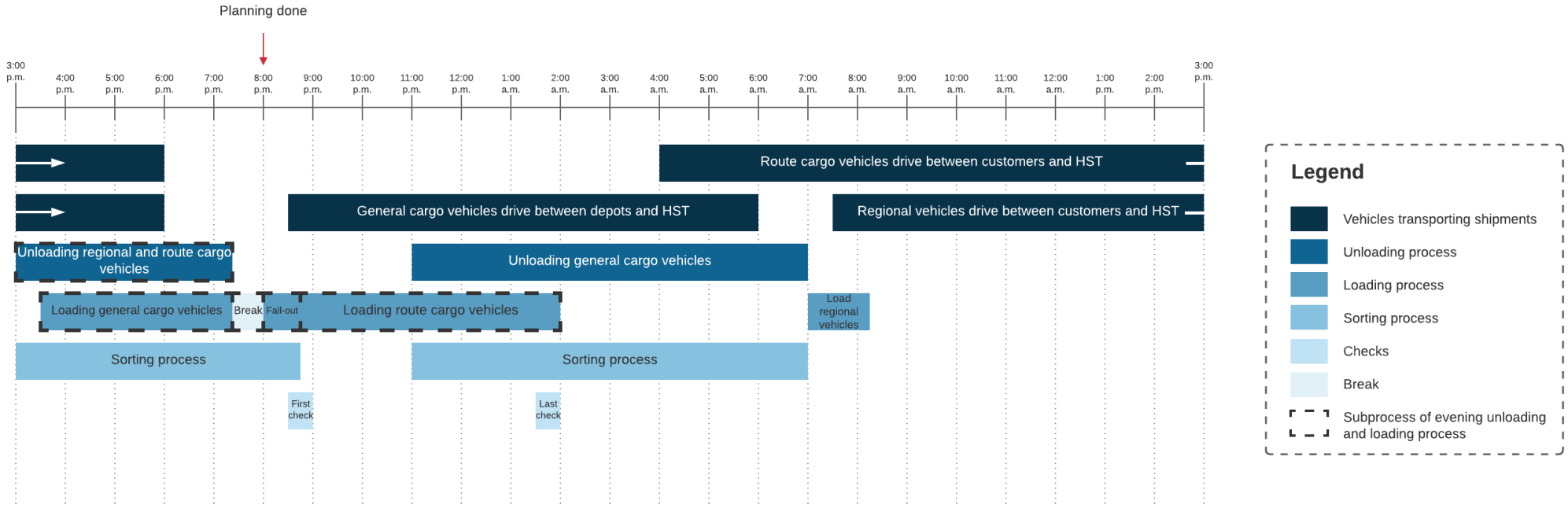
The first general cargo vehicle already departs at 8:30 p.m. to deliver shipments to another depot. The other general cargo vehicles all depart before 11:00 p.m. When arriving at the depot of destination, the general cargo vehicles are unloaded and loaded. The driver returns to HST Groep to deliver the picked up shipments. All general cargo vehicles arrive back at HST Groep before 6:00 a.m. the following morning. As soon as a general cargo vehicle arrives, the transport hall employees start unloading. As soon as the first package appears, the sorting process starts again.

After loading, the route cargo vehicles depart during the night between 4:00 a.m. and 7:00 a.m. to deliver shipments to the customers. After that, they pick up shipments from other customers and return them to HST Groep. In addition, the driver himself loads his regional vehicle in the morning, starting at 7:00 a.m. If loaded, the regional vehicles depart at around 8:00 a.m. to deliver the shipments to the customers. After delivering their shipments, the route cargo and regional vehicles pick up shipments from other customers and return them to HST Groep. These vehicles arrive between 3:00 p.m. and 6:00 a.m., and the process starts again.

The striking thing from the timeline is the fact that the process must wait for the planning before continuing. It might be possible to start planning earlier, make the planning more efficient, or deploy another planner to help. The process must also wait for the fall-out to happen. The fewer fall-out products, the earlier the process can start again.

The following section elaborates on this process with a specific focus on the evening unloading and loading process and its subprocesses. This evening unloading and loading process takes from 3:00 p.m. until 2:00 a.m. Therefore, throughout this thesis, with evening we mean the period between 3:00 p.m. and 2:00 a.m. Figure 4 depicts these subprocesses with the use of a black dashed border.

Figure 4: Timeline overall unloading and loading process

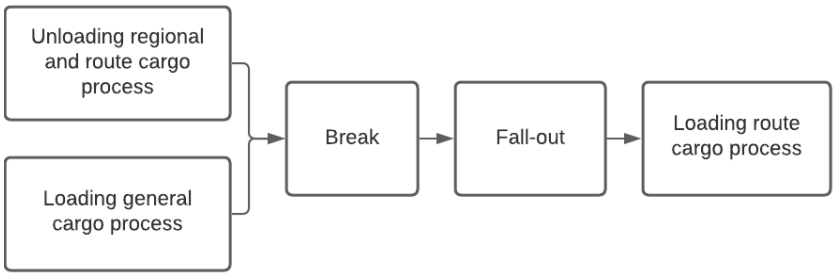


2.4 EVENING UNLOADING AND LOADING PROCESS

This section outlines the developed BPMs from observing the evening unloading and loading process and conducting a semi-structured interview. According to Neto, Cavalcante, Hachem, and Santos (2017), BPM has well-established notations. Therefore, it increases communication and documentation. It provides insight into the process to build research upon. Subsection 2.4.1 discusses several modelling techniques and chooses one of them to use in this research.

Figure 5 maps the overall evening unloading and loading process. The process starts from the arrival of the first regional or route cargo vehicle and finishes once all nonregional vehicles are loaded. This figure splits the process into several sub-processes. Subsections 2.4.2, 2.4.3, 2.4.4, and 2.4.5 each focus on one of the sub-processes, except for the break.

Figure 5: Overall evening unloading and loading process



The team executing the tasks connected to the evening unloading and loading process consists of seven different functions. Below the main tasks of the functions are described.

Planner

The general cargo items are already appointed to the several depot vehicles in the morning. However, the planner must still schedule the route cargo items. The planner composes shipments, appoints them to the route cargo vehicles, and schedules the order of delivery for each vehicle. All information about the shipments is gathered into planning lists. The transport hall employees and manager use these lists for loading the items. Not all items automatically appointed to route cargo fit into the route cargo vehicles. Therefore, the planner must choose which items have priority. He appoints the items with a lower priority as general cargo anyway. The pump truck employees filter out these items from the zip code boxes. This process is called the fall-out. Subsection 2.4.4 discusses this further. He bases his decisions on possible time limits for delivery, the size and type of shipment, and the destination. For example, a shipment consisting of 2 Euro-pallets that is already on the planned route has priority over a shipment consisting of 1 colli for which the driver must make a detour. The shipment of 1 colli is then outsourced to the depot closest to the shipping address.

Pump truck employees

These employees unload the vans, box trucks, and trailer trucks using pump trucks. When the tailgate of a vehicle opens, the light on the inside of the dock shelter turns green, and the vehicle can be (un)loaded according to a specific sequence. We elaborate further on this in Section 2.4. When the tailgate is closed, the light on the inside of the dock shelter is red. After unloading, the pump truck employees move around the items inside the transport hall to eventually load them again. Every employee in the transport hall can execute these tasks.

Fork truck employee

When loading the vehicles, the fork truck employee first loads the doors in the front of the

designated vehicle. That way, the driver can unload them quickly at the customer. This task must be done correctly to keep the efficiency as high as possible without damaging the doors.

Scanner employee
The scanner employee scans the labels of the items in the dump box. The two screens in the transport hall show a number corresponding to the depot of destination. The scanner employee puts the correct sticker on the item and moves on to the next one. This task requires precision and must be done correctly so that the items are transported to the correct depot. There are two shifts on one night since only a few people can do this because it requires attention and precision.

Sorting belt employees
The sorting belt is not entirely automatic. One or more employees place the items from a yellow rack onto the sorting belt. Then they scan the items so that the sorting belt knows whether the item must go to the left or right on the belt. Next to both sides of the belt, an employee sorts the items and places them on the correct red rack corresponding to a depot. As Subsection 1.4.2 describes, the sorting belt and thus the sorting belt employees are out of scope.

Employee outside
The employee outside the transport hall ensures that the correct vans, box trucks, and trailer trucks are placed on the dock shelters. He gets a list of the customers of the evening, including the items to be transported. With the use of that list, he makes a schedule in his head on when to place which vehicle on a dock shelter. This is very reliable since the employee outside works at HST Groep already for a long time. When the light on the outside of a dock shelter turns green, the van, box truck, or trailer truck is (un)loaded and ready. The employee outside can then move it to the parking space if necessary. Otherwise, the light is red. The pump truck employees can choose the order of unloading the vans, box trucks, and trailer trucks themselves. However, the employee outside might tell them to start with a specific vehicle if he wants to move it away quickly.

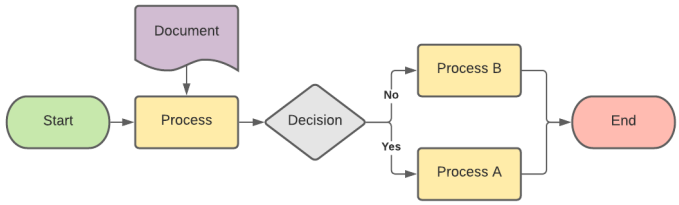
Manager transport hall
The manager of the transport hall manages all employees in the transport hall. He steers the process in the right direction by appointing tasks to the employees. For example, if an employee is not utilizing his time efficiently, he tells him to pick up another task. Furthermore, he sends employees home if there are too many employees for the work to be done. For example, only a few employees stay to load the route cargo vehicles if the fall-out process is done. The transport hall manager also performs checks. These checks aim to find the items that are not in the right place.

2.4.1 BPM techniques
Three commonly used BPM techniques are flowcharts, Business Process Modelling Notation (BPMN), and Unified Modelling Language (UML) diagrams. All three have their advantages and disadvantages. This subsection discusses them below.

In the beginning phase of process modelling, flowcharts were the dominant technique (Kim, Gangolly, & Elsas, 2017). According to Harrington (As cited in Silva, Longaray, Munhoz, & Castelli, 2019), it describes ongoing processes, showing the sequence of activities for process improvement. It presents all steps and events of the activities in the process relying on sequential flows. It is easy to understand, but it cannot capture much information. When a flowchart is large and complex, it is difficult to comprehend, tough to use, and insufficient for decision making (Kim et al., 2017). Some flowcharts contain a lot of pages, and symbols can have ambiguous meanings. Thus, flowcharts should preferable only be used for simple and predictable processes. Moreover, the structure and behaviour of a process are absent in a flowchart model (Kim et al., 2017). However, a structured and

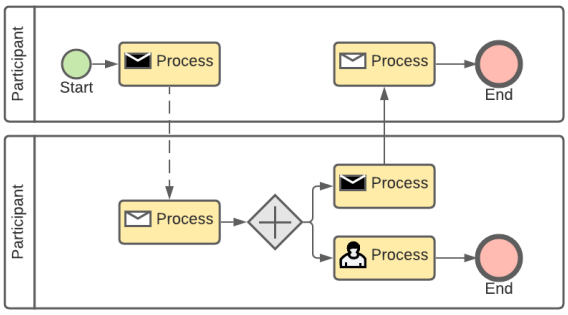
understandable BPM is important in this research since new employees will use the model as an introduction to the evening unloading and loading process. This should not take much time. Besides that, understanding the behavior of a process is essential for calculating productivity and developing a dashboard. The behaviour of a process gives a first impression of the ways to perform this. Therefore, the process modelling technique of flowcharts does not fit this research. Figure 6 shows an example of the setup of a flowchart.

Figure 6: Example set-up flowchart



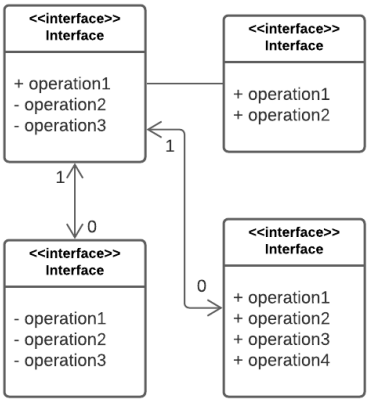
BPMN is based on the flowchart notation and has the similar aim of defining business processes (White & Miers, 2008). However, BPMN is structured in both simple and more complex models. This is due to the objective of having one notation for all process models. Therefore, companies do not have to retrain their employees since it is accessible for all business users (White & Miers, 2008). At HST Groep, most employees already understand how to implement it, and there are more than enough guides available on the internet. Since BPMN is accessible for all business users, it can serve as communication between business managers and process implementers (BPMN Group, 2017). Both parties can understand the models without much explanation, which saves time. Thanks to the standard identified objects, the developer can easily convert process diagrams to other languages or, for example, programming codes (Lopez-Campos, Cannella, Miranda, & Stegmaier, 2018). The unloading and loading process of HST TransMission is complex, so we split it into four sub-processes. Therefore, BPMN would be an adequate choice to use to have enough structure in the process models. Moreover, multiple stakeholders of this research should be able to interpret the process models easily. The accessibility of BPMN can ensure this. Figure 7 shows an example of a model using the BPMN.

Figure 7: Example BPMN



According to Pender (As cited in Carnaghan, 2006), UML diagrams are the standard for modelling object-oriented information systems. The process model in this research aims to get insights into several activities to identify the different segments of the process. However, developers use UML diagrams to visualize, specify, construct, and document the artefacts of a software-intensive system (Booch, Rumbaugh, & Jacobson, 1999). They are more technology-oriented rather than focusing on business objects and business process flows (Venkatraman & Venkatraman, 2019). Therefore, the process modelling technique of UML diagrams does not fit this research. Figure 8 shows an example of a UML diagram.

Figure 8: Example UML diagram



In this research, we use the BPMN technique to map the current process. Appendix B explains which elements a BPM using the BPMN consists of. These elements are the foundation for developing the BPMs for each sub-process of the evening unloading and loading process. The following subsections map and explain these BPMs.

2.4.2 Unloading regional and route cargo process

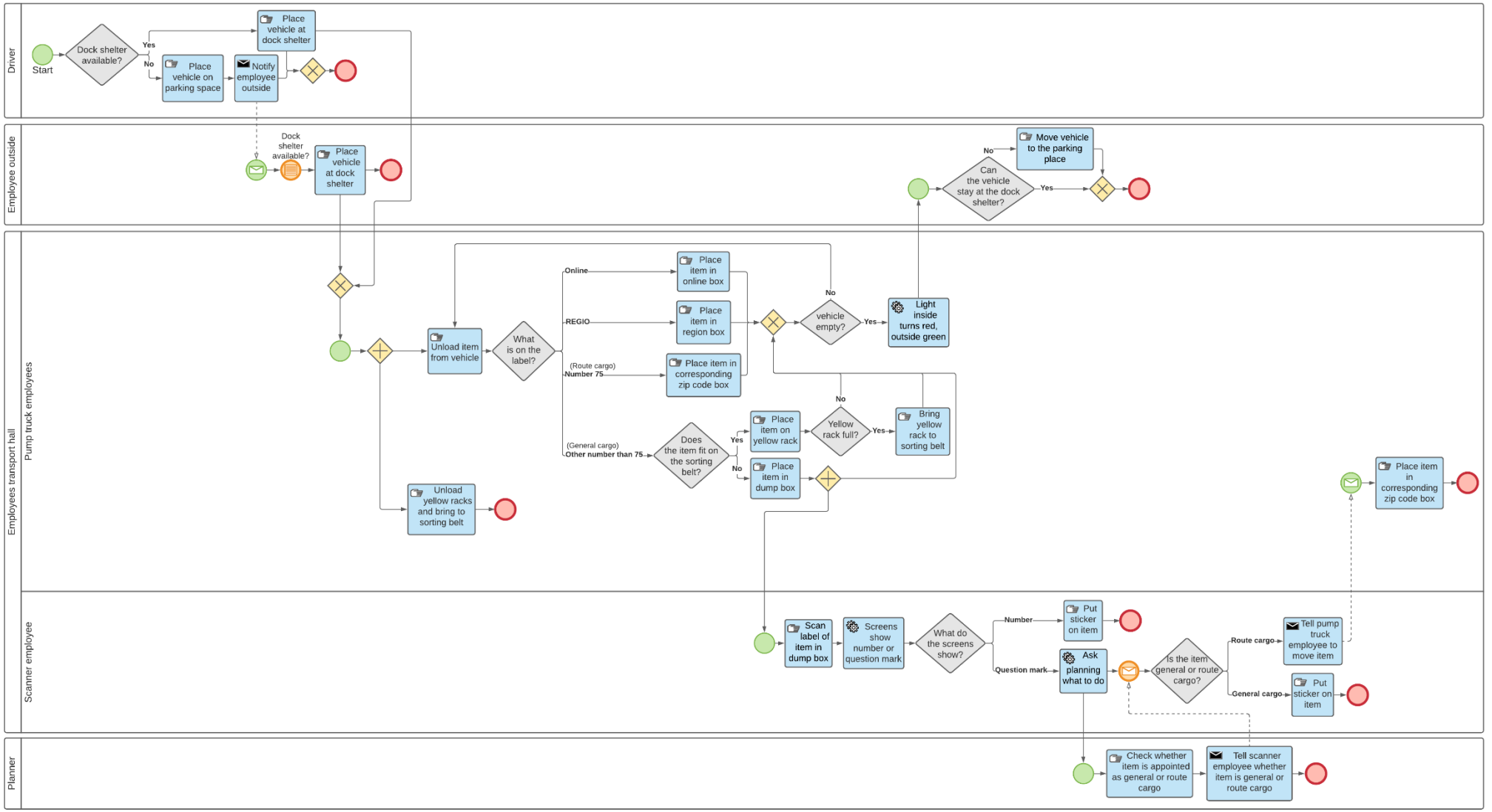
This process contains the unloading of the regional and nonregional shipments from the vans, box trucks, and trailer trucks. Figure 9 shows the BPM of the unloading regional and route cargo process. When a new vehicle arrives, the process starts all over.

The process starts with the driver or employee outside placing a vehicle at a dock shelter. The pump truck employees unload all items from the vehicle. They place the items in the boxes inside the transport hall according to what the external label on an item says. If the label says Online, the employee places it in an online box. REGIO means that the employee places it in a region box. 75 indicates that the item is outsourced by another depot to HST TransMission. Thus, the item is route cargo, and the employee places it in the corresponding zip code box. Items with other numbers than 75 are general cargo. The employee places such an item either on a yellow rack or in the dump box, depending on the item's size.

A small item, often a package, is placed on a yellow rack. If a yellow rack is full, the transport hall employee brings it to the sorting belt. A bigger item, often a pallet, is placed in the dump box. The scanner employee immediately scans items inside the dump box to process them further and make room for other items. The two screens in the transport hall show a number or a question mark. If they show a number, the scanner employee puts a sticker with the correct number on the item. If they show a question mark, he asks the planning what to do.

When the vehicle is empty, the employee outside decides whether the vehicle must be moved or not. His decision depends on dock shelter availability and whether a vehicle must be loaded soon. Often an empty vehicle must make room because there are too few dock shelters. This unloading regional and route cargo process is repeated for each vehicle.

Figure 9: BPM unloading regional and route cargo process

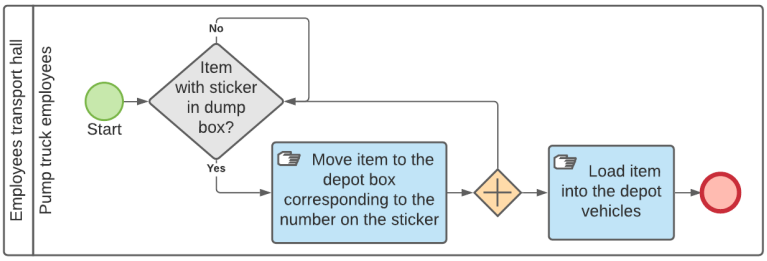


2.4.3 Loading general cargo process

This process contains the loading of the general cargo shipments. Figure 10 shows the BPM of the loading general cargo process. The process starts with the pump truck employees moving the items from the dump box to the correct depot box. The pump truck employees start loading the items into the depot vehicles as soon as possible to make room in the depot boxes for other items. Otherwise, not all items will fit in the depot boxes since they are small. Thus, the loading process already starts during unloading.

The aim during loading is to first load heavy or large items so that they are in the back of the vehicle. The problem is that the pump truck employees cannot reach every item in the transport hall since there is little space. For example, the depot boxes are right next to each other, so there is little movement space around them. The pump truck employees must move aside other items to reach the correct one. This causes time waste.

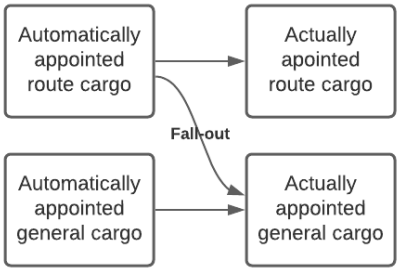
Figure 10: BPM loading general cargo process



2.4.4 Fall-out

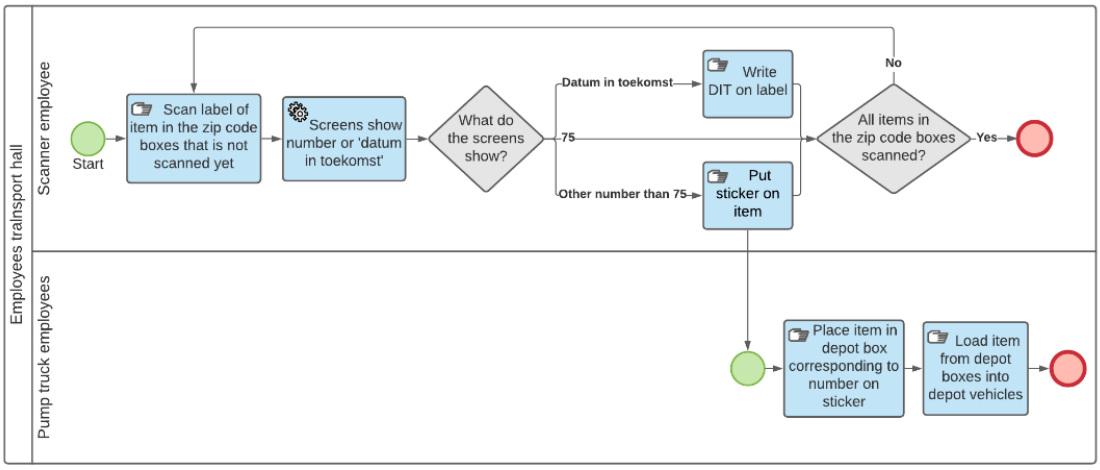
When the planner is finished, the fall-out starts. The system automatically appoints nonregional shipments to either general or route cargo. Section 2.1 discusses the difference between general and route cargo. The fall-out aims to filter out items that the planner eventually appointed to general cargo instead of route cargo, as the system automatically did in the first place. Figure 11 explains this.

Figure 11: Fall-out explained



The pump truck employees must load the fall-out items from the zip code boxes into the depot vehicles after all. Figure 12 shows the BPM of the fall-out. The scanner employee scans all labels of the items in the zip code boxes to search for the fall-out items. The fall-out items are the ones of which the screens show a different number than 75. The scanner employee puts a sticker with this number on the fall-out items. This number corresponds to the depot of destination. The pump truck employees move the fall-out items directly to the correct depot box and into the depot vehicle. In addition to showing a number, the screens can show ‘datum in toekomst’. Usually, items are delivered as soon as possible. However, these items have a delivery date somewhere far in the future. The scanner employee writes DIT on the label of such an item, and it stays in the transport hall.

Figure 12: BPM fall-out



2.4.5 Loading route cargo process

This process contains the loading of the regional route cargo shipments. Figure 13 shows the BPM of the loading route cargo process. First, the planner appoints the shipments to the drivers and prints the planning lists. The manager of the transport hall marks items on the lists to check. These items are mainly the items with a time limit for delivery since, if wrongly placed, they need to be loaded quickly. He puts another set of lists in the blue array and starts with the first check. He scans multiple items that are still in the zip code boxes. These items include the marked items from the planning lists and suspicious items.

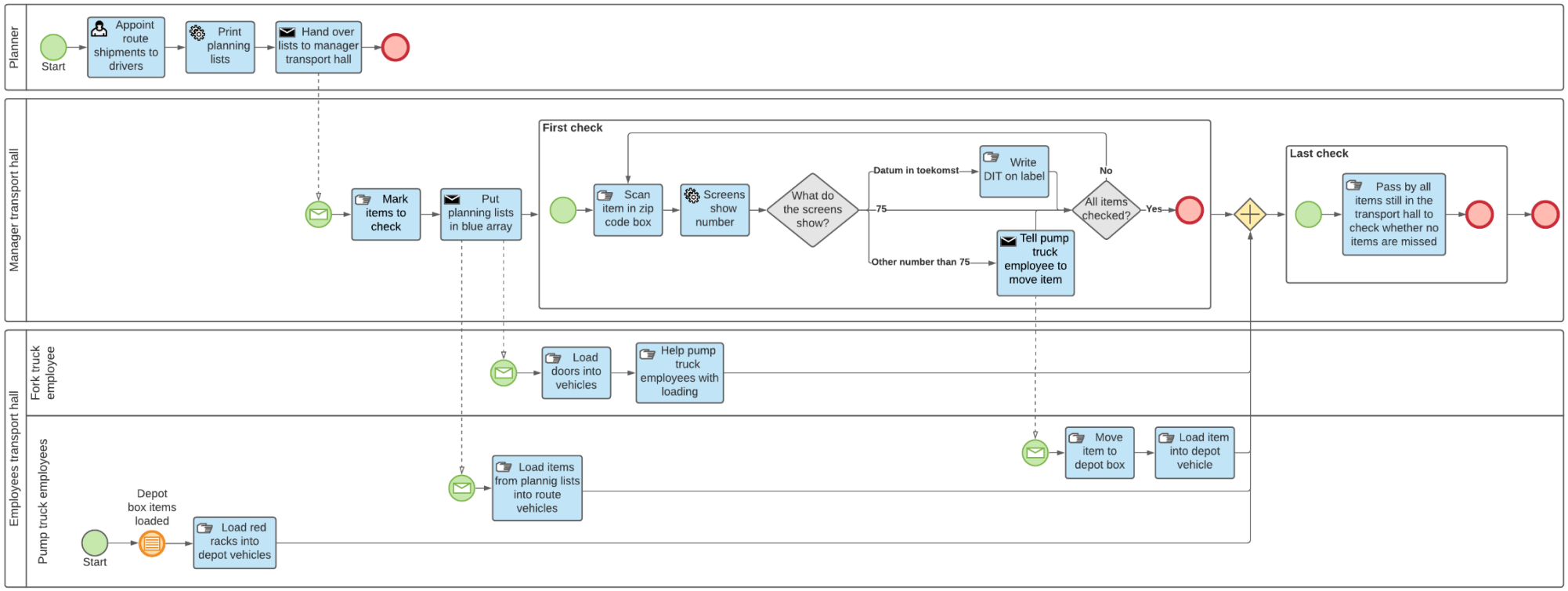
When scanning, the screens in the transport hall might show another number than 75, meaning that it is a general cargo item. Then, the transport hall manager tells the pump truck employee to move the item to the correct depot box. Another pump truck employee loads the item into the correct depot vehicle. Moreover, the screens might show ‘datum in toekomst’ when scanning an item. Then the transport hall manager writes DIT on the label, if not done yet.

While the transport hall manager performs the check, the transport hall employees start loading the route cargo using pump trucks. All employees take a planning list from the blue array corresponding to the shipment of one vehicle. They load the vehicles from the top of the list to the bottom so that the drivers can easily deliver the items from bottom to top. The planning list is thus the sequence of customers to visit. HST TransMission makes an exception for one of their permanent customers that transports doors. The fork truck employee loads these doors since they are relatively large and must be loaded in a specific way so that the driver can easily unload them. An experienced fork truck is required so that the doors will not get damaged.

Other pump truck employees start loading the red racks as soon as all general cargo is loaded. Thus, the red racks end up in the back of the vehicle, which ensures that the partner can first unload the red racks. The packages on the red racks can therefore be sorted out on time. Only the red racks, so not the yellow racks, are transported between the depots since the franchise owns them.

When all shipments are loaded, the transport hall manager performs the last check. During this last check, he passes by all items still in the transport hall. If he comes across items that the pump truck employees missed, they can still load them on time.

Figure 13: BPM loading route cargo process



2.5 SPAGHETTI DIAGRAM OF THE FLOWS IN THE TRANSPORT HALL

This section develops a spaghetti diagram to show examples of the flow of items through the transport hall. Figure 14 depicts this spaghetti diagram. With the use of this spaghetti diagram, we can visualize and analyze the movements of items within the transport hall of HST TransMission. We distinguish between four types of items: route cargo (displayed in Figure 14 with the dashed line), general cargo packages (dashed-dotted line), general cargo no package (solid line), and fall-out items (dotted line).

After unloading, a route cargo item moves to a zip code box before being loaded (dashed line). A package must always move to the sorting belt so that the employees can place it on the correct depot rack and into the vehicle (dashed-dotted line). Pump truck employees place a general cargo item, that is not a package, in the dump box (solid line). The scanner scans and stickers the items in the dump box so that the pump truck employees can place them into a depot box and into the correct general cargo vehicle. Pump truck employees first place fall-out items in a zip code box (dotted line) since the system automatically appointed such an item as route cargo. After planning, it becomes general cargo, and the pump truck employees move the item to a depot box and into the correct general cargo vehicle.

When analysing this spaghetti diagram, two things stand out. Firstly, the pump truck employees must completely drive around the boxes to move an item throughout the transport hall since most of the time the boxes are filled. Even if a pump truck employee moves an item aside two boxes, he must drive around a box. This takes time, and the pump truck employees cannot bypass each other easily next to the boxes. Secondly, the crowdedness around the dump and depot boxes stands out. The pump truck employees move all the general cargo items, that are no package, to the dump and depot boxes. This is a large number of items, and thus they must drive there frequently.

Besides the movements mapped in the spaghetti diagram, the pump truck employees constantly move other items aside to reach the correct item. HST TransMission aims to load items in a particular order to reduce time waste for the driver when unloading. However, this wastes a lot of time during the unloading and loading process.

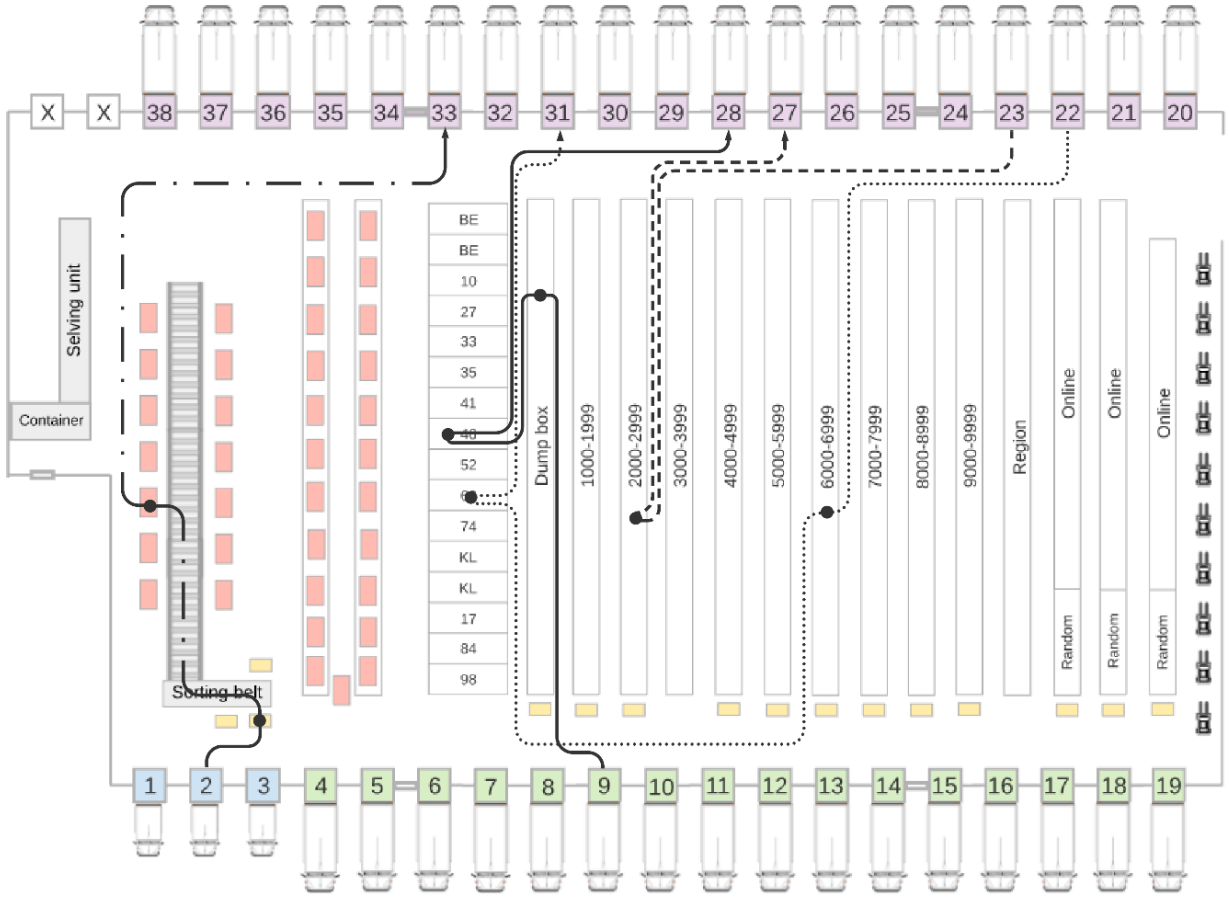
2.6 CONCLUSION

This chapter mapped and described the current situation of the layout of the transport hall and the evening unloading and loading process of HST TransMission. First, the difference between route cargo and general cargo is explained, then the floor plan on the layout of the transport hall is developed. After that, we elaborated on a timeline of the overall unloading and loading process. The chapter finished by mapping and describing the evening unloading and loading process in BPMs and the flows of items throughout the transport hall in a spaghetti diagram. The reason for choosing the BPMN is also discussed. This chapter answers the first research question:

1. *What does the current evening unloading and loading process look like?*

The evening unloading and loading process is divided into four subprocesses. It starts with unloading the regional and route cargo vehicles (Subsection 2.4.2) and loading the general cargo vehicles (Subsection 2.4.3). Then after the break, the fall-out starts (Subsection 2.4.4). The fall-out aims to filter out items that the planner eventually assigned to general cargo instead of route cargo. The process ends with loading the route cargo vehicles (Subsection 2.4.5).

Figure 14: Spaghetti diagram



1.1 What does the current layout of the transport hall look like?

The transport hall of HST TransMission consists of a sorting belt, red racks, depot boxes, a dump box, zip code boxes, a region box, online boxes, and random boxes (Section 2.2). It is arranged in a functional manner so that the transport hall employees can move around the items inside the transport hall.

1.2 What are the transport flows of the items in the transport hall?

There are four flows of items in the transport hall (Section 2.5):

- The flow of a route cargo item. After unloading, the item moves to a zip code box and into a route cargo vehicle.
- The flow of a general cargo package. After unloading, the item moves to the sorting belt, onto a red rack, and into a general cargo vehicle.
- The flow of a general cargo item that is not a package. After unloading, the item moves to the dump box and then the correct depot box before getting loaded.
- The flow of a fall-out item. After unloading, the item first moves to a zip code box, just like a route cargo item. When the planner is finished, the item moves to the correct depot box and into a general cargo vehicle.

This chapter has four main findings. Firstly, the transport hall seems tight. Especially the depot boxes are narrow and close to each other, and more than half of the red racks unnecessarily take up space since they do not fit at the sorting belt. Secondly, two subprocesses must wait for other tasks to end before they can start. The productivity of the process can increase by ensuring that this is not the case anymore. Thirdly, the pump truck employees must completely drive around the boxes to move an item throughout the transport hall. This takes time, and the pump truck employees cannot bypass each other easily. Lastly, it is crowded around the dump and depot boxes. To conclude, the layout of the transport hall and the evening unloading and loading process are designed inefficiently. Because of these inefficiencies, there are multiple possibilities for improvement.

3 DATA VISUALIZATION TOOLS AND KEY PERFORMANCE INDICATORS

This chapter develops a theoretical framework on data visualization tools and measurement of performance with the use of available literature. The aim is to answer the second and third knowledge question:

2. What data visualization tool is used to develop the performance dashboard of this research?
3. What are the most important characteristics of an effective KPI?

Section 3.1 elaborates on the process of choosing a visualization tool and the usage of the chosen tool. Section 3.2 explains the characteristics of an effective KPI. Section 3.3 concludes this chapter by answering knowledge questions 2 and 3.

3.1 DATA VISUALIZATION TOOL

This section discusses several data visualization tools and chooses one of them to create the performance dashboard. Important in this decision is the user-friendliness and the ability of HST TransMission to implement and use the performance dashboard. After that, it explains the way to use the chosen data visualization tool.

3.1.1 Selection data visualization tool

Three commonly used data visualization tools are Qlik Sense, Tableau Desktop, and Microsoft Power BI. All three have their advantages and disadvantages.

Qlik is a software company providing QlikView and Qlik Sense. According to Podeschi (As cited in Reddy, Sangam, & Rao, 2019), developers use QlikView for guided analytics and Qlik Sense for self-service visualization. In this research, we create a dashboard from scratch, so Qlik Sense fits better. Qlik Sense gives the user insights into data by visualization (Vashisht & Dharia, 2020). According to Reddy, Sangam, and Rao (2019), Qlik Sense has some great advantages, such as the ability to generate reports to Excel and PDF and the availability of robust mobile apps. However, they mention that using Qlik Sense requires a trained developer (Reddy et al., 2019). A training program for employees of HST TransMission would be necessary, which takes a lot of time and resources. Therefore, Qlik Sense is not the best option to use.

According to Alksne, Jansone, and Berzkalne (2019), Tableau is a powerful and fast-growing data visualization tool used in the business intelligence industry. It is an important tool to make data analytics and visualizations. It is popular because of its user-friendly interface (Alksne et al., 2019; Zhang, Chen, & Wei, 2020). User-friendliness is essential, and not much time should be wasted to understand and get used to the visualization tool. Nevertheless, the website of Tableau provides multiple training platforms if necessary (Zhang et al., 2020). Besides user-friendliness, the tool needs to have the ability to import a large amount of data. According to Reddy et al. (2019), Tableau can connect with multiple data sources, and the amount of data is based on the availability of memory. Thus, Tableau does not obstruct the amount of imported data. Moreover, the data can be transformed into very complex visualizations (Shivakumar, 2019). Therefore, a developer can customize the results to the wishes of the company. Next to these advantages, Tableau has some disadvantages as well. It does not provide all statistical features (Alksne et al., 2019). Thus, Tableau obstructs some freedom from the analysis of data. Moreover, the graphs of Tableau are not dynamic (Alksne et al., 2019). This means that the performance dashboard does not update automatically with real-time data. Dynamic graphs are, however, important for having a consistent performance dashboard.

Power BI has analytical self-service capabilities that create reports and dashboards (Reddy et al., 2019). Power BI has some advantages compared with other visualization tools. It has a great interactive capability that ensures a user-friendly interface (Gurdon, Esmahi, Amponsah, & Wang, 2020). This is due to the user interface being similar to other Microsoft services (Shivakumar, 2019). Most people have used a Microsoft service at least once in their life. Besides that, HST TransMission already is a Microsoft client, and Power BI can therefore be used. According to Setiawan and Sudecanto (2019), Power BI has many easier to use features compared with other visualization tools. In a Power BI dashboard, the user can select scenarios and explore solutions (Gurdon et al., 2020). This contributes to the success of this research since we can prove improvements within the unloading and loading process and the layout of the transport hall. The main disadvantage of Power BI is that it does not deal well with vast information sources (Reddy et al., 2019). This could be a problem when having millions of rows and columns of data.

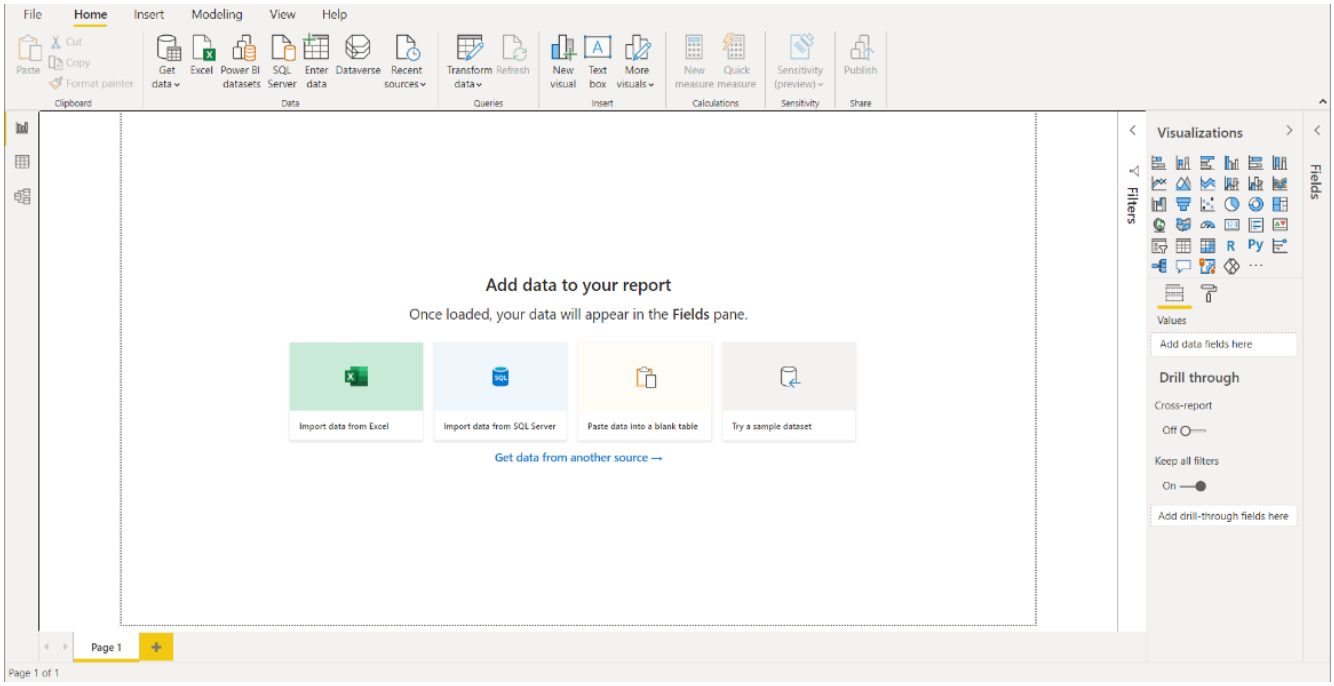
Tableau and Power BI are both suitable options. Therefore, we need to compare the two more in-depth. Power BI is more user-friendly than Tableau (Shivakumar, 2019). It is easier to create a logical layout and story by using Power BI. Besides that, the IT department of HST Groep already uses Power BI. Thus, if we choose Tableau, HST TransMission must purchase it, which is not the case for Power BI. Moreover, the IT employees are already used to apply this tool.

Every year, Gartner develops a report about visualization tools based on thousands of reviews. According to Gartner (2021), Microsoft Power BI, Tableau, and Qlik are the market leaders. It also shows that Power BI has more completeness of vision and a higher ability of execution. With all considerations kept in mind, we decide to use the visualization tool Power BI in this research.

3.1.2 Power BI

Power BI converts data into relevant analytics and reports (Gurdon et al., 2020). To do this, the developer must upload and transform data, create visualizations, and import the performance dashboard. Figure 15 shows the home page of the Power BI desktop.

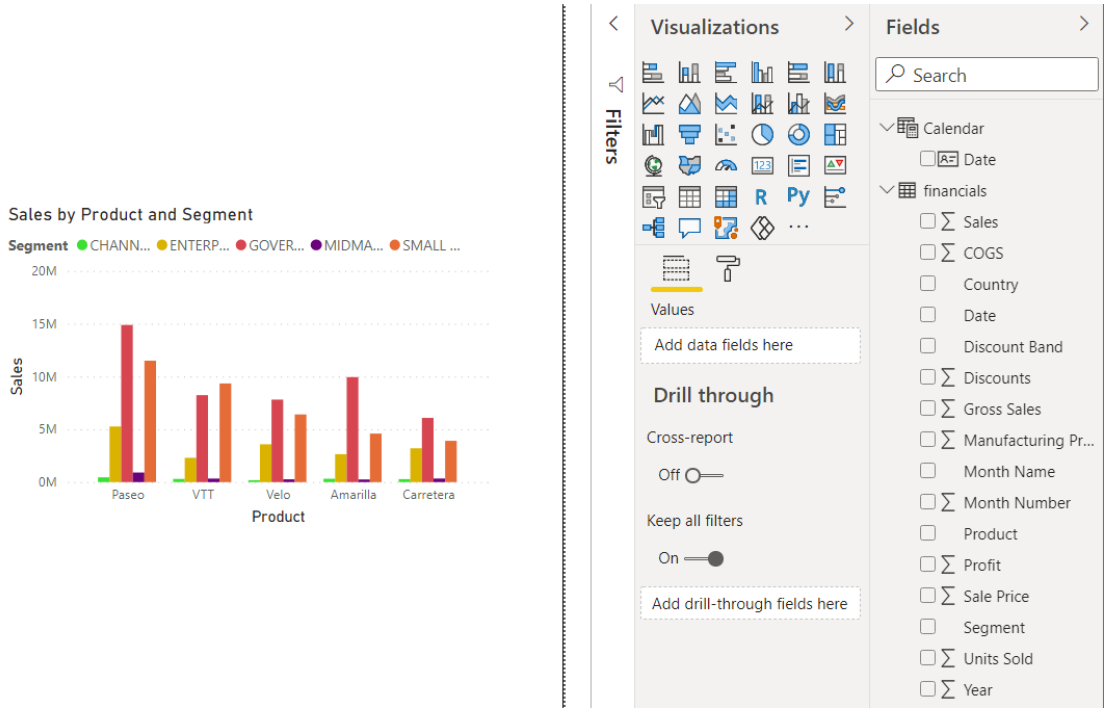
Figure 15: Home page Power BI



The first thing to do is to upload a dataset from, for example, SQL or Excel. Once uploading a dataset, the Navigator screen pops up. The developer can transform the data by clicking on 'transform data'. The Power Query Editor appears. In there, the developer can transform the data in several ways. According to Sparkman and Sherer (2021), we must make transformations before loading the dataset to make the visualizations easier to read later. A few of these transformations are the column title, data type, text format, delete rows, column and text filters, and merge queries. The developer can change the title of a column by double-clicking on it. The data type (whole number or decimal), text format (lowercase or capital each word), and delete rows transformation can be found in the window on the top. By clicking on the dropdown of a column, the developer can add column or text filters. With the use of a filter, the developer can exclude specific values from the data. Merging queries ensures that several datasets can be merged so that all required data is available.

Once the developer is finished with transforming the data, he can start developing the dashboard. The developer adds visuals by dragging multiple fields into the working space. He defines the axis and values. Besides that, he chooses a visualization type and the format colors. Figure 16 shows an example of a possible visual. For this example, we use a build-in sample dataset from Power BI. We plot the sales against the products for each segment. The visualization is a column chart.

Figure 16: Example visual



More information about Power BI can be found in Ferrari and Russo (2016). This book introduces Power BI by explaining the basics.

3.2 Effective KPI

KPIs are quantifiable measures used to evaluate the success of a company, product, employee, team, and so on (Kamari & Kirkegaard, 2019). They compare the current performance against a target required to fulfil business objectives (Tardio & Peral, 2015). In this research, we use KPIs to show the performance of the productivity in the transport hall of HST TransMission. Chapter 5 defines these KPIs. When changes are made in either the layout of the transport hall or the design of the process, they can be monitored using the KPIs.

We make the KPIs visible using a performance dashboard. With this performance dashboard, the user can directly identify differences in the KPI values before and after implementing a change. This allows him to quickly determine whether the change is positive and whether the productivity has improved. For this to be useful, the KPIs must be effective. The characteristics of an effective KPI found in literature are: measurable, frequently monitored, improvability, decision-based, quantifiable and visualizable, and user-friendly. When defining the KPIs of this research, we check whether each KPI matches the characteristics of an effective KPI. If not, we can adjust them so that they are indeed effective.

Measurable

According to Alwear (as cited in Kamari & Kirkegaard, 2019), an effective KPI presents a measure of performance (Tardio & Peral, 2015). This performance refers to an individual, group, company, or process. Therefore, the KPI ties responsibility down to, for example, a team. A manager can call a team leader who can take action based on the performance of the measured KPI. This measurement shows the efficiency and quality improvement of a process or company (Ying, Tookey, & Seadon, 2018). The KPI calculates the efficiency and quality before and after a decision so that the KPI can show the differences. Besides that, the measure is implementable and monitored in practice so that decisions can be based on the KPI (Lop, Ismail, & Isa, 2017; Ying et al., 2018). This refers to the fourth characteristic, decision-based.

Frequently monitored

An effective KPI is frequently monitored (Lop et al., 2017). This could be 24/7, daily, or weekly. The KPI can then be updated frequently. By doing this, the management always knows what is happening. It also allows them to compare and contrast different options (Kamari & Kirkegaard, 2019). To be able to do this, they should understand what a particular KPI value means. Therefore, an effective KPI includes a yardstick to measure progress along the way (Kamari & Kirkegaard, 2019). In advance, the management can link responses and decisions to certain values. As soon as the value of the KPI changes, they immediately know how they should act.

Improvability

An effective KPI successfully improves the process or company (Loumos, Christonakis, Mpardis, & Tziova, 2010). As earlier mentioned, the measure of performance shows this improvement. This means that the managers can identify opportunities for progressive improvements with the use of KPIs (Ying et al., 2018). They can check whether adaptions in their processes and changes in their way of working have a positive impact.

Decision-based

An effective KPI is decision-based, so it encourages appropriate action in the right direction (Kamari & Kirkegaard, 2019; Loumos et al., 2010). The management, for example, should evaluate the KPI to minimize the negative risks and maximize the potential gains. Based on the KPI, the management identifies performance targets and standards (Kamari & Kirkegaard, 2019; Tardio & Peral, 2015; Ying et al., 2018). These performance targets and standards are clear statements of what might be achieved. They can be part of the company's business goal and objective (Loumos et al., 2010). This goal and objective, partly based on the KPI, are essential for external stakeholders as well. Thus, the KPI should contain a perspective for all stakeholders (Ying et al., 2018). They have an interest in how well the company performs. Each stakeholder wants the company to go well from their perspective, so their objectives might not align.

Quantifiable and visualizable

An effective KPI is quantifiable and visualizable so that users can directly see the performance

measure. Quantifiable means that it is expressed in numbers. A KPI can be quantitative or qualitative (Loumos et al., 2010). A qualitative KPI can be converted to a quantitative KPI with the use of indicators. A quantifiable KPI ensures that managers can easily compare values. If a KPI is quantifiable, it can be visually representable (Loumos et al., 2010). According to Tardio and Peral (2015), 'what you see is what you get'. A visually representable KPI is more effective since users less easily misinterpret it.

User-friendly
An effective KPI is user-friendly and usable by anyone (Kamari & Kirkegaard, 2019; Lop et al., 2017). This means that a simple and straightforward interface is needed (Kamari & Kirkegaard, 2019). This interface is often structured like a performance dashboard. The user should always be considered when developing a KPI. Choosing suitable types of visualization is crucial. Besides that, we should logically derive and explain the KPI so that it cannot be misinterpreted. An effective, user-friendly KPI is moreover specific (Lop et al., 2017). A specific KPI is less vague and thus easier to understand. Section 4.3 further elaborates on the user-friendliness of a performance dashboard based on KPIs.

The developed KPIs of this research focus on calculating and mapping the productivity of the evening unloading and loading process. The formula of such a measurement is often vague and not specific. Therefore, we use KPIs to provide more clarity. Furthermore, the KPIs give insights into the origin of the productivity value by displaying the input values of the productivity formula. It shows the reason why the productivity is higher or lower than expected. Moreover, the KPIs can focus on the different segments of the process by adjusting the productivity formula. Based on this, the manager of HST TransMission can identify in what part of the process improvements can be made. At the moment, such insights to base decision on are missing at HST TransMission.

3.3 PRODUCTIVITY

Productivity is a measure that states how well resources are managed and utilized to achieve the highest outcome (Akbar, Chumaidiyah, & Rendra, 2020). In other words, it is the efficiency of production. It describes how much output is obtained from a given set of inputs (Syverson, 2011). The output of a process is the quantity produced, and the input is the resources used to produce it. Researchers often express productivity as an output-input ratio (Chew, 1988). This output-input ratio is the relationship between the output and input. The higher the ratio, the higher the efficiency in production. This ratio is complex, and thus we make it measurable with the use of KPIs.

There is no single measure of productivity (OECD, 2001). This makes the calculation difficult but simultaneously provides freedom. However, a distinction is made between three main types of productivity: labor, capital, and intermediate input productivity. These types are depending on how the input is calculated. The most commonly used type is labor productivity (Syverson, 2011). The choice of which type to calculate depends on the purpose of productivity measurement and often on the availability of data (OECD, 2001). This research focuses on labor productivity since there is insufficient data available on the other types of productivity. Therefore, the input factor of the calculations is based on labor. Thus, throughout this thesis, by productivity we mean labor productivity. We elaborate further on this in Chapter 5 when identifying the KPIs.

3.4 CONCLUSION

This chapter develops a theoretical framework on data visualization tools and measurement of performance based on literature. First, we chose a visualization tool to create the performance dashboard by discussing several options and explain how to use that tool. Then, the characteristics

of an effective KPI are discussed. Lastly, the concept of productivity is defined. This chapter answers the second and third research question:

2. *What data visualization tool is used to develop the performance dashboard of this research?*

We chose the visualization tool Power BI because it has a more user-friendly interface compared to the other tools discussed (Subsection 3.1.1). Besides that, the IT department of HST Groep already uses Power BI. Therefore, there are no purchase costs involved, and the employees of the IT department can answer questions regarding the development of the performance dashboard. In Power BI, the developer can upload and transform data, create visualizations, and import the performance dashboard (Subsection 3.1.2).

3. *What are the most important characteristics of an effective KPI?*

The most important characteristics of an effective KPI are: measurable, frequently monitored, improvable, decision-based, quantifiable and visualizable, and user-friendly (Section 3.2).

4 PERFORMANCE DASHBOARD REQUIREMENTS

This chapter discusses the performance dashboard conditions of this research. We derive the information from conducting a semi-structured interview with the manager of HST TransMission. Having the conditions of the performance dashboard straight is essential to meet the requirements of HST TransMission. This chapter aims to answer the fourth knowledge question:

4. Which requirements of HST TransMission should be considered when developing the performance dashboard?
4.1 What current possibilities to display a dashboard are there within HST TransMission?
4.2 How can the performance dashboard be made user-friendly?

Section 4.1 explains the requirements of HST TransMission for a performance dashboard. Section 4.2 describes the current dashboard possibilities within HST TransMission. Section 4.3 elaborates on the user-friendliness of performance dashboards. Section 4.4 concludes this chapter by answering knowledge question 4.

4.1 REQUIREMENTS HST TRANSMISSION

At the end of each working day, the manager of HST TransMission should have an overall image of the productivity of the evening unloading and loading process of that day. The performance dashboard should automatically compare the total productivity with a specific norm that is predetermined. To compare the productivity of a specific day with the norm, the input data and way of calculating should be the same.

If the norm is not met, the manager should be able to zoom into the productivity of the several segments of the evening unloading and loading process to see what causes the deviation from the norm. The visuals for this will be accessible by going to the other pages of the performance dashboard. Besides that, one page should compare the productivity of the different segments. However, the required data might not be complete or might not be easily accessible in one place. This means that we must find ways to get all data or even develop missing data.

In the future, the manager of HST TransMission would like to have all input data of the dashboard in the portal system of HST TransMission to increase automatization. By executing this research, we can find out what data is missing and collect all required data. After this research, the IT department of HST Groep can make sure that the missing data is incorporated into the portal system. The system should then be linked to Excel to directly load the input data of the performance dashboard into Excel. This ensures that the data is automatically transformed and transferred to Power BI.

4.2 CURRENT PERFORMANCE DASHBOARD POSSIBILITIES

As Subsection 3.1.1 describes, HST TransMission is already using Power BI to display its data and statistics. These current Power BI performance dashboards might support this research. Unfortunately, the current performance dashboards that are available are limited. In the past, data was not structured, and statistics did not exist at HST TransMission. The manager aims to make drastic changes. About half a year ago, he started a project to calculate and map certain KPIs within the company. This thesis is part of that project, focussing on the transport hall. Since the overall project is still in the beginning phase, the existing performance dashboards are still in progress. Therefore, there are no performance dashboards from HST TransMission to serve as a template for

this research. However, HST TransMission might use the performance dashboard of this research as a template for other dashboards.

4.3 USER-FRIENDLY PERFORMANCE DASHBOARD

The user is the person for which we develop the performance dashboard. Thus, this section puts him in the center of the performance dashboard development. An essential factor in developing a user-friendly performance dashboard is understanding the users. The main user is the manager of HST TransMission. The user must be involved throughout the design process of the dashboard such that it, in the end, achieves its intended impact (Laurent et al., 2021). Section 4.1 describes the requirements of HST TransMission. These requirements express the main purpose of the performance dashboard. The main purpose is to show the productivity in the different segments of the process. By doing this, the manager should directly see the useful data and statistics related to the productivity. Besides that, the performance dashboard should be attractive to look at, and the meaning of the productivity KPIs must be clear and comprehensible. This section discusses these three requirements.

Firstly, in a user-friendly dashboard, the user can directly see the useful data. The most important data is the productivity in the different segments. This is a lot of data to be shown. However, less is more (Holjevac & Jakopec, 2020). Therefore, the front page of a user-friendly dashboard is kept clear and straightforward. So, the front page of the performance dashboard of this research would, for example, only show the productivity in the different segments of the process. Then, other pages can zoom into the details to derive the cause of a high or low productivity. Moreover, the user should be able to customize the dashboard if he would like to focus on specific data. The slicer function of Power BI, for example, can add the option of customization by creating the option of filtering the dataset.

Secondly, a user-friendly performance dashboard is attractive to look at. The font, chart types, layout, and color combinations should be kept in mind. The chart types of the visualizations ensure that they effectively tell the story of the performance dashboard. Some charts might aim to see whether a target is met or to compare the performance to dates in the past. The layout of the performance dashboard supports the navigation by making important pieces larger and grouping related data next to each other. In this specific case, the color combination of the dashboard should be color-blind-friendly since the user is color blind. According to Bailey (As cited in De Araújo, Dos Reis, & Bonacin, 2017), color blindness is the inability to perceive certain colors or to make confusion between colors. Thus, we must consider which colors the manager can and cannot distinguish. However, this is not only important for this research. It should be a requirement for all performance dashboards since about one in twelve people are color-blind (Wei, Wang, & Kraak, 2020). When considering color blindness during the choice of colors, all possible users can distinguish between the different graphs and lines. According to Goedhart (2020), there exist several color-blind-friendly palettes to label data and statistics. For the performance dashboard of this research, we use the theme ‘Color Blind Friendly’ from the Power BI themes gallery of Microsoft (2017).

Thirdly, the meaning of the KPIs must be clear and comprehensive. The user, who is the manager of TransMission, must correctly understand them. The manager will give directions to people based on the performance dashboard. If he does not understand the KPIs, he might misinterpret the results depicted in the visuals. If that happens, the manager can give directions to people based on wrong interpretations. To ensure that the KPIs are clear and comprehensive, they should be logically derived. Besides that, the visuals of the performance dashboard should contain titles and legends. If the manager doubts the meaning of a KPI, he can fall back on them.

4.4 CONCLUSION

This chapter discussed the conditions of the performance dashboard of this research. First, the requirements of HST TransMission are discussed. After that, the current possibilities of the performance dashboard are explained. The chapter finished with discussing four requirements to develop a user-friendly performance dashboard. This chapter answers the fourth research question:

4. *Which requirements of HST TransMission should be considered when developing the performance dashboard?*

At the end of each working day, the manager would like to have an automatically generated performance dashboard displaying the productivity. It would compare the total productivity to a specific predetermined norm based on previous data. Moreover, he would like to zoom into the productivity in several segments of the process to understand the cause. The required data should be collected, and missing data should be developed (Section 4.1).

4.1 What current possibilities to display a dashboard are there within HST TransMission?

HST TransMission started about half a year ago on a project to map data and statistics. Since this is still in the beginning phase, the existing performance dashboards are still in progress. Therefore, there are no performance dashboards from HST TransMission that serve as a template for this research (Section 4.2).

4.2 How can the performance dashboard be made user-friendly?

There are three requirements for a dashboard to be user-friendly. The user of the performance dashboard should see the useful data directly, the performance dashboard should be attractive to look at, and the meaning of the KPIs must be clear and comprehensible. Besides that, this specific performance dashboard requires to be color-blind-friendly (Section 4.3).

5 DESIGN AND DEVELOPMENT PERFORMANCE DASHBOARD

This chapter discusses the design and development of the performance dashboard. It aims to answer the fifth knowledge question:

5. What productivity KPIs fit the loading and unloading process of HST TransMission and should be selected?
5.1 How can the selected productivity KPIs be calculated?
5.2 What data is required from the company to calculate the productivity KPIs?

Section 5.1 explains the process of defining the productivity KPIs to be displayed on the dashboard. Besides that, it discusses how to calculate these KPIs. Section 5.2 elaborates on the data required for calculating the KPIs. Section 5.3 discusses the final data set for the performance dashboard. Section 5.4 concludes this chapter.

5.1 PRODUCTIVITY KPIS

To measure the productivity performance of the evening unloading and loading process in the transport hall, we select several KPIs to be displayed on the performance dashboard. These KPIs are based on the output-input ratio with which researchers often express productivity (Chew, 1988).

$$Productivity = \frac{Output}{Input} \qquad (1)$$

We split the KPIs into three groups based on this ratio: output, input, and productivity. For each group, there are two types of KPIs: overall process KPIs and segment KPIs. The overall process KPIs refer to the productivity of the total evening unloading and loading process. The segment KPIs refer to the productivity of the several segments of the evening unloading and loading process.

The segment productivity KPIs can be based on two methods of identifying the segments. Firstly, it can be based on the tasks within the subprocesses of the evening unloading and loading process. Thus, it will zoom into the productivity of each part of the process. Thus, KPIs for unloading, loading general cargo, loading route cargo, scanning pallets, and fall-out. A KPI for loading general cargo, for example, can be the employee hours for loading the general cargo per day.

Secondly, it can be based on the several functions within the evening unloading and loading process. Thus, the planner, pump truck drivers, fork truck drivers, scanner, sorting belt employees, employee outside, and transport hall manager. A KPI for the pump truck drivers, for example, can be the number of times they move a pallet.

For both methods, the data available is limited. The first method focuses on the process, while the second method focuses on the individual roles. For now, the focus on the process suits better since the purpose of developing the performance dashboard is, among other things, to recommend improvements to the process. Therefore, the segments refer to the tasks within the subprocesses of the evening unloading and loading process.

We calculate all productivity KPIs daily, thus per evening process. The performance dashboard can then calculate the monthly and yearly values. If a KPI is shown per month, it is the average of the daily KPI values of the corresponding dates of the month. The same holds for the yearly KPIs, which is the average of the daily KPI values of the corresponding dates of the year. The user can easily adjust the KPIs separately on the performance dashboard to daily, monthly, and yearly.

5.1.1 Output

To calculate the productivity of the process, the output should be determined. The output factor is dependent on the process of which the productivity is calculated. The output of a process is the number of products produced (Chew, 1988). In the evening unloading and loading process, the total output is the unloading and loading of the items. From now on, this research focuses on pallets instead of all types of items within the transport hall. To calculate the total output, we take the sum of the pallets in the shipments within a certain period. Thus, the overall process KPI, depicted in equation (2), represents the total output.

$$\text{Number of pallets moved throughout the whole evening process} = \Sigma\ Number\ of\ pallets\ in\ shipment \quad (2)$$

To show the number of pallets per type of transportation unit, we add another KPI, depicted in equation (3).

$$\text{Number of pallets from a specific type of transportation unit moved throughout the whole evening process} = \Sigma\ Number\ of\ [mini, disposable, euro, half]\ pallets\ in\ shipment \quad (3)$$

For the several segments, the output is the service of unloading pallets, loading general or route cargo pallets, scanning pallets, and moving fall-out pallets. Therefore, the following segment KPIs, depicted in equations (4) until (9), represent the several segment outputs.

Equation (4) indicates the unloading output. Every evening, the transport hall employees must unload all pallets of the shipments. Thus, the number of pallets unloaded is equal to the total number of pallets of all shipments.

$$\text{Number of pallets unloaded} = \Sigma\ Number\ of\ pallets\ in\ shipment \quad (4)$$

Equation (5) depicts the loading general cargo output, whereas equation (6) depicts the loading route cargo output. Every evening, the transport hall employees must load all general and route cargo pallets of the shipments. Figure 11 depicts these KPIs as the actually appointed general and route cargo. Thus, the loading general cargo output is the number of general cargo pallets, including the pallets that fell-out after planning. In addition, the loading route cargo output is the number of route cargo pallets, excluding the pallets that fell-out after planning.

$$\text{Number of general cargo pallets loaded} = \Sigma\ Number\ of\ general\ cargo\ pallets\ in\ shipment \quad (5)$$

$$\text{Number of route cargo pallets loaded} = \Sigma\ Number\ of\ route\ cargo\ pallets\ in\ shipment \quad (6)$$

Equation (7) indicates the scanning output. Every evening, the scanner employee must scan all pallets of the shipment. Thus, the number of pallets scanned is equal to the total number of pallets of all shipments.

$$\text{Number of pallets scanned} = \Sigma\ Number\ of\ pallets\ in\ shipment \quad (7)$$

Equations (8) and (9) depict the fall-out output. The data for calculating these KPIs can be derived from the planner, whereas the other data is obtained from somewhere else. It could be possible that the data values of the planner do not match the data values already obtained. If we then take the number of fall-out pallets from the data of the planner, it gives a distorted view. Therefore, we use

the percentage of fall-out pallets to derive the number of fall-out pallets from the already obtained data.

The percentage of fall-out pallets, equation (8), is the percentage of fall-out pallets of the number of automatically appointed route cargo pallets. So, the percentage of automatically appointed route cargo pallets that did not fit into the route cargo vehicles and thus the planner appointed to general cargo. The more automatically appointed route cargo pallets the planner can appoint to a route cargo vehicle, the lower the percentage of fall-out pallets. The lower the percentage of fall-out pallets, the fewer pallets the transport hall employees must move again. Thus, less input is needed for the same amount of output, causing the productivity to increase. Thus, the aim is to minimize this KPI.

$$\%\ \text{of fall} - \text{out pallets} = \frac{Number\ of\ fall - out\ pallets}{Number\ of\ automatically\ appointed\ route\ cargo\ pallets} * 100\% \quad (8)$$

The number of fall-out pallets, equation (9), is the number of actually appointed route cargo pallets divided by, 100% minus the percentage of fall-out pallets, times the percentage of fall-out pallets.

$$\text{Number of fall} - \text{out pallets} = \frac{\Sigma\ Number\ of\ route\ cargo\ pallets\ in\ shipment}{100\% -\ \%\ of\ fall - out\ pallets} * \%\ of\ fall - out\ pallets \quad (9)$$

5.1.2 Input

To calculate the productivity of the process, the input should be determined. The input of a process is the resources used to produce the service or product (Chew, 1988). Since this research focuses on labor productivity, there is a choice of whether to use the employee hours, the number of employees, or some quality-adjusted labor measure as an input factor (Syverson, 2011). We choose to use both the employee hours and the number of employees because then we can compare the team productivity with the individual productivity. The employee hours refer to the labor hours of the transport hall employees, and the number of employees refer to the transport hall employees of the evening unloading and loading process. The productivity based on the employee hours points out the efficiency of the whole transport hall team. In addition, the productivity based on the number of employees points out the individual efficiency of the employees. We explain this in more detail in Subsection 5.1.3. The overall process KPIs, depicted in equations (10) and (11), represent the two types of total input.

$$\text{Total employee hours of evening process} = \Sigma\ Total\ duration\ in\ hours\ of\ employees\ working \quad (10)$$

$$\text{Number of employees working during evening process} \quad (11)$$

To show the number of pallets per type of employee, we add two other KPIs, depicted in equations (12) and (13).

$$\text{Total employee hours of evening process from a specific type of employee} = \Sigma\ Total\ duration\ in\ hours\ of\ [HST, Timing]\ employee \quad (12)$$

$$\text{Number of [HST, Timing] employees working during evening process} \quad (13)$$

For the several segments, the input is the employee hours on the segment or the number of employees unloading, loading general or route cargo, scanning, and fall-out. Therefore, the following segment KPIs represent the several segment inputs.

Equations (14) and (15) indicate the two types of unloading input.

$$\text{Employee hours unloading} = \Sigma\ Employee\ hours\ unloading \quad (14)$$

$$\text{Number of employees who are unloading pallets} \quad (15)$$

Equations (16) and (17) depict the two types of loading general cargo input, whereas equations (18) and (19) depict the two types of loading route cargo input.

$$\text{Employee hours loading general cargo} = \Sigma\ Employee\ hours\ loading\ general\ cargo \quad (16)$$

$$\text{Number of employees who are loading the general cargo} \quad (17)$$

$$\text{Employee hours loading route cargo} = \Sigma\ Employee\ hours\ loading\ route\ cargo \quad (18)$$

$$\text{Number of employees who are loading the route cargo} \quad (19)$$

Equations (20) and (21) indicate the two types of scanning input.

$$\text{Employee hours scanning} = \Sigma\ Employee\ hours\ scanning \quad (20)$$

$$\text{Number of employees who are scanning pallets} \quad (21)$$

Equations (22) and (23) indicate the two types of fall-out input.

$$\text{Employee hours moving fall} - \text{out pallets} = \Sigma\ Employee\ hours\ fall - out \quad (22)$$

$$\text{Number of employees who are moving fall} - \text{out pallets} \quad (23)$$

5.1.3 Productivity

This research distinguishes between two types of productivity: team and individual productivity. The productivity of a process is the output per unit of input. Thus, the team productivity of the evening process is the number of pallets per transport hall employee hour. The team productivity points out the efficiency of the whole transport hall team. In addition, the individual productivity of the evening process is the number of pallets per transport hall employee. The individual productivity points out the efficiency per employees.

The hiring process of an employee is costly and time-consuming (Acemoglu & Hawkins, 2014). Therefore, HST TransMission wants to employ as less new employees as required. The individual productivity should be maximized so that the employees can still process the same workload. To reach this, employees must work more hours per evening process. However, as the number of hours per employee a day increases, an employee becomes less productive per hour (Collewet & Sauermann, 2017). This means that the team productivity decreases and in total more hours are needed to process the same workload. Since the salary of employee is based on the employee hours, it is more expensive to process one pallet. HST TransMission should search for the right balance

between the two types of productivity. Therefore, we choose to display both methods of calculating the productivity of the evening unloading and loading process on the performance dashboard.

$$Team\ productivity = \frac{Number\ of\ pallets}{Transport\ hall\ employee\ hours} \quad (24)$$

$$Individual\ productivity = \frac{Number\ of\ pallets}{Number\ of\ transport\ hall\ employees} \quad (25)$$

Therefore, the overall process KPI depicted in equation (26) represents the total team productivity, and the overall process KPI depicted in equation (27) represents the total individual productivity.

$$\text{Number of pallets processed per employee hour } = \frac{Total\ number\ of\ pallets}{Total\ employee\ hours} = \frac{\Sigma\ Number\ of\ pallets\ in\ shipment}{\Sigma\ Total\ duration\ in\ hours\ of\ employees\ working} \quad (26)$$

$$\text{Number of pallets processed per employee} = \frac{Total\ number\ of\ pallets}{Total\ number\ of\ employees} = \frac{\Sigma\ Number\ of\ pallets\ in\ shipment}{Number\ of\ employees\ working\ \ during\ evening\ process} \quad (27)$$

To evaluate the total team and individual productivity, the dashboard should outline two productivity norms. The productivity norms are benchmarks that the user can compare to the measured productivity to determine whether the evening unloading and loading process is efficient. We did not include norms for the output and input since the output cannot fully be influenced. Therefore, the productivity norms already check whether the optimal input value is reached. The productivity norms are based on the past since they should be a target that strives for better results. We choose to base it on 2019 and 2020. We do not include the years before 2019 since the state in the transport hall was completely different back then, whereas we do not include 2021 since the year is not finished yet. If we include 2021, the norm is seasonal and distorted. The norms are equal to the average productivity over 2019 and 2020 times a multiplier so that they have the ambition to improve. We choose a multiplier of 1.05 to ensures that it acts as a safety factor. The following overall process KPIs represent the productivity norms.

$$\text{Norm team productivity} = \text{Minimal number of pallets processed per employee hour} = Average\ of\ team\ productivity\ over\ 2019\ and\ 2020 * 1.05 \quad (28)$$

$$\text{Norm individual productivity} = \text{Minimal number of pallets processed per employee} = Average\ of\ individual\ productivity\ over\ 2019\ and\ 2020 * 1.05 \quad (29)$$

An essential requirement of the performance dashboard is that the user should directly see whether both norms are met. Therefore, the performance dashboard should automatically compare the total team and individual productivity KPIs with the productivity norm KPIs.

For the several segments, the team productivity is the number of pallets processed in the segment per employee hour on that segment. The individual productivity is the number of pallets processed

in the segment per employee working on that segment. Therefore, the following segment KPIs, equation (30) until (39), represent the several segment team and individual productivities.

Equation (30) depicts the team productivity of the unloading process, whereas equation (31) depicts the individual productivity of the unloading process.

$$\text{Number of pallets unloaded per employee hour} = \frac{Output\ unloading}{Employee\ hours\ unloading} = \frac{\Sigma\ Number\ of\ pallets\ in\ shipment}{\Sigma\ Employee\ hours\ unloading} \quad (30)$$

$$\text{Number of pallets unloaded per employee working} = \frac{Output\ unloading}{Number\ of\ employees\ unloading} = \frac{\Sigma\ Number\ of\ pallets\ in\ shipment}{Number\ of\ employees\ who\ are\ unloading\ pallets} \quad (31)$$

Equation (32) depicts the team productivity of the loading general cargo process, whereas equation (33) depicts the individual productivity of the loading general cargo process.

$$\text{Number of general cargo pallets loaded per employee hour} = \frac{Output\ loading\ general\ cargo}{Employee\ hours\ loading\ general\ cargo} = \frac{\Sigma\ Number\ of\ general\ cargo\ pallets\ in\ shipment}{\Sigma\ Employee\ hours\ loading\ general\ cargo} \quad (32)$$

$$\text{Number of general cargo pallets loaded per employee working} = \frac{Output\ loading\ general\ cargo}{Number\ of\ employees\ loading\ general\ cargo} = \frac{\Sigma\ Number\ of\ general\ cargo\ pallets\ in\ shipment}{Number\ of\ employees\ who\ are\ loading\ the\ general\ cargo} \quad (33)$$

Equation (34) depicts the team productivity of the loading route cargo process, whereas equation (35) depicts the individual productivity of the loading route cargo process.

$$\text{Number of route cargo pallets loaded per employee hour} = \frac{Output\ loading\ route\ cargo}{Employee\ hours\ loading\ route\ cargo} = \frac{\Sigma\ Number\ of\ route\ cargo\ pallets\ in\ shipment}{\Sigma\ Employee\ hours\ loading\ route\ cargo} \quad (34)$$

$$\text{Number of route cargo pallets loaded per employee working} = \frac{Output\ loading\ route\ cargo}{Number\ of\ employees\ loading\ route\ cargo} = \frac{\Sigma\ Number\ of\ route\ cargo\ pallets\ in\ shipment}{Number\ of\ employees\ who\ are\ loading\ route\ cargo} \quad (35)$$

Equation (36) depicts the team productivity of the scanning process, whereas equation (37) depicts the individual productivity of the scanning process.

$$\text{Number of pallets scanned per employee hour} = \frac{Output\ scanning}{Employee\ hours\ scanning} = \frac{\Sigma\ Number\ of\ pallets\ in\ shipment}{\Sigma\ Employee\ hours\ scanning} \quad (36)$$

$$\begin{aligned}&\text{Number of pallets scanned per employee working}\\&= \frac{Output\ scanning}{Number\ of\ employees\ scanning}\\&= \frac{\Sigma\ Number\ of\ pallets\ in\ shipment}{Number\ of\ employees\ who\ are\ scanning\ pallets}\end{aligned} \quad (37)$$

Equation (38) depicts the team productivity of the fall-out process, whereas equation (39) depicts the individual productivity of the fall-out process.

$$\begin{aligned}&\text{Number of fall} - \text{out pallets per employee hour}\\&= \frac{Output\ fall-out}{Employee\ hours\ fall-out}\\&= \frac{\frac{\Sigma\ Number\ of\ route\ cargo\ pallets\ in\ shipment}{100\% - \%\ of\ fall-out\ pallets} * \%\ of\ fall-out\ pallets}{\Sigma\ Employee\ hours\ fall-out}\end{aligned} \quad (38)$$

$$\begin{aligned}&\text{Number of fall} - \text{out pallets per employee}\\&= \frac{Output\ fall-out}{Number\ of\ employees\ moving\ fall-out\ pallets}\\&= \frac{\frac{\Sigma\ Number\ of\ route\ cargo\ pallets\ in\ shipment}{100\% - \%\ of\ fall-out\ pallets} * \%\ of\ fall-out\ pallets}{Number\ of\ employees\ moving\ fall-out\ pallets}\end{aligned} \quad (39)$$

5.2 REQUIRED DATA

Data is required to calculate and map the productivity in a performance dashboard. Information is needed on the output and input of both the overall evening unloading and loading process and the several segment processes. Figure 17 shows the required data.

Figure 17: Required data

Output: Shipments
Date
Quantity
Type of transportation unit
Type of cargo

Fall-out
Date
Number of pallets automatically assigned as route cargo
Number of fall-out pallets

Input: Employee hours
Date
Employee Name
Employee ID
Start time
End time
Time worked on different segments

The output data should consist of information about the shipments that arrive at HST TransMission on a specific day. The transport hall is a cross-docking location without storage, so the items that arrive on a day already depart the same evening or the morning after. They are unloaded, scanned, sorted, and loaded within 24 hours. The information should include the quantity of pallets in a shipment so that Excel can calculate the number of pallets arriving on a day. Besides that, the type of cargo of a shipment is required to calculate the output of the loading general cargo and loading route cargo processes. Moreover, the type of transport unit, such as a mini pallet, is essential to determine the number of a specific type of transportation unit. This information is stored when scanning a pallet. We should derive all this output data from the portal system of HST TransMission.

Besides that, information about the fall-out of each day is required to calculate the output of the fall-out. This includes the date, number of pallets automatically assigned as route cargo, and the number of fall-out pallets. With the use of this, we can calculate the fall-out percentage.

The input data should consist of information about the employee hours of each employee working in the evening process. We need this information on both the permanent (employed by HST TransMission) and temporary employees (employed via employment agency Timing). When an employee arrives or leaves HST Groep, he clocks in or out so that their start and end time is sored. We derive the information on the permanent employees from the portal system. The employment agency should deliver the information on the temporary employees. To keep the privacy of the employees, we generate random ID numbers with Excel that correspond to their names. For calculating the total employee hours, each employee's start and end times per day are required. In addition, for calculating the employee hours per segment, the time worked on each segment per employee is required. The sum of these hours should be equal to the sum of the total logged time. For all hours, the breaks should be excluded since they are unpaid.

The portal system might not have all the required data for determining the employee hours per segment. To solve this, we develop a simple form on which the transport hall manager can manually fill in the data.

With this data, we can calculate the team and individual productivity of the overall process and several segment processes, including their norms. The performance dashboard should indicate whether the norms are met during a certain period by changing the color of the data in the productivity chart. To automate the performance dashboard for future use, HST TransMission should link the portal system to Excel, which can then automatically load this into Power BI. Besides that, the accountant of HST Groep should keep track of the start and end times of the temporary employees.

5.3 DATA SET

The required data should be gathered and prepared to develop the final data set. Figure 18 and Figure 19 show excerpts of the Excel sheets gathered from the portal system of HST TransMission. Unfortunately, it still misses data on the fall-out and the time the employees worked on different segments for calculating all productivities.

The fall-out data is derived from the planner of HST TransMission. Every day, he gets a list of all shipments automatically appointed as route cargo. With the use of that list, he composes the shipments and appoints them to the route cargo vehicles. The shipments that do not fit into the route cargo vehicles are on the fall-out list. The transport hall employees filter the items of those shipments to load them into general cargo vehicles. From these lists, the fall-out data can be derived to calculate the fall-out percentage. With that percentage, Excel can calculate the output of the fall-out.

No data is available on the time worked on different segments of the evening unloading and loading process. Thus, we develop a form that the transport hall manager can fill in every day. On this form, he fills in the number of hours each employee spent on each segment of the process. For this thesis, the transport hall manager filled in the form for one day. Another option is that someone else fills it in while observing and monitoring the process. However, more than twenty employees are working on the process during one evening. Therefore, we can assume that only the transport hall manager can keep an eye on the activities of all of them.

Figure 18: Output sheet of received data

	A	B	C	D	E	F
1	**Date**	**Goods on pallet**	**Volume**	**Quantity**	**Unit**	**Load meter**
2	02/01/2019	0	21.22	974	Colli	0.4
3	02/01/2019	2604	130.92	183	Euro pallet	289.45
4	02/01/2019	210	73.12	106	Wegwerp pallet	145.22
5	03/01/2019	0	1.2	2	Halve pallet	0.5
6	03/01/2019	0	0.15	1	Mini pallet	0.13
7	03/01/2019	0	7.38	16	Wegwerp pallet	12.97
8	02/01/2019	0	3	5	Bundel > 274 cm	2
9	02/01/2019	0	0.04	1	Bundel t/m 274 cm	0
10	02/01/2019	724	13.28	128	Halve pallet	36.93
11	02/01/2019	338	9.8	44	Mini pallet	8.55
12	03/01/2019	0	0.63	25	Colli	0
13	03/01/2019	0	3.07	10	Euro pallet	9.73
14	04/01/2019	0	0	10	Colli	0
15	04/01/2019	0	13.44	7	Wegwerp pallet	19.6
16	07/01/2019	0	0	2	Halve pallet	1
17	07/01/2019	30	0	1	Wegwerp pallet	0.5
18	01/01/2019	0	0	2	Colli	0
19	02/01/2019	2	1.37	2	Wegwerp pallet	1.31
20	03/01/2019	0	0.04	1	Bundel > 274 cm	0.4
21	03/01/2019	1607	80.26	136	Euro pallet	188.75
22	03/01/2019	302	11.46	51	Mini pallet	7.24
23	04/01/2019	0	0	14	Colli	0
24	04/01/2019	5	31.61	24	Wegwerp pallet	30.51
25	08/01/2019	0	0	1	Halve pallet	0.25
26	02/01/2019	0	0	2	Colli	0
27	03/01/2019	0	2.38	14	Bundel t/m 274 cm	5.67

Output Worked employee hours

Figure 19: Employee hours of received data

	A	B	C	D	E	F	G
1	**Employee ID**	**Start date/time**	**Start date**	**Start time**	**End date**	**End time**	**End date/time**
2	136	2019-01-02 16:30:00.000	02/01/2019	16:30:00	03/01/2019	01:18:00	2019-01-03 01:18:00.000
3	136	2019-01-03 16:30:00.000	03/01/2019	16:30:00	04/01/2019	01:15:00	2019-01-04 01:15:00.000
4	136	2019-01-04 16:30:00.000	04/01/2019	16:30:00	05/01/2019	01:15:00	2019-01-05 01:15:00.000
5	136	2019-01-07 16:30:00.000	07/01/2019	16:30:00	08/01/2019	01:17:00	2019-01-08 01:17:00.000
6	136	2019-01-08 16:30:00.000	08/01/2019	16:30:00	09/01/2019	01:16:00	2019-01-09 01:16:00.000
7	136	2019-01-09 16:30:00.000	09/01/2019	16:30:00	10/01/2019	01:19:00	2019-01-10 01:19:00.000
8	136	2019-01-10 16:30:00.000	10/01/2019	16:30:00	11/01/2019	02:00:00	2019-01-11 02:00:00.000
9	136	2019-01-11 16:30:00.000	11/01/2019	16:30:00	12/01/2019	01:32:00	2019-01-12 01:32:00.000
10	136	2019-01-14 16:30:00.000	14/01/2019	16:30:00	15/01/2019	01:17:00	2019-01-15 01:17:00.000
11	136	2019-01-15 16:30:00.000	15/01/2019	16:30:00	16/01/2019	01:15:00	2019-01-16 01:15:00.000
12	136	2019-01-16 16:30:00.000	16/01/2019	16:30:00	17/01/2019	01:19:00	2019-01-17 01:19:00.000
13	136	2019-01-17 16:30:00.000	17/01/2019	16:30:00	18/01/2019	01:15:00	2019-01-18 01:15:00.000
14	136	2019-01-18 16:30:00.000	18/01/2019	16:30:00	19/01/2019	01:48:00	2019-01-19 01:48:00.000
15	136	2019-01-21 16:30:00.000	21/01/2019	16:30:00	22/01/2019	01:45:00	2019-01-22 01:45:00.000
16	136	2019-01-22 16:30:00.000	22/01/2019	16:30:00	23/01/2019	03:15:00	2019-01-23 03:15:00.000
17	136	2019-01-23 16:30:00.000	23/01/2019	16:30:00	24/01/2019	01:16:00	2019-01-24 01:16:00.000
18	136	2019-01-24 16:30:00.000	24/01/2019	16:30:00	25/01/2019	01:15:00	2019-01-25 01:15:00.000
19	136	2019-01-25 16:30:00.000	25/01/2019	16:30:00	26/01/2019	01:31:00	2019-01-26 01:31:00.000
20	136	2019-01-28 16:30:00.000	28/01/2019	16:30:00	29/01/2019	01:16:00	2019-01-29 01:16:00.000
21	136	2019-01-29 16:30:00.000	29/01/2019	16:30:00	30/01/2019	01:17:00	2019-01-30 01:17:00.000
22	136	2019-01-30 16:30:00.000	30/01/2019	16:30:00	31/01/2019	01:20:00	2019-01-31 01:20:00.000
23	136	2019-01-31 16:30:00.000	31/01/2019	16:30:00	01/02/2019	01:39:00	2019-02-01 01:39:00.000
24	136	2019-02-01 16:30:00.000	01/02/2019	16:30:00	02/02/2019	01:31:00	2019-02-02 01:31:00.000
25	136	2019-02-04 16:30:00.000	04/02/2019	16:30:00	05/02/2019	01:15:00	2019-02-05 01:15:00.000
26	136	2019-02-05 16:30:00.000	05/02/2019	16:30:00	06/02/2019	01:18:00	2019-02-06 01:18:00.000
27	136	2019-02-06 16:30:00.000	06/02/2019	16:30:00	07/02/2019	01:18:00	2019-02-07 01:18:00.000

Orders **Worked employee hours**

The breaks of an employee should be excluded from the employee hours since they are unpaid. However, the data on the total employee hours includes the breaks of the employees since there is no data available on the breaks. For the different segments, the breaks are excluded since the transport hall manager can indicate them for each employee.

Appendix C shows the final Excel sheets after cleaning, including the Visual Basic for Applications (VBA) code. VBA is used to delete certain rows and generate data.

5.4 CONCLUSION

This chapter discussed the selected overall process and segment productivity KPIs including calculations. Finally, it explained the required data and the gathering process of the final data set. This chapter answers the fifth research question:

5. What productivity KPIs fit the loading and unloading process of HST TransMission and should be selected?

5.1 How can the selected productivity KPIs be calculated?

All selected KPIs belong to one of the three groups: output, input, and productivity. Table 4, Table 5, and Table 6 summarize the selected KPIs, including their calculation (Section 5.1).

Table 4: Selected output KPIs

Process	KPI	Calculation
Total evening process	Number of pallets moved throughout the whole evening process	$\Sigma\ Number\ of\ pallets\ in\ shipment$
Total evening process	Number of pallets from a specific type of transportation unit moved throughout the whole evening process	$\Sigma\ Number\ of\ [mini, disposable, euro, half]\ pallets\ in\ shipment$
Unloading	Number of pallets unloaded	$\Sigma\ Number\ of\ pallets\ in\ shipment$
Loading general cargo	Number of general cargo pallets loaded	$\Sigma\ Number\ of\ general\ cargo\ pallets\ in\ shipment$
Loading route cargo	Number of route cargo pallets loaded	$\Sigma\ Number\ of\ route\ cargo\ pallets\ in\ shipment$
Scanning	Number of pallets scanned	$\Sigma\ Number\ of\ pallets\ in\ shipment$
Fall-out	% of fall-out pallets	$\frac{Number\ of\ fall-out\ pallets}{Number\ of\ automatically\ appointed\ route\ cargo\ pallets} * 100\%$
Fall-out	Number of pallets that fell out	$\frac{\Sigma\ Number\ of\ route\ cargo\ pallets\ in\ shipment}{100\% - \%\ of\ fall-out\ pallets} * \%\ of\ fall-out\ pallets$

Table 5: Selected input KPIs

Process	KPI	Calculation
Total evening process	Total employee hours of evening process	$\Sigma\ Total\ duration\ in\ hours\ of\ employees\ working$
Total evening	Number of employees	-

process	working during evening process	
Total evening process	Total employee hours of evening process from a specific type of employee	$\Sigma\ Total\ duration\ in\ hours\ of\ [HST, Timing]\ employee$
Total evening process	Number of [HST, Timing] employees working during evening process	-
Unloading	Employee hours unloading	$\Sigma\ Employee\ hours\ unloading$
Unloading	Number of employees who are unloading pallets	-
Loading general cargo	Employee hours loading general cargo	$\Sigma\ Employee\ hours\ loading\ general\ cargo$
Loading general cargo	Number of employees who are loading general cargo	-
Loading route cargo	Employee hours loading route cargo	$\Sigma\ Employee\ hours\ loading\ route\ cargo$
Loading route cargo	Number of employees who are loading route cargo	-
Scanning	Employee hours scanning	$\Sigma\ Employee\ hours\ scanning$
Scanning	Number of employees who are scanning pallets	-
Fall-out	Employee hours moving fall-out pallets	$\Sigma\ Employee\ hours\ fall-out$
Fall-out	Number of employees who are moving fall-out pallets	-

Table 6: Selected productivity KPIs

Process	**KPI**	**Calculation**
Total evening process	Number of pallets processed per employee hour	$\frac{\Sigma\ Number\ of\ pallets\ in\ shipment}{\Sigma\ Total\ duration\ in\ hours\ of\ employees\ working}$
Total evening process	Number of pallets processed per employee working	$\frac{\Sigma\ Number\ of\ pallets\ in\ shipment}{Number\ of\ employees\ working\ during\ evening\ process}$
Total evening process	Norm team productivity	$Average\ of\ team\ productivity\ over\ 2019\ and\ 2020 * 1.05$
Total evening process	Norm individual productivity	$Average\ of\ individual\ productivity\ over\ 2019\ and\ 2020 * 1.05$

Unloading	Number of pallets unloaded per employee hour	$\frac{\Sigma\ Number\ of\ pallets\ in\ shipment}{\Sigma\ Employee\ hours\ unloading}$
Unloading	Number of pallets unloaded per employee working	$\frac{\Sigma\ Number\ of\ pallets\ in\ shipment}{Number\ of\ employees\ who\ are\ unloading\ pallets}$
Loading general cargo	Number of general cargo pallets loaded per employee hour	$\frac{\Sigma\ Number\ of\ general\ cargo\ pallets\ in\ shipment}{\Sigma\ Employee\ hours\ loading\ general\ cargo}$
Loading general cargo	Number of general cargo pallets loaded per employee working	$\frac{\Sigma\ Number\ of\ general\ cargo\ pallets\ in\ shipment}{Number\ of\ employees\ who\ are\ loading\ general\ cargo}$
Loading route cargo	Number of route cargo pallets loaded per employee hour	$\frac{\Sigma\ Number\ of\ route\ cargo\ pallets\ in\ shipments}{\Sigma\ Employee\ hours\ loading\ route\ cargo}$
Loading route cargo	Number of route cargo pallets loaded per employee working	$\frac{\Sigma\ Number\ of\ route\ cargo\ pallets\ in\ shipments}{Number\ of\ employees\ who\ are\ loading\ route\ cargo}$
Scanning process	Number of pallets scanned per employee hour	$\frac{\Sigma\ Number\ of\ pallets\ in\ shipments}{\Sigma\ Employee\ hours\ scanning}$
Scanning process	Number of pallets scanned per employee working	$\frac{\Sigma\ Number\ of\ pallets\ in\ shipments}{Number\ of\ employees\ who\ are\ scanning\ pallets}$
Fall-out	Number of fall-out pallets per employee hour	$\frac{\frac{\Sigma\ Number\ of\ route\ cargo\ pallets\ in\ shipments}{100\% - \%\ of\ fall-out\ pallets} * \%\ of\ fall-out\ pallets}{\Sigma\ Employee\ hours\ fall-out}$
Fall-out	Number of fall-out pallets per employee working	$\frac{\frac{\Sigma\ Number\ of\ route\ cargo\ pallets\ in\ shipments}{100\% - \%\ of\ fall-out\ pallets} * \%\ of\ fall-out\ pallets}{Number\ of\ employees\ who\ are\ moving\ fall-out\ pallets}$

5.2 What data is required from the company to calculate the productivity KPIs?

The required data is information on the output, fall-out, and input of the evening unloading and loading process (Section 5.2). With the use of this, the team and individual productivity can be calculated, including their norms.

6 DEMONSTRATION PERFORMANCE DASHBOARD

This chapter aims to demonstrate the prototype of the performance dashboard of this research. It explains the several pages and the data model.

Section 6.1 shows and explains the choice of the front page of the performance dashboard. Section 6.2 shows and explains the choices of the segment pages of the performance dashboard. Section 6.3 discusses the data model of the performance dashboard. Section 6.4 analyses the performance dashboard developed in this research. Section 6.5 concludes the chapter.

6.1 FRONT PAGE

The goal of the front page of the performance dashboard is to show the overall process KPIs. Therefore, the page is called 'Total productivity'. The main message this page must convey is the values of the team and individual productivity. Besides that, the page must show whether these productivity values meet the predetermined norms. Figure 21 shows the front page of the performance dashboard.

The page is divided into two parts. On the left, it shows the team and individual productivity graphs, including the corresponding output and input graphs. The values of the norms are placed above the graphs so that they stand out against the rest of the performance dashboard. The productivity norms are calculated like Subsection 5.1.3 explains.

Since this page aims to show the team and individual productivities, these graphs are on top of the output and input graphs. The output is the same for both productivities, so the output graph is placed over both sides. On the upper right side, the performance dashboard shows more information about the several types of input and output. Underneath these graphs, the performance dashboard shows a filter.

The user can customize the category of the x-axis of the productivity, output, and input graphs to their likings. There are three options: day, month, and year. If the category is per day, it refers to the evenings (total productivity charts in Figure 21). If the category is per month, the values are the averages over the dates corresponding to the month (total output chart in Figure 21). If the category is per year, the values are the averages over the dates corresponding to the year (total input charts in Figure 21). If the columns on the x-axis do not fit, the user can scroll from left to right.

To let the exact value of a certain point on the x-axis appear, the user can hover over the visual (Figure 20). However, if they would like to show the dashboard on a big screen, this is not possible. Thus, for the productivity, output, and input charts, Power BI shows the values of the data inside the columns.

Figure 20: Exact data value in performance dashboard

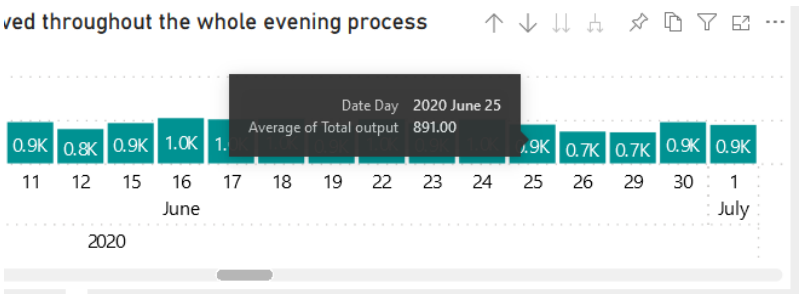
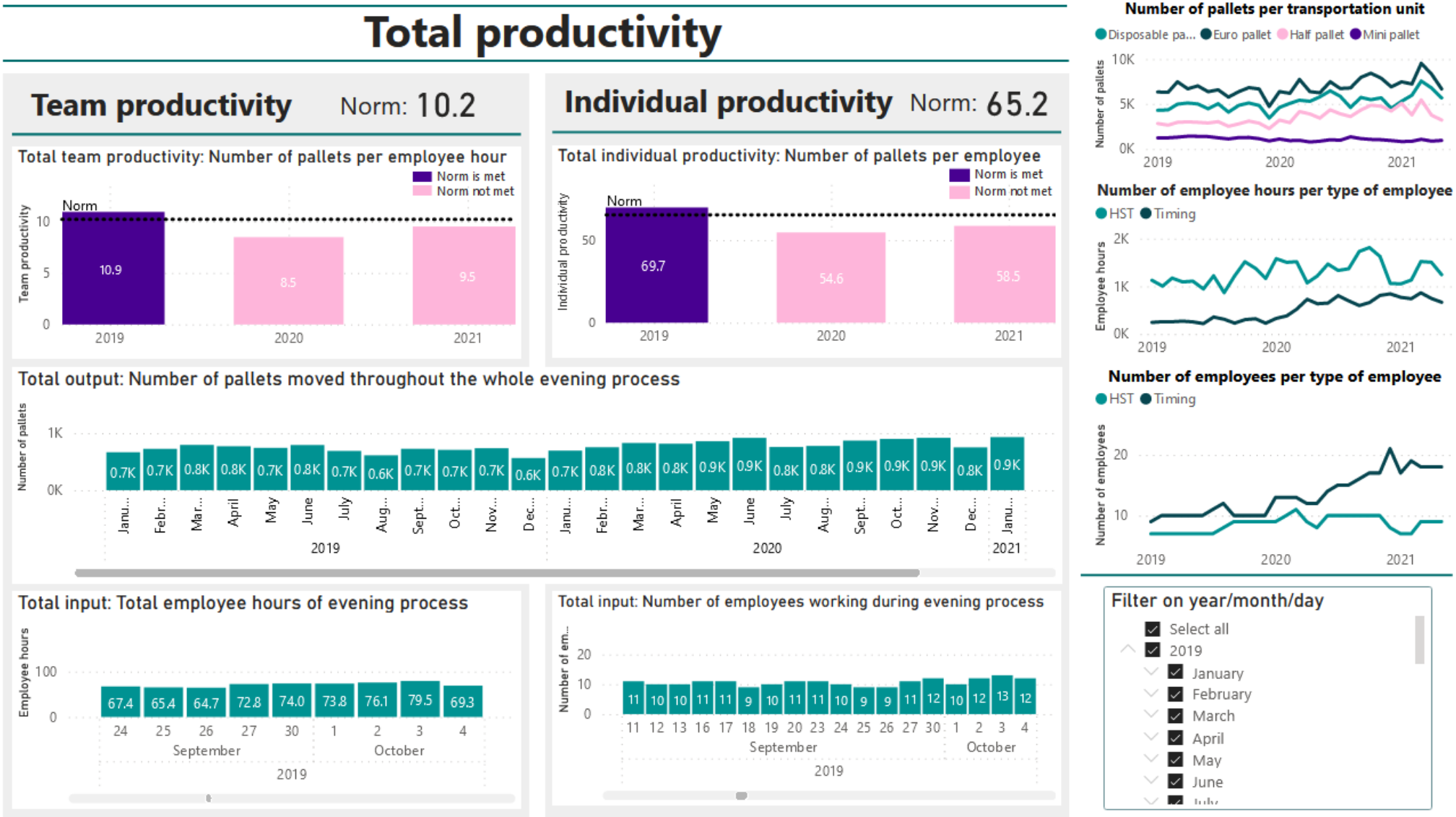


Figure 21: Front page performance dashboard



Total team and individual productivity charts

Figure 22, Figure 23, and Figure 24 show these charts based on the category on the x-axis. The total team productivity graph represents the number of pallets processed per employee hour, whereas the total individual graph represents the number of pallets processed per employee. Both graphs are column charts because then the emphasis lies on the difference between values. For example, the user can compare the month April of the three years. Besides that, the value of the current day is clearer. In front of the productivity graphs, the norms are presented as a dotted line. The colors of the columns indicate whether the norms are met. If the column is pink, the norm is not met, whereas the norm is met if the color is purple.

Figure 22: Total team and individual productivity charts, average over all days per year

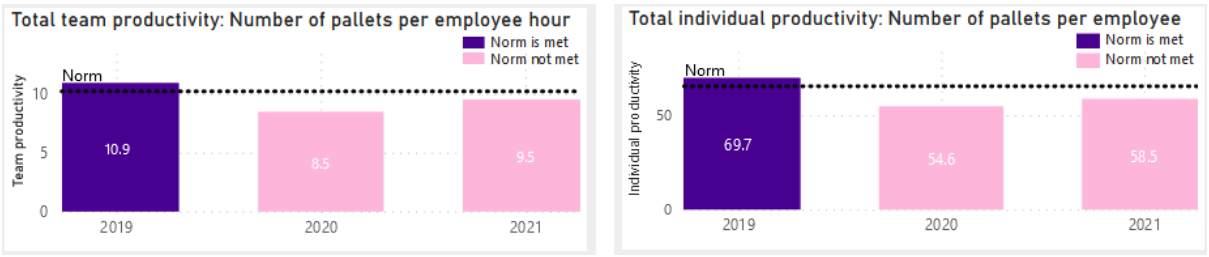


Figure 23: Total team and individual productivity charts, average over all days per month

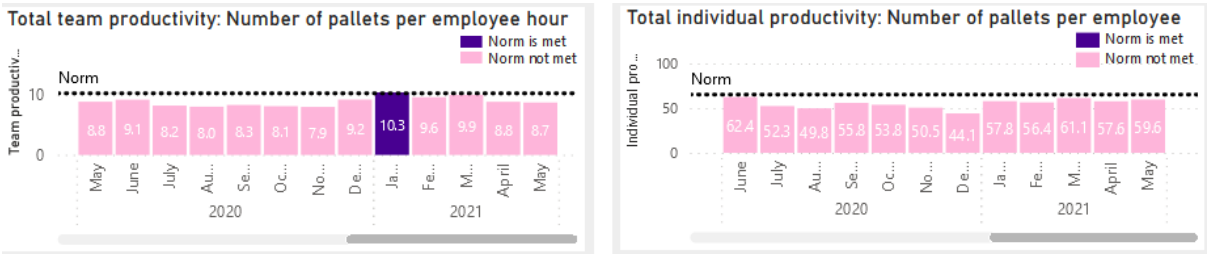
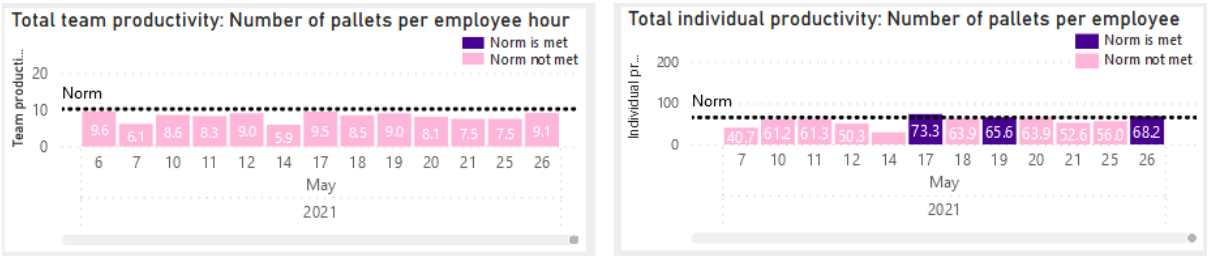


Figure 24: Total team and individual productivity charts, per day



Total output chart

Figure 25, Figure 26, and Figure 27 show this chart based on the category on the x-axis. The total output chart represents the number of pallets moved throughout the whole evening process. Just like the productivity charts, it is a column chart so that the user can easily compare values. Both productivities are calculated with the same output. Instead of having the same chart two times, the chart is stretched.

Figure 25: Total output chart, average over all days per year

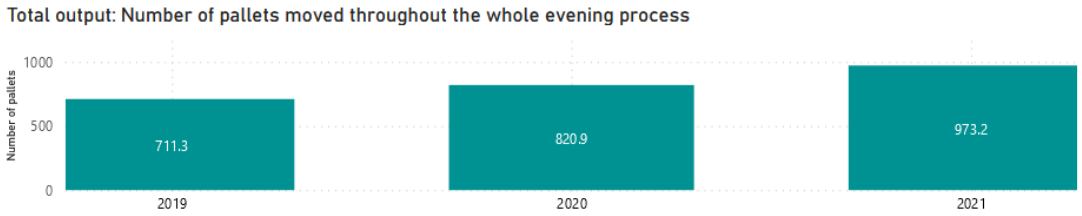


Figure 26: Total output chart, average over all days per month

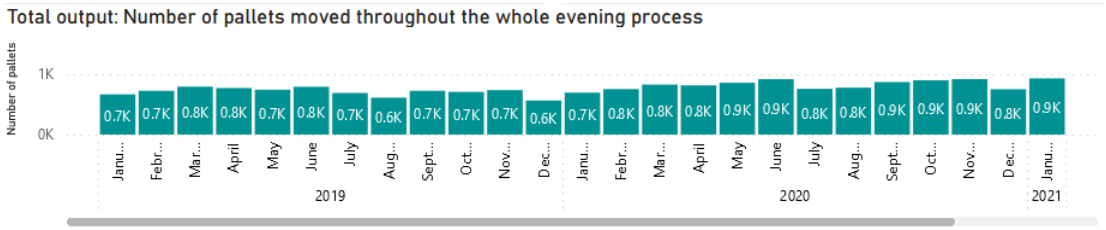
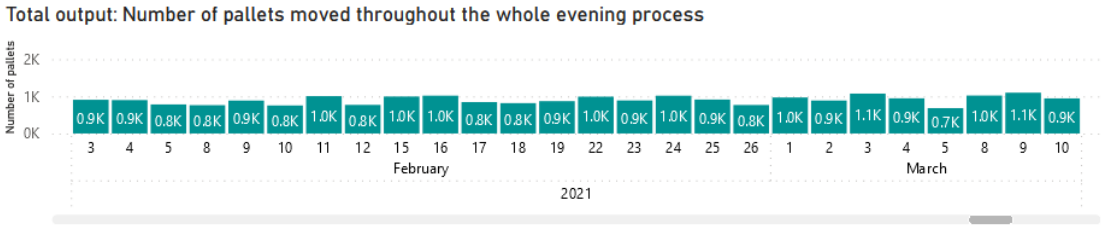


Figure 27: Total output chart, per day



Total input charts

Figure 28, Figure 29, and Figure 30 show these charts based on the category on the x-axis. The total input chart on the left represents the total employee hours of the evening process and is used to calculate the team productivity. The total input chart on the right represents the number of employees working during the evening process and is used to calculate the individual productivity. Again, the column chart is used so that the user can compare values.

Figure 28: Total input chart, average over all days per year

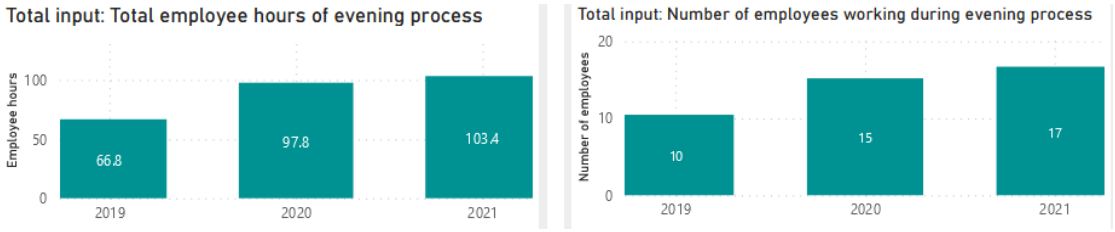


Figure 29: Total input chart, average over all days per month

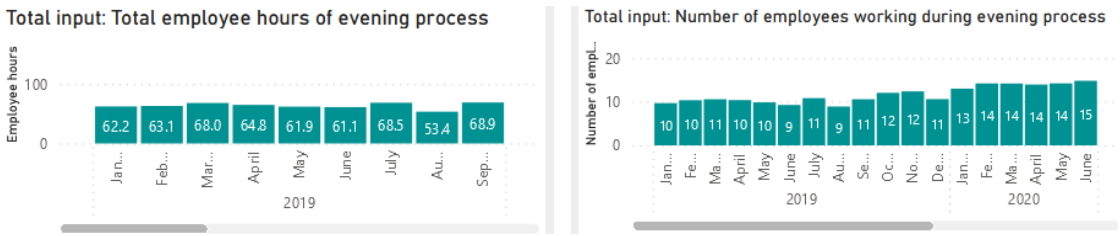
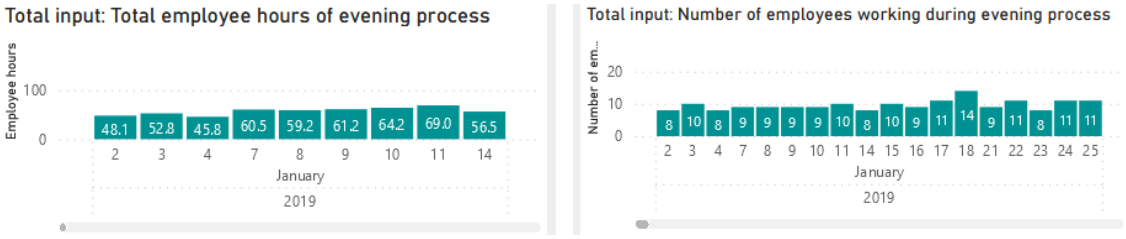


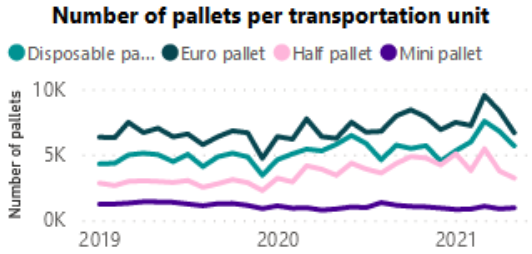
Figure 30: Total input chart, per day



Number of pallets per transportation unit chart

Figure 31 shows this chart. This chart represents the sum of the number of pallets of each transportation unit per month. This chart gives more insight into the origination of the output. It uses the line chart type because then it shows the overall progress.

Figure 31: Number of pallets per transportation unit chart



Number of employee hours/employees per type of employee charts

Figure 32 and Figure 33 show these charts. The top employee type chart represents the number of employee hours by each employee type per month. The bottom employee type chart represents the number of unique employees of each employee type per month. These charts give more insight into the origination of the input. The line chart type is used because the overall progress is the most interesting for the user.

Figure 32: Number of employee hours per type of employee chart

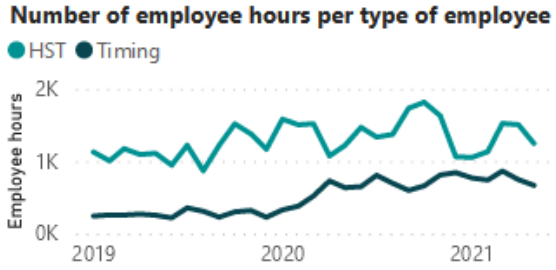
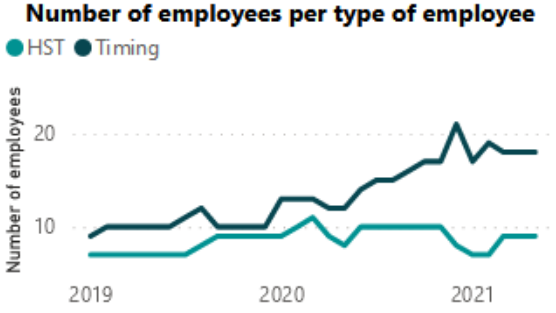


Figure 33: Number of employees per type of employee chart

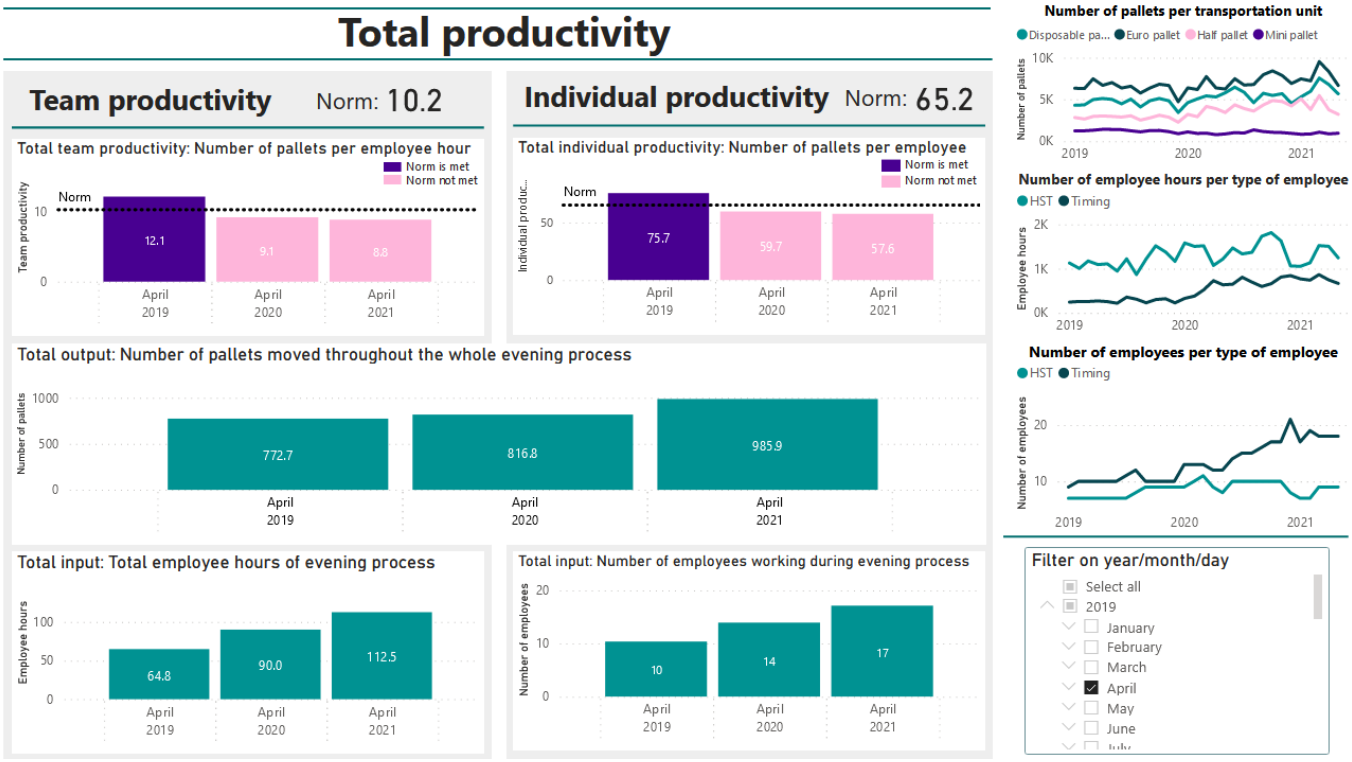


Slicer

Figure 34 shows the slicer. The slicer is used to filter the productivity, output, and input charts. The user can check the boxes of the slicer by clicking on them, causing the charts to adapt. With the use of this, the user can compare multiple years, months, or days. Figure 35 shows an example where the month April from each year is selected.

Figure 34: Slicer, per year/month/day

Figure 35: Chart adapted to slicer, April of all years



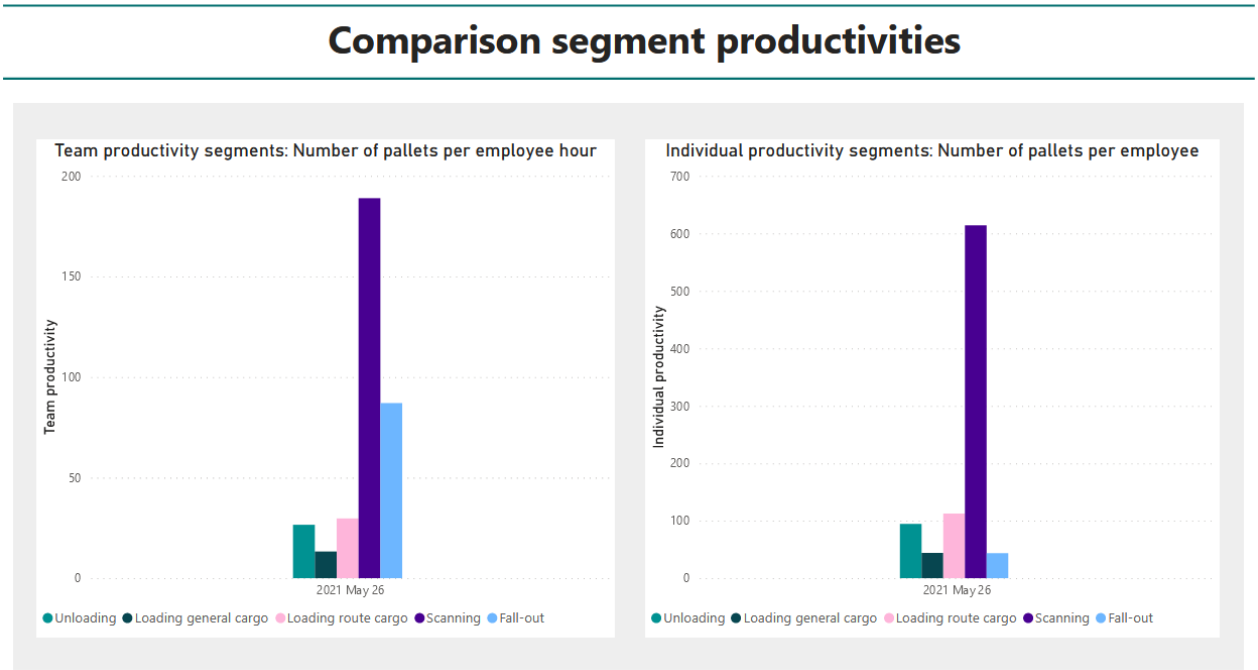
6.2 SEGMENT PAGES

The goal of the segment pages of the performance dashboard is to show the segment KPIs. All data of the segments is only available for one day. As soon as more data is available, the charts will expand.

The first segment page compares the team and individual productivity of the several segments. Figure 36 shows the first segment page. For each type of productivity, a chart shows the productivity of the five segments: unloading, loading general cargo, loading route cargo, scanning, and fall-out.

The column chart type compares the several segments so that an overall view of the segments is sketched.

Figure 36: Comparison segment productivity page performance dashboard

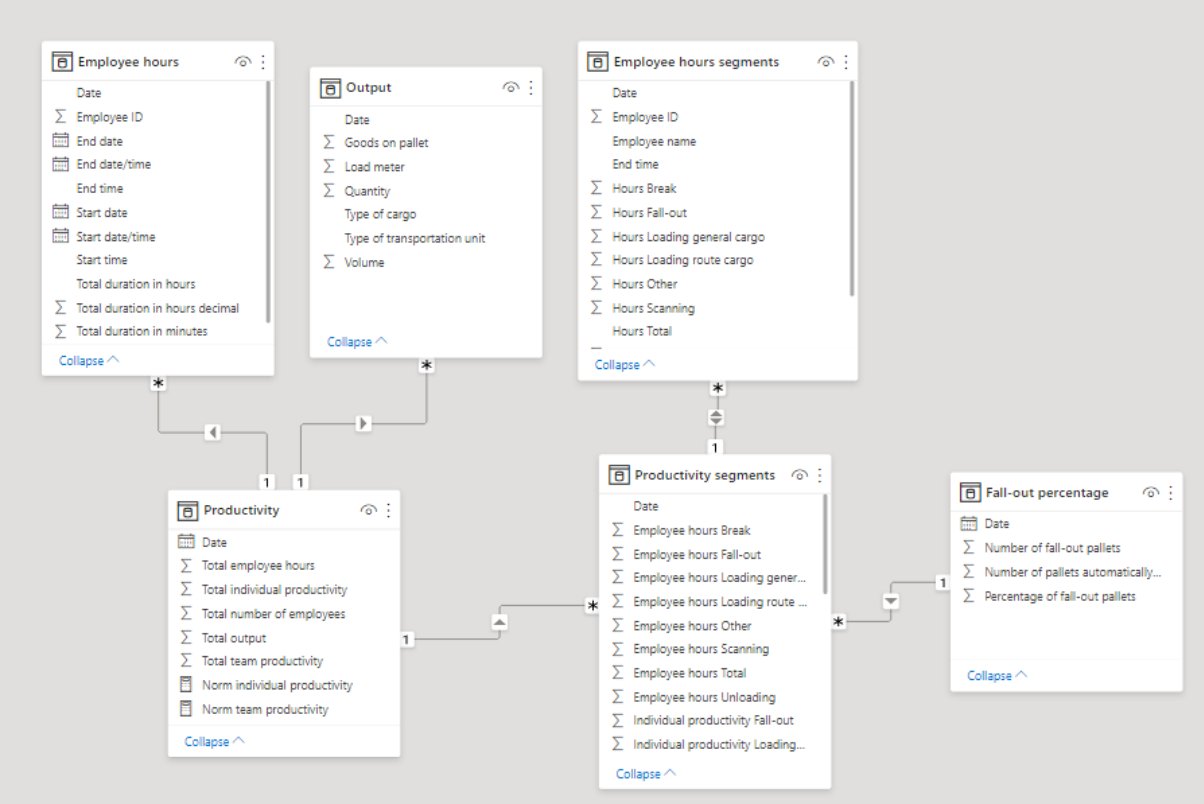


The other segment pages all focus on one of the segments. Figure 71 in Appendix D shows the results for the unloading process, Figure 72 in Appendix D the results for the loading general cargo and Figure 73 in Appendix D for the route cargo process. Figure 74 in Appendix D focuses on the scanning process, whereas Figure 75 in Appendix D focuses on the fall-out. These pages show the team productivity, individual productivity, output, employee hours, and number of employees of the specific segment. All these charts use the column chart type so that the user can easily compare values. For now, the data is only available over one day, and thus this is not possible. However, if HST TransMission keeps track of this data longer, it can easily be added, and more columns will appear.

6.3 Data model

Some of the data is generated. It is not based on real data and is, therefore, fictional. It is not clear yet whether it is possible to implement this into the system portal in the way described in this thesis. The transport hall manager should be able to fill in the hours of the different segments corresponding to the employees. Then, the generated data can be transported to Excel and linked to the real data. Since the system portal is still in development, there exist opportunities for doing this. In Power BI, all data is linked to each other. The data model of the Power BI dashboard contributes to the understanding of the relationships in the data set. Besides that, the compatibility between the data is made visible. Figure 37 shows the data model.

Figure 37: Data model Power BI performance dashboard



6.4 ANALYSIS PERFORMANCE DASHBOARD

Like the front page of the performance dashboard shows, the total team productivity has decreased by 22.02% from 2019 to 2020. The front page is based on real data. At the start of 2020, the COVID-19 virus broke out. The government took measures. Eventually, they introduced a lockdown. The demand for transporting goods increased since a large part of public life was shut down. People could not go to physical shops, so they started to order products online. The front page also shows this development since the output has increased by 15.41% from 2019 to 2020. More pressure occurred on the supply chain of HST TransMission. Especially on the unloading and loading process because the transport hall was already tight and had no possibilities to expand. HST TransMission had to employ more employees to keep up with the supply of goods. However, more pallets and employees in the same tight transport hall create problems. For instance, the transport hall employees place the pallets in the wrong place since they do not fit in the correct box anymore. Later, they must search and move them to the correct place. Besides that, employees get in each other's way because they cannot move through the same place simultaneously. Therefore, the employee hours are less efficiently used, and thus they have increased by 46.41% to keep up with the increasing output. Moreover, the efficiency per employee has decreased since the number of employees has increased by 50% to keep up with the output. Therefore, the total individual productivity of the transport hall employees decreased by 21.66%.

Like the front page of the performance dashboard shows, the total team productivity has increased by 11.76% and the total individual productivity by 7.15% from 2020 to 2021. The output has increased by 18.55%, which is a little bit more than the year before. However, the employee hours have increased by 5.73% and the number of employees by 13.33%. The employee hours are used more efficiently, and the efficiency per employee has increased. This rise could have multiple causes.

Firstly, there could be a relationship between the productivity and the number of pallets per transportation unit. One type might take more time to unload and load than another type. Secondly, it might be that in 2021 the temporary employees gained a positive effect on the productivity of the process compared to 2020. According to Calcagnini, Marin, and Perugini (2021), job flexibility through temporary employees is in the first place damaging for productivity. However, when their share increases above a threshold, they could contribute to the productivity. The temporary workers in 2021 could have a bigger share to the process than the ones in 2020, because of more experience. The cause for this increase might be that more temporary employees stayed at HST TransMission during 2020 than 2019. Lastly, it might be that the total team and individual productivity will still decrease during the rest of 2021. The starting months could be more productive than other months because, for example, the employees set good intentions in January. More research is needed to substantiate this.

Next, we analyse the team and individual productivity of the different segments of the evening unloading and loading process. The segments pages are based on generated data. Three things stand out. Firstly, as the charts on the 'Comparison segment productivities' page show, the productivity of the scanning segment is remarkably higher than the other segments. This is due to a large output and small inputs. The transport hall employees must scan all pallets in the transport hall. However, scanning a pallet does not take much time, and only two employees are assigned to the task. Secondly, the team and individual productivity of the fall-out segment differ a lot. The team productivity of the fall-out segment is rather high. The fall-out percentage is relatively small and thus the output as well. At the time of the fall-out, a small part of the items remain in the transport hall. Thus, it is easier to move items, so less time is needed. In addition, the individual productivity is small. This is due to a relatively large number of employees being assigned to the fall-out tasks. Thirdly, both the team and individual productivity of the loading of the general cargo is relatively low. This could be caused by the crowdedness around the dump and depot boxes, where the general cargo pallets flow around.

We cannot say anything about the other segments since we cannot compare them to other dates as the data on the different segments is only available for the 26th of May 2021. Moreover, the big difference in productivity between the scanning segment and the rest could indicate that the different segments of the process are hard to compare.

We cannot recommend improvements based on the different segment pages since the manager of HST TransMission cannot base decisions on one day. If more data is gathered, the manager can make decisions. For example, he might tell the transport hall manager to send less or more transport hall employees home after unloading the general cargo vehicles. Besides that, the manager could change the hiring strategy. For example, hire less or more temporary employees.

6.5 Conclusion

The performance dashboard consists of a front page, including the overall process KPIs (Section 6.1) and segment pages, including the segment KPIs (Section 6.2). The data model in Power BI indicates the relationships between the data in the Excel sheets (Section 6.3). The performance dashboard shows that the total productivity decreased from 2019 to 2020 and increased from 2020 to 2021. This could have multiple causes (Section 6.4). The segment data is only available for one day, so no decisions can be based on that.

7 PRODUCTIVITY IMPROVEMENTS LAYOUT AND PROCESS TRANSPORT HALL

This chapter converts the research into practice by recommending possible improvements to the layout of the transport hall and the design of the evening unloading and loading process. The goal is to increase productivity. It aims to answer the sixth knowledge question:

6. What improvements to increase productivity can be suggested to the design of the evening unloading and loading process and the layout of the transport hall from conducting this research?

Section 7.1 elaborates on a possible improvement to the design of the evening unloading and loading process, whereas section 7.2 elaborates on a possible improvement to the layout of the transport hall. Section 7.3 concludes the chapter.

7.1 IMPROVEMENT DESIGN EVENING UNLOADING AND LOADING PROCESS

What stands out in the design of the evening unloading and loading process is that almost all tasks are executed manually. The downside of a manual process is that tasks are time-consuming. A task may seem short, but an employee must perform most of them a few times a day. This quickly adds up to a lot of wasted time. Besides that, the quality decreases since employees can easily make mistakes. Moreover, a lack of data arises since it is more difficult to store data for a manual process than an automated process. For this process, eliminating the manual tasks is the easiest way of improving. Therefore, automating parts of the process is crucial to increase productivity, quality, and data storage (Mispan, Mustafa, Sarkawi, & Jidin, 2020).

The scanner employee must scan the pallets with a scanner to derive the depot number to which it is transported. Then, the screens in the transport hall show this number. If it is not a question mark, the scanner employee puts the correct sticker on the pallet. This is a cumbersome way and thus can be improved. There are only a few employees who can do this task since precision is necessary. If the employee makes a mistake, a shipment can end up at the wrong depot on the other side of the country. Therefore, it is even more important to ease this task. At the moment, there is no data available on the number of items that end up at the wrong depot. However, further research could focus on deriving this. The solution is to buy a scanner that prints stickers as well. The scanner employee can then scan the pallet and put the printed sticker on it. If a question mark would appear, the scanner could, for example, make a noise. By implementing this solution, a manual task with a high risk of error is eliminated.

Another manual task that can be eliminated is the task of writing DIT on a label if the screen shows ‘datum in toekomst’. Introducing a sticker with DIT on it could improve this. The employee does not have to get a pencil but can just put the sticker on the pallet. If HST TransMission gets a scanner, including a printer, it can also print this sticker. They can also choose to let the sticker have a notable color. The sticker is less easily overlooked than a pencil scribble.

7.2 IMPROVEMENT TRANSPORT HALL LAYOUT

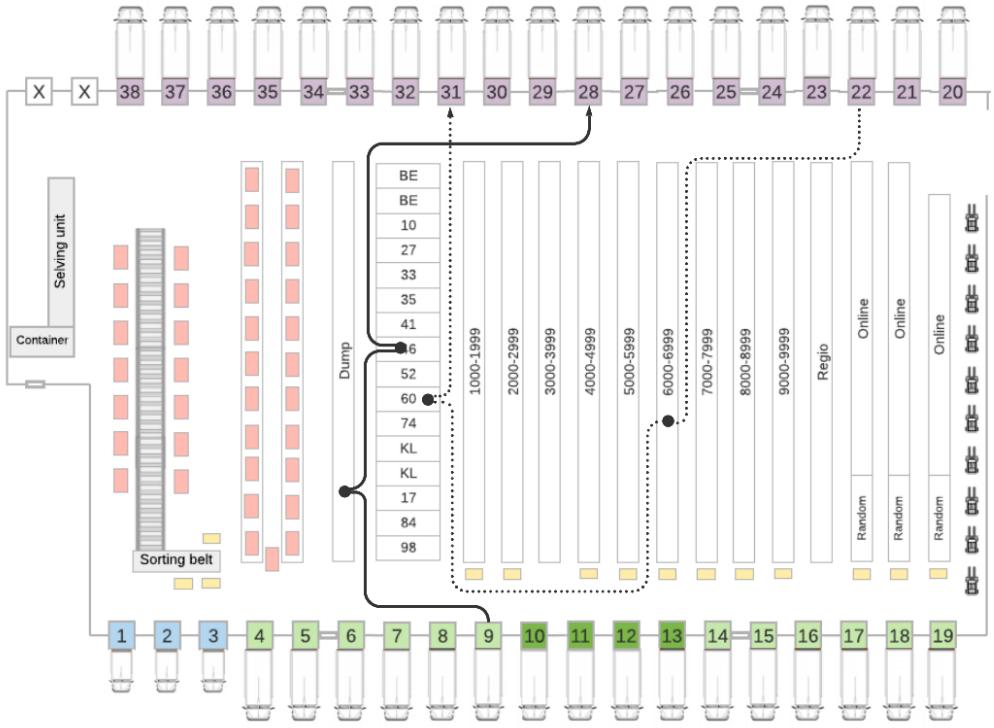
To present possible improvements with the largest impact, we identify bottlenecks. Bottlenecks are parts of the process that disturb the smoothness of the process and limit the production lines’ possibilities (Kikolski, 2016). Two possible causes can be the reason for this. Firstly, items can block an activity in the process from proceeding because they accumulate before the bottleneck. Items keep stuck at the activity in front of the bottleneck. Secondly, the supply of items to an activity in the

process can be too low. This causes the activity to starve. This blocking and starving of the process will limit the utilization of the bottleneck and hence degrade throughput (Hopp & Spearman, 2009, p. 324).

The main bottleneck we found based on the layout of the transport hall is the movement of items to, between, and from the dump and depot boxes. The dump and depot boxes are blocking items to flow through the process since they are tight and often full. Therefore, the focus of the improvement in the layout of the transport hall is on those boxes. The transport hall employees move items from the dump box and zip code boxes to the depot boxes. They do not, however, move items between the zip code boxes and the dump box. Therefore, it is more logical to switch the depot boxes and the dump box. Figure 38 shows the improved spaghetti diagram, only including the flows that are adapted because of the improvement. They cross less than before the improvement in Figure 14.

The downside of this improvement is that the dump box is even more to the side of the transport hall than before the improvement. When unloading the general cargo pallets, the pump truck employees have to drive a greater distance to reach the dump box on average. HST TransMission should make a cost-benefit analysis between the crowdedness around the boxes and the detour of the pump truck employees.

Figure 38: Spaghetti diagram after improvement



7.3 CONCLUSION

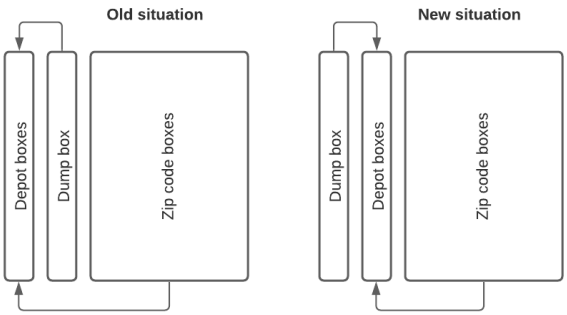
This chapter elaborated on two possible improvements, one on the layout of the transport hall and one on the evening unloading and loading process. It answers the sixth research question:

6. What improvements to increase productivity can be suggested to the design of the evening unloading and loading process and the layout of the transport hall from conducting this research?

Almost all tasks of the evening unloading and loading process are executed manually. This is time-consuming and has a high risk of errors. These manual tasks must be eliminated to automize the process (Section 7.1).

The flow of items between the depot boxes, dump box, and zip code boxes only goes to the depot boxes. Therefore, the layout of the transport hall can be improved by switching the depot boxes with the dump box so that the depot boxes are in the middle (Section 7.2). Figure 39 shows this improvement, including the flow of items depicted as arrows.

Figure 39: Improvement layout transport hall



8 CONCLUSION

The problem I identified at HST Groep is the decreasing labor productivity caused by a lack of information regarding the productivity of the unloading and loading process in the transport hall of HST TransMission. Understanding and measuring the productivity of this process is essential to identify and investigate bottlenecks to improve the process. The visualization tool Power BI is used to display productivity KPIs into a performance dashboard. By developing this dashboard based on historical data, the total productivity and the productivity in the different segments are calculated. Section 8.1 explains how this result and conclusion is reached by summarizing the answers to the research questions and answering the main research question. Section 8.2 creates a final discussion, including further research and limitations.

8.1 RESEARCH QUESTIONS

The main research question, "What is the productivity in the different segments of the evening unloading and loading process, displayed in a performance dashboard?" is answered using the sub research questions below.

1. *What does the current evening unloading and loading process look like?*
   1.1 What does the current layout of the transport hall look like?
   1.2 What are the transport flows of the items in the transport hall?

Chapter 2 discusses the current evening unloading and loading process at HST TransMission using the BPMN. The process is divided into four subprocesses and thus four sub-BPMs:

- Unloading the regional and route cargo vehicles
- Loading the general cargo vehicles
- Fall-out (filtering out the general cargo items)
- Loading the route cargo vehicles.

The current layout of the transport hall consists of a sorting belt, red racks, depot boxes, a dump box, zip code boxes, a region box, online boxes, and random boxes. It is arranged in a functional manner so that the transport hall employees can move around the items inside the transport hall. However, the transport hall is tight which causes some troubles.

There are four flows of items throughout the transport hall based on the type of item: route cargo items, general cargo packages, general cargo items (no package), and fall-out items. The employees must move around the items more than needed to reach other items.

2. *What data visualization tool is used to develop the performance dashboard of this research?*

We chose the visualization tool Power BI because it has a more user-friendly interface compared to other tools. Besides that, the IT department of HST Groep already uses Power BI. Therefore, there are no purchase costs involved, and the employees of the IT department can answer questions regarding the development of the performance dashboard.

3. *What are the most important characteristics of an effective KPI?*

Chapter 3 discusses the most important characteristics of an effective KPI: measurability, frequently monitored, improvability, decision-based, quantifiable and visualizable, and user-friendly.

4. *Which requirements of HST TransMission should be considered when developing the performance dashboard?*
   4.1 What current possibilities to display a dashboard are there within HST TransMission?
   4.2 How can the performance dashboard be made user-friendly?

At the end of each working day, the manager would like to have an automatically generated performance dashboard displaying the productivity. It would compare the total productivity to a specific predetermined norm based on previous data. Moreover, he would like to zoom into the productivity in several segments of the process to understand the cause.

Since the project of developing dashboards based on data is still in the beginning phase, there does not exist a performance dashboard that can serve as a template for this research.

There are three requirements for a performance dashboard to be user-friendly:

- The user of the dashboard should see the useful data directly.
- The dashboard should be attractive and color-blind-friendly.
- The meaning of the KPIs must be clear and comprehensible.

5. *What productivity KPIs fit the loading and unloading process of HST TransMission and should be selected?*
   5.1 How can the selected productivity KPIs be calculated?
   5.2 What data is required from the company to calculate the productivity KPIs?

The selected KPIs all focus on the goal of calculating the productivity with the use of the output and input of the evening unloading and loading process. The output is the number of pallets, whereas the input is the employee hours or the number of employees, dependent on the type of productivity. The KPIs are calculated with the use of Excel and VBA. Chapter 5 discusses the productivity KPIs and their formulas.

The required data is information on the output, fall-out, and input of the evening unloading and loading process. With the use of this, the team and individual productivity can be calculated.

6. *What improvements to increase productivity can be suggested to the design of the evening unloading and loading process and the layout of the transport hall from conducting this research?*

For improving the design of the evening unloading and loading process, manual tasks must be eliminated to automize the process. An automated process saves time and decreases the risk of errors. For improving the layout of the transport hall, the depot boxes can be switched with the dump box. It is more logical to have the dump box between the depot and zip code boxes since items only flow between the dump box and the other boxes. However, the pump truck employees have to drive a greater distance to reach the dump box on average when unloading the general cargo pallets. HST TransMission should make a cost-benefit analysis between the crowdedness around the boxes and the detour of the pump truck employees.

"What is the productivity in the different segments of the evening unloading and loading process, displayed in a performance dashboard?"

Using the answers to research questions one until five, a performance dashboard is created using Power BI. By creating the performance dashboard in Chapter 7, the main research question is answered. Research question six converts the research into practice.

8.2 DISCUSSION

The performance dashboard of this research contributes to having an insight into the productivity of the evening unloading and loading process in the transport hall. The performance dashboard is useful for the manager of HST TransMission. The theme of the performance dashboard is color-blind-friendly to ensure that the manager can differentiate between the colors. The data must be automatically transferrable to the performance dashboard to show the productivity to the manager daily. It provides an overview based on which the manager can make decisions. A few days after the decision is made, the manager can evaluate the implementation using the performance dashboard. With this, he can communicate the progress of the evening unloading and loading process towards the management of HST Groep. He can learn from mistakes so that better and substantiated decisions are made in the future. This thesis document is sent to the manager to ensure that he understands and interprets all KPIs correctly. Besides that, an employee from IT has enough knowledge about Power BI to help him if necessary.

In line with the presumption, the results of this research indicate that the output of the evening unloading and loading process increased rapidly. More and more shipments of pallets must be processed each day. Therefore, more personnel is employed to cope with this increase. The transport hall is tight and there is no possibility of expanding, causing a lack of space and structure. The transport hall employees place the products in the wrong boxes and bump into each other. They get fewer tasks done in the same amount of time, causing the efficiency per employee to decrease. To keep up with the rising demand, HST TransMission again employs more personnel. This causes the productivity to decline even more. However, the results show that the productivity increased from 2020 to 2021. This could be due to a shift in the number of pallets per transportation units, temporary employees gaining more experience, or the starting months of the year being more productive. More research is needed to substantiate this. Due to the lack of data on the productivity of the several segments of the process, recommendations and decisions cannot be based on these results.

With the results of this thesis, HST TransMission has a starting point for mapping the productivity in the different segments of the process. A methodology for selecting and displaying KPIs is presented. This research demonstrates an example of developing a performance dashboard that displays the productivity of a transportation company. Since it is adapted to the wishes of HST TransMission, it can easily be used as a template for calculating and mapping the productivity of other processes in other departments of HST Groep. The downside to this is that the generalizability is limited. Therefore, it is hard for other researchers to perform this research at other companies. However, they can use this research as a guideline.

8.2.1 Further research

Further research is needed to find the cause of the shift in productivity. All optional causes should be taken into account. Proof must be found to exclude causes and find the root cause. This can be done by creating more detailed charts to analyse and find a relationship. For example, research into the relationship between the productivity and the percentage of temporary employees can be done.

This research focuses on labor productivity. However, there are several other types of productivity, such as capital and material productivity. In further research, these other types can be calculated and mapped in a performance dashboard. The manager can then get an even more extensive overview of the progress of the evening unloading and loading process in the transport hall.

Further research should focus on the automatization of the unloading and loading process. Almost all tasks in the transport hall are currently executed manually, which is time-consuming and has high

risks of errors. The researcher should go through the whole process to search for possibilities. While doing this, he should also research the possibilities of tracking data automatically, especially data about the several segments of the process.

8.2.2 Limitations

During this research, the input data of the several segments were missing. This lack of data was filled by creating a form that the transport hall manager could fill in. With the employee hours provided by the transport hall manager, estimates could be made. It is assumed that this provides an accurate representation of the truth. However, the real input is still unknown, which could influence the outcome.

The time available for this thesis is limited to ten weeks. Therefore, parts of the process are considered out of scope, such as the sorting belt, online and regional shipments, small items, and processes that are executed during the night or morning. Multiple times, data was not correct or incomplete. A critical eye was needed to find these inconsistencies. Resolving this took time since third parties were responding late, and some data could not be found. Besides that, creating the code in VBA took more time than anticipated.

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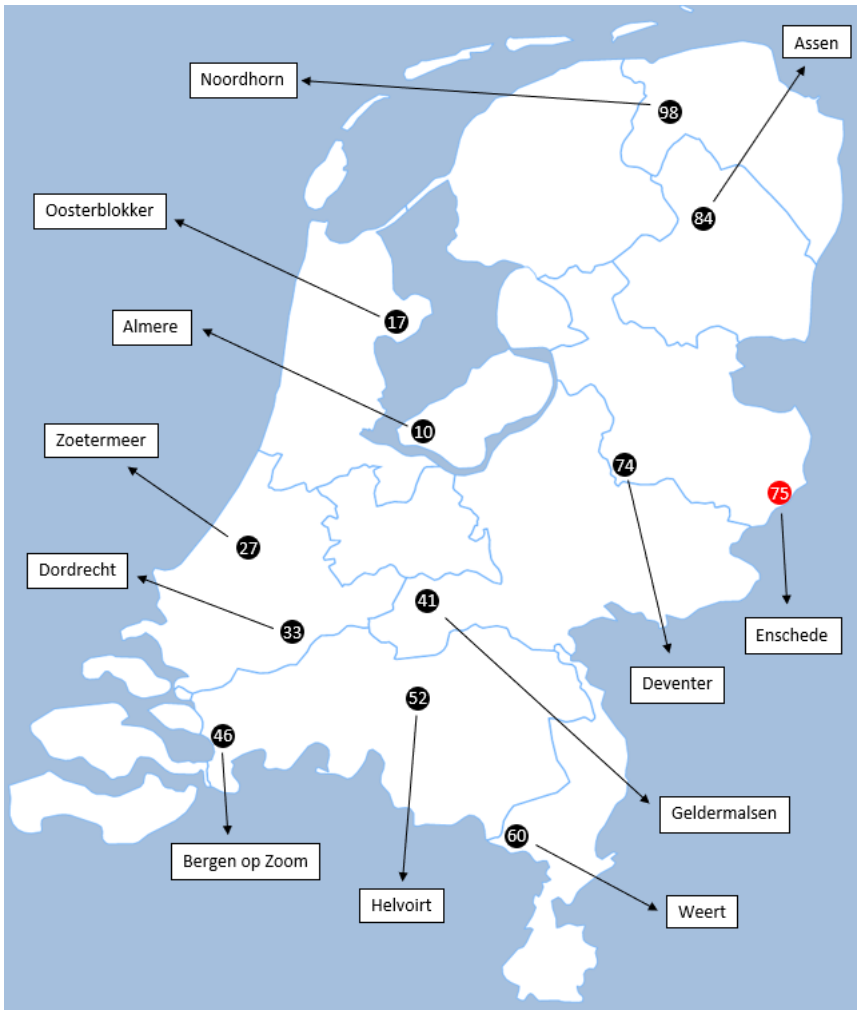
APPENDICES

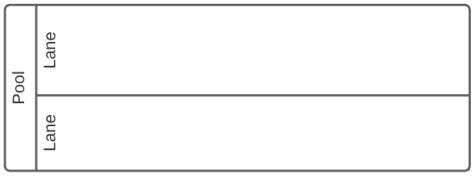
APPENDIX A
Locations of TransMission partners

Figure 40: Locations of TransMission partners



APPENDIX B
Explanation BPM

A BPM consists of pools covering the entire length of the model. These pools correspond to a group of participants divided over lanes. Each lane corresponds to a participant. Each participant only executes the activities within its lane (Briol, 2013). Messages describe the collaboration between participants. The pools are arranged horizontally in this report, meaning that the process flows from left to right, following the arrows.



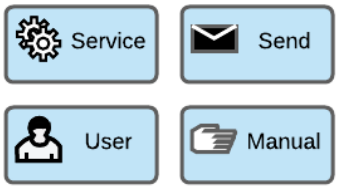
The three main elements in a BPM are called flow objects and consist of events, activities, and gateways (White & Miers, 2008).

Event: Triggers or is triggered by an activity. There are three types of events. A start event is triggered at the start of the process. An intermediate event is triggered somewhere inside the process. Finally, an end event shuts down the process.

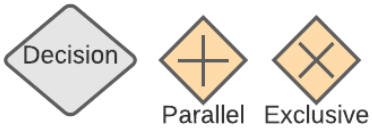
The icon inside the event refers to the type of event. We use two types in the BPMs of this report. A message event starts once the message is received, and a condition event starts once the condition is met.

Activity: Task executed by a participant.

The icon in the corner of the activity refers to the type of task. We use four types in the BPMs of this report. The participant executing the service task uses, for example, a web service or automated application. The send task sends a message to another pool or lane. Tasks performed with the use of a software application are called user tasks. The participant executing the manual task perform their task manually.



Gateway: Decision being made, or flows join or distribute. There are two types of flow joining and distributing gateways: parallel and exclusive. A parallel gateway ensures that both flows are executed before continuing. An exclusive gateway approves with only one executed flow.



There are two types of connecting objects: sequence flow and message flow.

Sequence flow: Activities are connected through sequence flows.

Message flow: Messages between two participants are connected through message flows.

APPENDIX C
Data gathering for performance dashboard

Appendix C.1
Output sheet

The 'Output' sheet contains data of all the shipments from the 1st of January 2019 to the 26th of May 2021. Figure 41 shows an excerpt of the 'Output' sheet. In the sheet, each row is one shipment of pallets of a certain type. The data consists of the date (column A), load meter (column B), volume (column C), goods on pallet (column D), quantity (column E), type of transportation unit (column F), and type of cargo (column G). The date is the shipping date of the shipment. The load meter is the number of meters from the back of the truck in the length. Since the width of a truck is 2.4 meters, one load meter is 2.4 square meters. This is a standard size for road transport. The volume is the amount of space the shipment occupies. The load meter and volume do not have to be equal because not all shipments can be stacked until the roof of the truck. The goods on a pallet is the number of goods the pallet(s) contain(s). The type of transportation unit is the type of pallet the shipment consists of. This can be a mini pallet, euro pallet, disposable pallet, or half a pallet. The type of cargo is general or route cargo. The type of cargo is only available for the 26th of May 2021.

Figure 41: Output sheet of data set

	A	B	C	D	E	F	G
1	**Date**	**Load meter**	**Volume**	**Goods on pallet**	**Quantity**	**Type of transportation unit**	**Type of cargo**
2	02/01/2019	0.4	0	10	1	Euro pallet	
3	02/01/2019	1	0	50	2	Euro pallet	
4	02/01/2019	2	0	104	5	Euro pallet	
5	02/01/2019	0	0.18	0	1	Disposable pallet	
6	02/01/2019	0	0.38	0	1	Half pallet	
7	02/01/2019	0.25	0.38	0	1	Half pallet	
8	02/01/2019	1	1.15	1	3	Disposable pallet	
9	02/01/2019	0.13	0.15	0	1	Mini pallet	
10	02/01/2019	0.13	0.15	0	1	Mini pallet	
11	02/01/2019	0	0.15	0	1	Mini pallet	
12	02/01/2019	0	0.09	1	1	Mini pallet	
13	02/01/2019	4	0	0	11	Euro pallet	
14	02/01/2019	0	0	0	1	Euro pallet	
15	02/01/2019	0	0	0	1	Euro pallet	
16	02/01/2019	0.4	0	0	1	Euro pallet	
17	02/01/2019	1	0	0	1	Disposable pallet	
18	02/01/2019	0	0	0	1	Half pallet	
19	02/01/2019	0	0	0	1	Disposable pallet	
20	02/01/2019	0	0	0	1	Half pallet	
21	02/01/2019	0.67	0	0	1	Disposable pallet	
22	02/01/2019	1	0	0	1	Disposable pallet	
23	02/01/2019	0	0	0	1	Disposable pallet	
24	02/01/2019	0	0	0	1	Half pallet	
25	02/01/2019	0.25	0	0	1	Half pallet	
26	02/01/2019	0.25	0	0	1	Half pallet	
27	02/01/2019	0.25	0	0	1	Half pallet	
28	02/01/2019	0.25	0	0	1	Half pallet	
29	02/01/2019	0.25	0	0	1	Half pallet	

Output | Employee hours | Productivity | Employee hours segments | Productivity segme

The output data first consisted of all types of units. Thus, colli and bundles are included as well. To filter those out, VBA is used. Figure 42 shows the OnlyPallets macro, including code and explanation (green text/sentence starting with quotation mark). Only the euro pallets, half pallets, mini pallets, and disposable pallets should remain.

Figure 42: Macro OnlyPallets (VBA) of Output sheet

```
Sub OnlyPallets()
'Output sheet

'Delete all transportation units that are not pallets

Dim LastRow, i As Long

'Ensure that the code uses the output sheet
With Sheets("Output")
    'Count rows of output sheet
    LastRow = Cells(Rows.Count, 1).End(xlUp).Row

    'Loop through the rows
    For i = LastRow To 2 Step -1
        'If the transportation unit is a pallet, do nothing
        If Cells(i, 6) = "Euro pallet" Then
        ElseIf Cells(i, 6) = "Half pallet" Then
        ElseIf Cells(i, 6) = "Mini pallet" Then
        ElseIf Cells(i, 6) = "Disposable pallet" Then
        Else
            'If the transportation unit is something else, delete the row
            Rows(i).EntireRow.Delete
        End If
    Next i
End With

End Sub
```

Appendix C.2
Employee hours sheet

The 'Employee hours' sheet contains data of all employee hours of the TransMission transport hall employees in the evening unloading and loading process from the 1st of January 2019 to the 26th of May 2021. Figure 43 shows an excerpt of the 'Employee hours' sheet. In the sheet, each row contains data on the worked hours of a specific employee on a specific date. The data consist of the employee ID (column A), start date/time (column B), start date (column C), start time (column D), end date/time (column E), end date (column F), end time (column G), date (column H), total duration in hours (column I), total duration in minutes (column J), total duration in hours decimal (column K), and type of employee (column L). The employee ID for each employee is linked to the 'Timing employee' and 'HST employee' sheets. Appendix C. discusses these sheets. The start date/time is the start date and start time combined, calculated with equation (40).

$$B[number] = StartDate + StartTime = TEXT(C[number], \text{“dd/mm/yyyy”})\&\text{“ ”}\&(D[number], \text{“hh:mm”}) \quad (40)$$

The same holds for the end date/time, which is calculated with equation (41).

$$E[number] = EndDate + EndTime = TEXT(F[number], \text{“dd/mm/yyyy”})\&\text{“ ”}\&(G[number], \text{“hh:mm”}) \quad (41)$$

The date is the same as the start date and is added to make it easier in Power BI. The total duration in hours of the permanent employees (HST employees) is the difference between the start time and the end time of an employee on a specific date in hours. Equation (42) calculates this. The total duration of hours of the temporary employees (Timing employees) is derived from the total duration in hours decimal, depicted in equation (43).

$$\text{Permanent employees: } I[number] = IF(G[number] > D[number], G[number] - D[number], G[number] + 1 - D[number]) \quad (42)$$

Temporary employees: I*[number]* = K*[number]* / 24 (43)

The total duration in minutes is the same value as the total duration in hours converted to minutes. Equation (44) indicates this.

J*[number]* = I*[number]* * 24 * 60 (44)

The total duration in hours decimal is the total duration in hours as a comma number. Equation (45) depicts the values of the permanent employees (HST employees). The values of the temporary employees (Timing employees) are derived from the employment agency.

Permanent employees: K*[number]* = J*[number]* / 60 (45)

The type of employee is HST or Timing. HST means that it is a regular employee employed by HST TransMission itself, whereas Timing means that it is a temporary employee hired through an employment agency.

Figure 43: Employee hours sheet of data set

	A	B	C	D	E	F	G	H	I	J	K	L
1	Employee ID	Start date/time	Start date	Start time	End date/time	End date	End time	Date	Total duration in hours	Total duration in minutes	Total duration in hours decimal	Type of employee
2	136	02/01/2019 16:30	02/01/2019	16:30	03/01/2019 01:18	03/01/2019	01:18	02/01/2019	08:48	528	8.80	HST
3	964	02/01/2019 14:00	02/01/2019	14:00	02/01/2019 22:20	02/01/2019	22:20	02/01/2019	08:20	500	8.33	HST
4	1026	02/01/2019 16:30	02/01/2019	16:30	02/01/2019 22:20	02/01/2019	22:20	02/01/2019	05:50	350	5.83	HST
5	1115	02/01/2019 14:00	02/01/2019	14:00	02/01/2019 21:48	02/01/2019	21:48	02/01/2019	07:48	468	7.80	HST
6	1278	02/01/2019 23:00	02/01/2019	23:00	03/01/2019 03:00	03/01/2019	03:00	02/01/2019	04:00	240	4.00	HST
7	746	02/01/2019 16:15	02/01/2019	16:15	02/01/2019 22:28	02/01/2019	22:28	02/01/2019	06:13	373	6.22	HST
8	903							02/01/2019	02:18	138	2.30	Timing
9	46							02/01/2019	04:48	288	4.80	Timing
10	136	03/01/2019 16:30	03/01/2019	16:30	04/01/2019 01:15	04/01/2019	01:15	03/01/2019	08:45	525	8.75	HST
11	964	03/01/2019 16:15	03/01/2019	16:15	03/01/2019 00:00	03/01/2019	00:00	03/01/2019	07:45	465	7.75	HST
12	1026	03/01/2019 16:30	03/01/2019	16:30	03/01/2019 22:00	03/01/2019	22:00	03/01/2019	05:30	330	5.50	HST
13	1058	03/01/2019 16:30	03/01/2019	16:30	03/01/2019 20:31	03/01/2019	20:31	03/01/2019	04:01	241	4.02	HST
14	1115	03/01/2019 14:00	03/01/2019	14:00	03/01/2019 21:53	03/01/2019	21:53	03/01/2019	07:53	473	7.88	HST
15	1278	03/01/2019 23:00	03/01/2019	23:00	04/01/2019 03:00	04/01/2019	03:00	03/01/2019	04:00	240	4.00	HST
16	746	03/01/2019 16:15	03/01/2019	16:15	03/01/2019 22:02	03/01/2019	22:02	03/01/2019	05:47	347	5.78	HST
17	903							03/01/2019	02:30	150	2.50	Timing
18	608							03/01/2019	03:18	198	3.30	Timing
19	46							03/01/2019	03:18	198	3.30	Timing
20	136	04/01/2019 16:30	04/01/2019	16:30	05/01/2019 01:15	05/01/2019	01:15	04/01/2019	08:45	525	8.75	HST
21	964	04/01/2019 16:00	04/01/2019	16:00	04/01/2019 23:12	04/01/2019	23:12	04/01/2019	07:12	432	7.20	HST
22	1026	04/01/2019 16:30	04/01/2019	16:30	04/01/2019 22:30	04/01/2019	22:30	04/01/2019	06:00	360	6.00	HST
23	1058	04/01/2019 16:30	04/01/2019	16:30	04/01/2019 20:16	04/01/2019	20:16	04/01/2019	03:46	226	3.77	HST
24	1115	04/01/2019 14:00	04/01/2019	14:00	04/01/2019 21:34	04/01/2019	21:34	04/01/2019	07:34	454	7.57	HST
25	1278	04/01/2019 20:00	04/01/2019	20:00	05/01/2019 03:00	05/01/2019	03:00	04/01/2019	07:00	420	7.00	HST
26	608							04/01/2019	03:00	180	3.00	Timing
27	856							04/01/2019	02:30	150	2.50	Timing
28	136	07/01/2019 16:30	07/01/2019	16:30	08/01/2019 01:17	08/01/2019	01:17	07/01/2019	08:47	527	8.78	HST
29	964	07/01/2019 14:00	07/01/2019	14:00	07/01/2019 22:48	07/01/2019	22:48	07/01/2019	08:48	528	8.80	HST

Output | Employee hours | Productivity | Employee hours segments | Productivity segments | Fall-out percentage | Timing employees | HST employees

The ‘Employee hours’ sheet first consisted of the employee hours of the whole unloading and loading process. To filter out the morning shifts, VBA is again used. Figure 44 shows the DeleteMorningShifts macro, including code and explanation (green text/sentence starting with quotation mark). Broadly taken, the evening unloading and loading process takes from 2 p.m. until 3 a.m. Thus, there are four options:

1. Both the start time and end time are between 3 a.m. and 2 p.m. The code removes the entire row.
2. The start time is between 3 a.m. and 2 p.m., whereas the end time is between 2 p.m. and 3 a.m. The code changes the start time to 2 p.m.
3. The start time is between 2 p.m. and 3 a.m., whereas the end time is between 3 a.m. and 2 p.m. The code changes the end time to 3 a.m.
4. Both the start time and end time are between 2 p.m. and 3 a.m. The code skips this row.

The code only carries this out if the employee is a regular employee (employee type = HST). The employee hours of the temporary employees (employee type = Timing) are already only made during the evening unloading and loading process.

Figure 44: Macro DeleteMorningShifts (VBA) of Employee hours sheet

```
Sub DeleteMorningShifts()
'Employee hours sheet

'Delete all morning shifts

Dim LastRow, i As Long
Dim TimeSecondsAM, TimeSecondsPM As Double

'Ensure that the code uses the Employee hours sheet
With Sheets("Employee hours")

    'Determine the last row of the Employee hours sheet
    LastRow = Cells(Rows.Count, 1).End(xlUp).Row

    'The process is from 3 AM to 2 PM
    'Set the minimum time to 3 AM
    TimeSecondsAM = 10800
    'Set the maximum time to 2 PM
    TimeSecondsPM = 50400

    'Loop through the Employee hours sheet, from bottom to top
    For i = LastRow To 2 Step -1
        'If the type of employee is HST
        If Cells(i, 12) = "HST" Then
            'If the start time is before 2 PM and after 3 AM
            If Cells(i, 4) < 1 / 86400 * TimeSecondsPM And Cells(i, 4) > 1 / 86400 * TimeSecondsAM Then
                'If the end time is before 2 PM and after 3 AM
                If Cells(i, 7) < 1 / 86400 * TimeSecondsPM And Cells(i, 7) > 1 / 86400 * TimeSecondsAM Then
                'Then delete the row
                Rows(i).EntireRow.Delete
                Else 'If the end time is after 2 PM and before 3 AM
                'Change the start time to 2 PM
                Cells(i, 2) = Cells(i, 3).Value & " " & Format(1 / 86400 * TimeSecondsPM, "hh:mm:ss")
                Cells(i, 4) = 1 / 86400 * TimeSecondsPM
                End If
            Else 'If the start time is after 2 PM and before 3 AM
                'If end time is after 3 AM and before 2 PM
                If Cells(i, 7) > 1 / 86400 * TimeSecondsAM And Cells(i, 7) < 1 / 86400 * TimeSecondsPM Then
                    'Change end time to 3 AM
                    Cells(i, 5) = Cells(i, 6).Value & " " & Format(1 / 86400 * TimeSecondsAM, "hh:mm:ss")
                    Cells(i, 7) = 1 / 86400 * TimeSecondsAM
                'If the end time is before 3 AM and after 2 PM, do nothing
                End If
            End If
        'If the type of employee is not HST, do nothing
        End If
    Next i
End With

End Sub
```

The 'Employee hours' sheet first consisted of all transport hall employees. Thus, also the sorting belt employees and employees from other halls, such as the Germany hall. Figure 45 shows the DeleteEmployeeIDs macro, including code and explanation (green text/sentence starting with quotation mark). Only the scanners, managers, and loading/unloading employees remain. The 'Timing employee' and 'HST employee' sheets are used for this. We discuss these in Appendix C..

Figure 45: Macro DeleteEmployeeIDs (VBA) of Employee hours sheet

```
Sub DeleteEmployeeIDs()
'Employee hours sheet

'Delete the IDs that are not loading/unloading, manager transport hall, or scanner

Dim i, j, k, LastRowEmployeeHours, LastRowTiming, LastRowHST, IDToCheck As Long
Dim IDFunction As String
'Set the worksheets to be used
Dim S1 As Worksheet
Set S1 = Sheets("Employee hours")
Dim S2 As Worksheet
Set S2 = Sheets("Timing employees")
Dim S3 As Worksheet
Set S3 = Sheets("HST employees")

'Determine the last row of the sheets
LastRowEmployeeHours = S1.Cells(Rows.Count, 1).End(xlUp).Row
LastRowTiming = S2.Cells(Rows.Count, 1).End(xlUp).Row
LastRowHST = S3.Cells(Rows.Count, 1).End(xlUp).Row

'Loop through Employee hours sheet, from bottom to top
For i = LastRowEmployeeHours To 2 Step -1
    'Reset IDToCheck and IDFunction
    IDToCheck = 0
    IDFunction = Empty

    'Determine the Employee ID to check
    IDToCheck = S1.Cells(i, 1)

    'Determine the function of the employee in the Timing employee en HST employee sheet
    'Loop through HST Employees sheet first (less employees, but more often the one needed)
    For j = 2 To LastRowHST
        'Check whether the ID is in the Employee ID column
        If S3.Cells(j, 3) = IDToCheck Then
            'If so, determine the function of the ID
            IDFunction = S3.Cells(j, 2)
            'And exit the loop
            Exit For
        End If 'Otherwise, continue to next j
    Next j
    'If the IDFunction is not known yet
    If IDFunction = Empty Then
        'Loop through Timing employees sheet
        For k = 2 To LastRowTiming
            'Check whether the ID is in the Employee ID column
            If S2.Cells(k, 3) = IDToCheck Then
                'If so, determine the function of the ID
                IDFunction = S2.Cells(k, 2)
                'And exit the loop
                Exit For
            End If 'Otherwise continue to next k
        Next k
    'If the IDFunction is known, skip the loop through the Timing employees sheet
    End If

    'If the IDFunction is equal to loading/unloading, manager transport hall, or scanner, do nothing
    If IDFunction = "Loading/unloading" Then
    ElseIf IDFunction = "Scanner" Then
    ElseIf IDFunction = "Manager" Then
    'If not equal
    Else
        'Delete the row in the Hours Worked sheet
        S1.Rows(i).EntireRow.Delete
    End If
Next i

End Sub
```

Appendix C.3
Productivity sheet

The 'Productivity' sheet consists of the data of the overall productivity of the evening unloading and loading process per day from the 1st of January 2019 to the 26th of May 2021. Figure 46 shows an excerpt of the 'Productivity' sheet. In the sheet, each row contains data on the productivity on a specific date. The data consists of the date (column A), total output (column B), total employee hours (column C), total team productivity (column D), total number of employees (column E), and total individual productivity (column F). The date refers to the dates from the 'Output' and 'Employee hours' sheet. The total output is the sum of the quantity of the pallets in a shipment on a specific date derived from the 'Output' sheet. The total employee hours is the sum of the total duration in hours (as a decimal number) of the employees working on a specific date derived from the 'Employee hours' sheet. The total team productivity is the total output divided by the total employee hours per day. The total number of employees is the number of employees working on the evening process per day. The total individual productivity is the total output divided by the total number of employees per day.

Figure 46: Productivity sheet of the data set

	A	B	C	D	E	F
1	**Date**	**Total output**	**Total employee hours**	**Total team productivity**	**Total number of employees**	**Total individual productivity**
2	02/01/2019	500	48.08	10.40	8	62.50
3	03/01/2019	466	52.78	8.83	10	46.60
4	04/01/2019	538	45.78	11.75	8	67.25
5	07/01/2019	676	60.48	11.18	9	75.11
6	08/01/2019	730	59.18	12.33	9	81.11
7	09/01/2019	687	61.20	11.23	9	76.33
8	10/01/2019	745	64.15	11.61	9	82.78
9	11/01/2019	615	69.03	8.91	10	61.50
10	14/01/2019	688	56.52	12.17	8	86.00
11	15/01/2019	735	65.43	11.23	10	73.50
12	16/01/2019	715	68.42	10.45	9	79.44
13	17/01/2019	766	73.48	10.42	11	69.64
14	18/01/2019	654	76.27	8.58	14	46.71
15	21/01/2019	694	62.23	11.15	9	77.11
16	22/01/2019	659	66.12	9.97	11	59.91
17	23/01/2019	629	54.28	11.59	8	78.63
18	24/01/2019	627	65.63	9.55	11	57.00
19	25/01/2019	668	61.38	10.88	11	60.73
20	28/01/2019	715	67.55	10.58	11	65.00
21	29/01/2019	765	67.93	11.26	10	76.50
22	30/01/2019	649	59.83	10.85	9	72.11
23	31/01/2019	761	62.28	12.22	9	84.56
24	01/02/2019	669	68.50	9.77	12	55.75
25	04/02/2019	749	58.00	12.91	12	62.42
26	05/02/2019	683	60.43	11.30	12	56.92
27	06/02/2019	816	54.92	14.86	9	90.67
28	07/02/2019	787	53.97	14.58	9	87.44
29	08/02/2019	647	60.70	10.66	11	58.82

Output | Employee hours | **Productivity** | Employee hours segments | Productivity segments | Fall-out percenta

To generate the dates in the 'Productivity' sheet, VBA is used. Figure 47 shows the GenerateDates macro, including code and explanation (green text/sentence starting with quotation mark). The dates are derived from the 'Employee hours' sheet. To only have unique dates, the code checks whether the date is already in the 'Productivity' sheet.

Figure 47: Macro GenerateDates (VBA) of Productivity sheet

```
Sub GenerateDates()
'Productivity sheet

'Generate the dates

Dim LastRowEmployeeHours, LastRowProductivity, i, j, InProductivitySheet As Long
'Set the worksheets to be used
Dim S1 As Worksheet
Set S1 = Sheets("Productivity")
Dim S2 As Worksheet
Set S2 = Sheets("Employee hours")

'Determine the last row of the employee hours sheet
LastRowEmployeeHours = S2.Cells(Rows.Count, 1).End(xlUp).Row

'Fill in first cell with date
Cells(2, 1) = S2.Cells(2, 3)

'Now fill in the other date cells
'Loop through employee hours sheet
For i = 3 To LastRowEmployeeHours
    'Determine the last row of the productivity sheet
    LastRowProductivity = S1.Cells(Rows.Count, 1).End(xlUp).Row

    'Loop through productivity sheet
    For j = 2 To LastRowProductivity
        'If the date is already in the productivity sheet
        If S2.Cells(i, 3) = S1.Cells(j, 1) Then
            'Change inproductivitysheet to 1
            InProductivitySheet = 1
            'And exit the loop
            Exit For
        'If the date is not in there, do nothing (inproductivitysheet stays 0)
        End If
    Next j

    'If the date was not already in the sheet
    If InProductivitySheet = 0 Then
        'Add the date to the productivity sheet
        S1.Cells(LastRowProductivity + 1, 1) = S2.Cells(i, 3)
    'If the date was already in the sheet, do nothing
    End If

    'Reset the inproductivitysheet for the next date
    InProductivitySheet = 0
Next i
```

To generate the total output in the 'Productivity' sheet, VBA is used. Figure 48 shows the GenerateTotalOutput macro, including code and explanation (green text/sentence starting with quotation mark). The total output is derived from the 'Output' sheet. The code sums up all output values corresponding to one date to derive the total output of that date. At the end of the code, VBA calls the GenerateTotalTeamProductivity macro, which automatically updates the total team productivity column.

Figure 48: Macro GenerateTotalOutput (VBA) of Productivity sheet

```
Sub GenerateTotalOutput()
'Productivity sheet

'Generate total output in productivity sheet

Dim LastRowProductivity, LastRowOutput, j, i As Long
Dim Output As Double
Dim DateToCheck As Date
'Set worksheets to be used
Dim S1 As Worksheet
Set S1 = Sheets("Output")
Dim S2 As Worksheet
Set S2 = Sheets("Productivity")

'Determine last row productivity sheet
LastRowProductivity = S2.Cells(Rows.Count, 1).End(xlUp).Row

'Loop through productivity sheet
For i = 2 To LastRowProductivity
    'Reset output
    Output = 0
    'Set the date to check from output sheet
    DateToCheck = S2.Cells(i, 1)
    'Determine last row of ouput sheet
    LastRowOutput = S1.Cells(Rows.Count, 1).End(xlUp).Row

    'Loop through output sheet
    For j = 2 To LastRowOutput
        'If the date in output sheet matches the date in productivity sheet
        If S1.Cells(j, 1) = DateToCheck Then
           'Add quantity of that date to output
            Output = Output + S1.Cells(j, 5)
        'If the data in output sheet does not match the date in productivity sheet, do nothing
        End If
    Next j

    'Fill in the output in the productivity sheet
    S2.Cells(i, 2) = Output

Next i


'Ensure that the total team and individual productivity are refreshed
Call GenerateTotalTeamProductivity
Call GenerateTotalIndividualProductivity

End Sub
```

To generate the total employee hours in the 'Productivity' sheet, VBA is used. Figure 49 shows the GenerateTotalWorkedEmployeeHours macro, including code and explanation (green text/sentence starting with quotation mark). The total employee hours are derived from the 'Employee hours' sheet. The code sums up all total duration in hours values corresponding to one date to derive the total employee hours. At the end of the code, VBA calls the GenerateTotalTeamProductivity macro, which automatically updates the total team productivity column.

Figure 49: Macro GenerateTotalEmployeeHours (VBA) of Productivity sheet

```
Sub GenerateTotalEmployeeHours()
'Productivity sheet

'Generate the total employee hours in the productivity sheet

Dim LastRowProductivity, LastRowEmployeeHours, j, i As Long
Dim EmployeeHours As Double
Dim DateToCheck As Date
'Set the worksheets to be used
Dim S1 As Worksheet
Set S1 = Sheets("Employee hours")
Dim S2 As Worksheet
Set S2 = Sheets("Productivity")

'Determine last row of productivity sheet
LastRowProductivity = S2.Cells(Rows.Count, 1).End(xlUp).Row

'Loop through productivity sheet
For i = 2 To LastRowProductivity
    'Reset employeehours
    EmployeeHours = 0
    'Set the date to check from employee hours sheet
    DateToCheck = S2.Cells(i, 1)
    'Determine last row of employee hours sheet
    LastRowEmployeeHours = S1.Cells(Rows.Count, 8).End(xlUp).Row

    'Loop through employee hours sheet
    For j = 2 To LastRowEmployeeHours
        'If the date in output sheet matches the date in productivity sheet
        If S1.Cells(j, 8) = DateToCheck Then
           'Add total duration to employeehours
            EmployeeHours = EmployeeHours + S1.Cells(j, 11)
        'If the date in output sheet does not match the date in productivity sheet, do nothing
        End If
    Next j
    'Fill in the employeehours in the productivity sheet
    S2.Cells(i, 3) = EmployeeHours
Next i

'Ensure that the total team productivity is refreshed
Call GenerateTotalTeamProductivity
End Sub
```

To generate the total team productivity, VBA is used. Figure 50 shows the GenerateTotalTeamProductivity macro, including code and explanation (green text/sentence starting with quotation mark). The total team productivity is the total output divided by the total employee hours.

Figure 50: Macro GenerateTotalTeamProductivity (VBA) of Productivity sheet

```
Sub GenerateTotalTeamProductivity()
'Productivity sheet

'Generate the total team productivity in the productivity sheet

Dim i, LastRow As Long

'Ensure that the productivity sheet is used
With Sheets("Productivity")
    'Determine the last row of the productivity sheet
    LastRow = Cells(Rows.Count, 1).End(xlUp).Row

    'Loop through the productivity sheet
    For i = 2 To LastRow
        'Calculate and fill in the total team productivity
        'Total team productivity = output/employee hours
        Cells(i, 4) = Cells(i, 2) / Cells(i, 3)
    Next i

End With

End Sub
```

To generate the total number of employees in the 'Productivity' sheet, VBA is used. Figure 51 shows the GenerateTotalNumberOfEmployees macro, including code and explanation (green text/sentence starting with quotation mark). The total number of employees is derived from the 'Employee hours' sheet. The code counts the number of employees working on a specific date. At the end of the code, VBA calls the GenerateTotalIndividualProductivity macro, which means that the total individual productivity column is updated automatically.

Figure 51: Macro GenerateTotalNumberOfEmployees (VBA) of Productivity sheet

```
Sub GenerateTotalNumberOfEmployees()
'Productivity sheet

'Generate the total number of employees

Dim i, j, LastRowProductivity, LastRowEmployeeHours, Count As Long
Dim DateToCheck As Date
'Set the worksheets to be used
Dim S1 As Worksheet
Set S1 = Sheets("Productivity")
Dim S2 As Worksheet
Set S2 = Sheets("Employee hours")

'Determine last row of productivity and employee hours sheet
LastRowProductivity = S1.Cells(Rows.Count, 1).End(xlUp).Row
LastRowEmployeeHours = S2.Cells(Rows.Count, 1).End(xlUp).Row
```

```
'Loop through productivity sheet
For i = 2 To LastRowProductivity
    'Reset count value
    Count = 0
    'Determine the date to check
    DateToCheck = S1.Cells(i, 1)
    'Loop through employee hours sheet
    For j = 2 To LastRowEmployeeHours
        'If the date in employee hours sheet is equal to date to check
        If S2.Cells(j, 8) = DateToCheck Then
            'Add one to the count value
            Count = Count + 1
        End If
    Next j

    'Fill in the count value in the productivity sheet
    S1.Cells(i, 5) = Count
Next i

'Ensure that the total individual productivity is refreshed
Call GenerateTotalIndividualProductivity

End Sub
```

To generate the total individual productivity, VBA is used. Figure 52 shows the GenerateTotalIndividualProductivity macro, including code and explanation (green text/sentence starting with quotation mark). The total individual productivity is the total output divided by the number of employees.

Figure 52: Macro GenerateTotalNumberOfEmployees (VBA) of Productivity sheet

```
Sub GenerateTotalIndividualProductivity()
'Productivity sheet

'Generate total individual prodcutivity

Dim i, LastRow As Long

'Ensure that the code runs through the productivity sheet
With Sheets("Productivity")
    'Determine the last row of the productivity sheet
    LastRow = Cells(Rows.Count, 1).End(xlUp).Row
    'Loop through the productivity sheet
    For i = 2 To LastRow
        'Calculate and fill in the total individual productivity
        'Total individual productivity = total output/number of employees
        Cells(i, 6) = Cells(i, 2) / Cells(i, 5)
    Next i
End With

End Sub
```

Appendix C.4
Employee hours segments sheet

The ‘Employee hours segments’ sheet consists of the employee hours in the different segments of the evening unloading and loading process. This data is only available for the 26th of May since it is the first day that HST TransMission kept track of this data. Figure 53 shows the macro of the ‘Employee hours segments’ sheet. In this sheet, each row contains data of the employee hours for each segment of a specific employee on a specific date. The data consists of the date (column A), employee name (column B), employee ID (column C), start time (column D), end time (column E), total duration in hours (column F), hours for each segment (column G until K), hours other (column L), hours break (column M), and hours total (column N). The date, employee name, start time, end time, hours for each segment, hours activities, and hours break are derived from the form that the transport hall manager filled in manually. The employee ID for each employee is derived from the employee sheets based on the employee name (Appendix C.). The hours other are the employee hours for other activities than the several segments. The hours break are the employee hours for taking a break. The total duration is the difference between the start time and end time, whereas the hours total is the sum of the employee hours for each segment and the employee hours for other activities.

Figure 53: Hours worked segments sheet of the data set

Date	EmployeeName	EmployeeID	StartTime	EndTime	TotalDurationInHours	Hours Unloading	Hours LoadingGeneralCargo	Hours LoadingRouteCargo	Hours Scanning	Hours FallOut	Hours Other	Hours break	Hours Total
26/05/2021		349	4:30 PM	11:00 PM	06:30			2.00	3.50	0.50		0.50	06:30
26/05/2021		1026	4:30 PM	1:30 AM	09:00	4.00		4.00		0.50		0.50	09:00
26/05/2021		136	4:30 PM	1:45 AM	09:15		3.00	5.75				0.50	09:15
26/05/2021		1530	3:30 PM	2:00 AM	10:30	5.00		4.50		0.50		0.50	10:30
26/05/2021		1454	3:30 PM	1:45 AM	10:15	5.00		4.25		0.50		0.50	10:15
26/05/2021		1278	4:30 PM	2:30 AM	10:00	3.00		4.00			2.50	0.50	10:00
26/05/2021		123	4:30 PM	7:30 PM	03:00		3.00						03:00
26/05/2021		361	4:30 PM	8:00 PM	03:30	4.00				0.50			04:30
26/05/2021		1934	2:00 PM	11:00 PM	09:00	2.50	3.00		3.00			0.50	09:00
26/05/2021		746	2:00 PM	11:30 PM	09:30	2.00					7.00	0.50	09:30
26/05/2021		964	4:30 PM	2:30 AM	10:00			2.00			7.50	0.50	10:00
26/05/2021		824	3:30 PM	7:30 PM	04:00		4.00						04:00
26/05/2021		342	4:30 PM	8:00 PM	03:30	3.50							03:30
26/05/2021		1455	2:00 PM	11:15 PM	09:15	2.75	6.00					0.50	09:15
26/05/2021		1058	3:30 PM	11:15 PM	07:45		7.25					0.50	07:45
26/05/2021		378	7:00 PM	9:00 PM	02:00			1.00			1.00		02:00

Output | Hours worked | Productivity | **Hours worked segments** | Productivity segments | Fall-out percentage | Timing employees | HST employees

To generate the employee ID based on the employee’s name, VBA is used. Figure 54 shows the GenerateEmployeeID macro, including code and explanation (green text/sentence starting with quotation mark). Excel derives the IDs from the employee sheets. Appendix C. discusses these sheets. Unlike the ‘Employee hours’ sheet, none of the rows must be removed based on employee IDs since the transport hall manager does not fill in employees that are not part of the evening unloading and loading process.

Figure 54: Macro GenerateEmployeeID (VBA) of Hours worked segments sheet

```
Sub GenerateEmployeeID()
'Employee hours segments

'Generate employee ID based on the employee name

Dim i, j, k, FirstEmptyRow, LastRowEmployeeHoursSegments, LastRowTiming, LastRowHST As Long
'Set worksheets to be used
Dim S1 As Worksheet
Set S1 = Sheets("Employee hours segments")
Dim S2 As Worksheet
Set S2 = Sheets("Timing employees")
Dim S3 As Worksheet
Set S3 = Sheets("HST employees")

'Determine the first empty row in the employee ID column
FirstEmptyRow = S1.Cells(Rows.Count, 3).End(xlUp).Row + 1
'Determine the last row of the employee name column
LastRowEmployeeHoursSegments = S1.Cells(Rows.Count, 2).End(xlUp).Row

'Loop through whole employee ID column
For i = FirstEmptyRow To LastRowEmployeeHoursSegments
    'Determine the last row of the Timing sheet
    LastRowTiming = S2.Cells(Rows.Count, 1).End(xlUp).Row

    'Loop through Timing sheet
    For j = 2 To LastRowTiming
        'If the name in timing sheet is equal to name in employee hours segments sheet
        If S1.Cells(i, 2) = S2.Cells(j, 1) Then
            'Fill in the employee ID
            S1.Cells(i, 3) = S2.Cells(j, 3)
            'Exit the loop
            Exit For
        'If the name in timing sheet is not equal to the name in employee hours segments sheet, do nothing
        End If
    Next j

    'Only do the same for the HST sheet if the cell is not filled in yet
    If S1.Cells(i, 3) = Empty Then
        'Determine the last row of the HST sheet
        LastRowHST = S3.Cells(Rows.Count, 1).End(xlUp).Row

        'Loop through HST sheet
        For k = 2 To LastRowHST
            'If the names are equal
            If S1.Cells(i, 2) = S3.Cells(k, 1) Then
                'Fill in the employee ID
                S1.Cells(i, 3) = S3.Cells(k, 3)
                'Exit the loop through the HST sheet
                Exit For
            'If the names are not equal, do nothing
            End If
        Next k
    End If
Next i


End Sub
```

To generate the total duration in hours, VBA is used. Figure 55 shows the GenerateTotalDurationInHours macro, including code and explanation (green text/sentence starting with quotation mark). The total duration is the difference between the end time and start time. At the end of the code, VBA calls the GenerateHoursTotal macro, which means that the hours total column is updated automatically.

Figure 55: Macro GenerateTotalDurationInHours (VBA) of Hours worked segments sheet

```
Sub GenerateTotalDurationInHours()
'Employee hours segments sheet

'Generate the total duration in hours

Dim i, LastRow As Long

'Perform macro in employee hours segments sheet
With Sheets("Employee hours segments")
    'Determine last row in employee hours segments sheet
    LastRow = Cells(Rows.Count, 1).End(xlUp).Row

    'Loop through employee hours segments sheet
    For i = 2 To LastRow
        'If end time is larger than start time
        If Cells(i, 5) > Cells(i, 4) Then
            'Calculate the total duration in hours
            Cells(i, 6) = Cells(i, 5) - Cells(i, 4)
        Else 'If end time is smaller than start time
            'Calculate the total duration in hours
            Cells(i, 6) = Cells(i, 5) + 1 - Cells(i, 4)
        End If
    Next i
End With

'Ensure that the hours total refreshes
Call GenerateHoursTotal

End Sub
```

To generate the hours total, VBA is used. Figure 56 shows the GenerateHoursTotal macro, including code and explanation (green text/sentence starting with quotation mark). The hours total is the sum of the hours of the segments and the hours of the other activities. The macro changes the hours total to a time format.

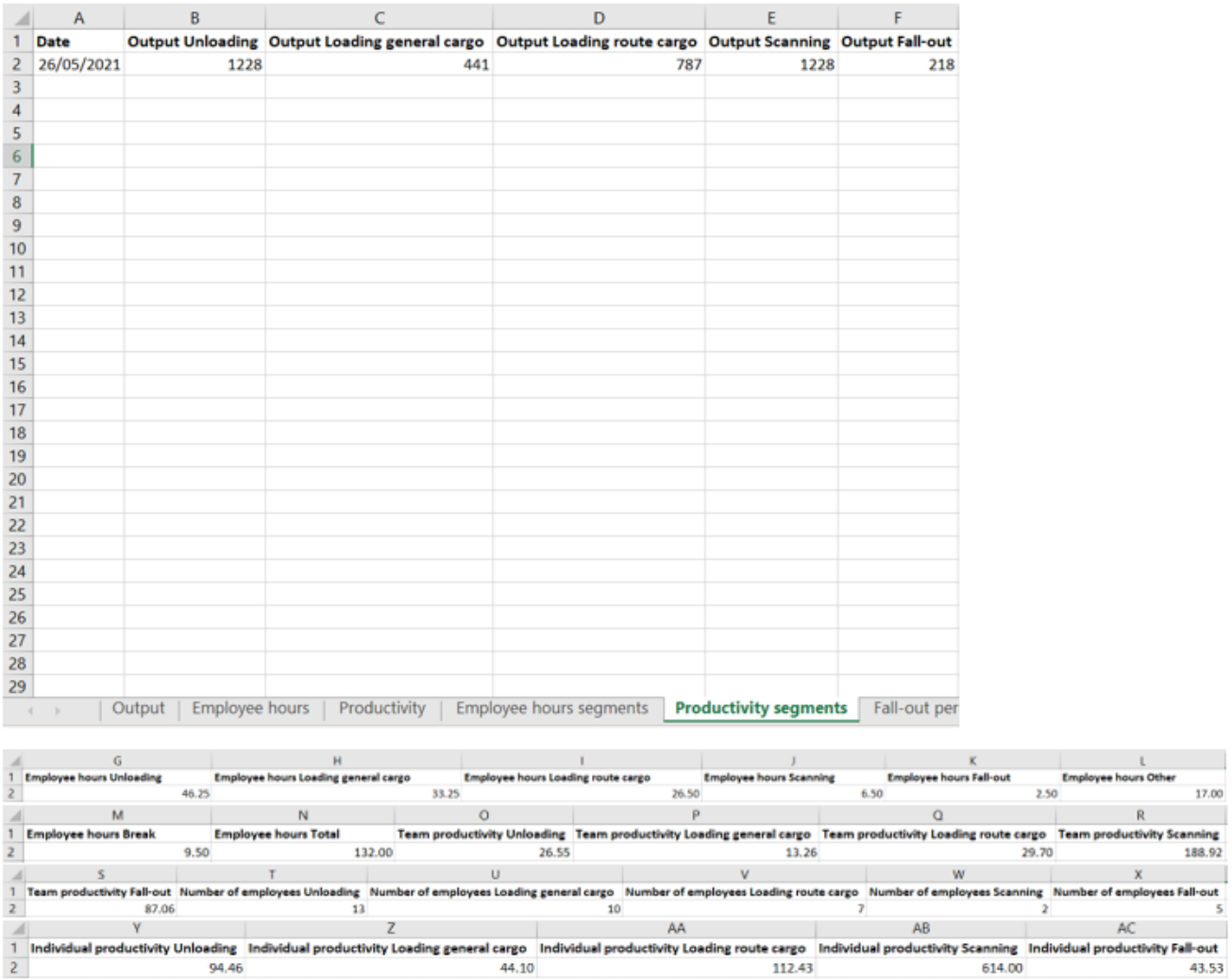
Figure 56: Macro GenerateHoursTotal (VBA) of Hours worked segments sheet

```
Sub GenerateHoursTotal()

Dim i, LastRow As Long

'Ensure that the code goes through the employee hours segments sheet
With Sheets("Employee hours segments")
    'Determine last row of employee hours segments sheet
    LastRow = Cells(Rows.Count, 1).End(xlUp).Row

    'Loop through employee hours segments sheet
    For i = 2 To LastRow
        'Calculate and fill in the total employee hours
        Cells(i, 14) = Cells(i, 7) + Cells(i, 8) + Cells(i, 9) + Cells(i, 10) + Cells(i, 11) + Cells(i, 12) + Cells(i, 13)

        'Change format
        Cells(i, 14) = Cells(i, 14) / 24
        Cells(i, 14).NumberFormat = "hh:mm"
    Next i
End With

End Sub
```

Appendix C.5
Productivity segments sheet

The 'Productivity segments' sheet consists of the data for the productivity in the different segments of the evening unloading and loading process. This data is only available for the 26th of May since it is the first day that HST TransMission kept track of this data. Figure 57 shows the 'Productivity segments' sheet. Since there are a lot of columns, the columns G until AC are below the sheet. In this sheet, each row contains data about the productivity of each segment on a specific date. The data consists of the date (column A), outputs of each segment (column B until F), employee hours of each segment (column G until K), employee hours of other activities (column L), employee hours of breaks (column M), total employee hours (column N), team productivity of each segment (column O until S), number of employees of each segment (column T until X), and individual productivity of each segment (column Y until AC). The date is derived from the 'Employee hours segments' sheet. The VBA macros of this sheet use the 'Productivity', 'Output', and 'Fall-out percentage' sheets to derive the outputs of the segments. The employee hours are derived from the 'Employee hours segments' sheet. The team productivity of a segment is the output of the segment divided by the employee hours of the segment. A VBA macro counts the number of employees in the 'Employee hours segments' sheet. The individual productivity of a segment is the output of the segment divided by the number of employees of the segment.

Figure 57: Productivity segments sheet of data set



	A	B	C	D	E	F
1	Date	Output Unloading	Output Loading general cargo	Output Loading route cargo	Output Scanning	Output Fall-out
2	26/05/2021	1228	441	787	1228	218

Output | Employee hours | Productivity | Employee hours segments | Productivity segments | Fall-out per

	G	H	I	J	K	L
1	Employee hours Unloading	Employee hours Loading general cargo	Employee hours Loading route cargo	Employee hours Scanning	Employee hours Fall-out	Employee hours Other
2	46.25	33.25	26.50	6.50	2.50	17.00

	M	N	O	P	Q	R
1	Employee hours Break	Employee hours Total	Team productivity Unloading	Team productivity Loading general cargo	Team productivity Loading route cargo	Team productivity Scanning
2	9.50	132.00	26.55	13.26	29.70	188.92

	S	T	U	V	W	X
1	Team productivity Fall-out	Number of employees Unloading	Number of employees Loading general cargo	Number of employees Loading route cargo	Number of employees Scanning	Number of employees Fall-out
2	87.06	13	10	7	2	5

	Y	Z	AA	AB	AC
1	Individual productivity Unloading	Individual productivity Loading general cargo	Individual productivity Loading route cargo	Individual productivity Scanning	Individual productivity Fall-out
2	94.46	44.10	112.43	614.00	43.53

To generate the dates in the ‘Productivity segments’ sheet, VBA is used. Figure 58 shows the GenerateDates macro, including code and explanation (green text/sentence starting with quotation mark). The dates are derived from the ‘Employee hours segments’ sheet. To only have unique dates, the code checks whether the date is already in the ‘Productivity segments’ sheet.

Figure 58: Macro GenerateDates (VBA) of Productivity segments sheet

```
Sub GenerateDates()
'Productivity segments sheet

'Generate the dates

Dim LastRowEmployeeHoursSegments, LastRowProductivitySegments, i, j, InProductivitySegmentsSheet As Long
'Set worksheets to be used
Dim S1 As Worksheet
Set S1 = Sheets("Productivity segments")
Dim S2 As Worksheet
Set S2 = Sheets("Employee hours segments")

'Determine last row of the employee hours segments sheets
LastRowEmployeeHoursSegments = S2.Cells(Rows.Count, 1).End(xlUp).Row

'Fill in first cell with date
S1.Cells(2, 1) = S2.Cells(2, 1)
'Change to date format
S1.Cells(2, 1).NumberFormat = "dd/mm/yyyy"

'Now fill in the other date cells
'Loop through employee hours segments sheet
For i = 3 To LastRowEmployeeHoursSegments
     'Determine the last row of the productivity segments sheet
     LastRowProductivitySegments = S1.Cells(Rows.Count, 1).End(xlUp).Row
     'Loop through productivity segments sheet to check whether date is in there
     For j = 2 To LastRowProductivitySegments
         'If the date is already in there
         If S2.Cells(i, 1) = S1.Cells(j, 1) Then
            'Change inproductivitysheet to 1
            InProductivitySegmentsSheet = 1
            'And exit the loop
            Exit For
         'If the date is not in there, do nothing and inproductivitysheet stays 0
         End If
     Next j


     'If the date was not in there
     If InProductivitySegmentsSheet = 0 Then
         'Add the date to the productivity segments sheet
         S1.Cells(LastRowProductivitySegments + 1, 1) = S2.Cells(i, 1)
         'Change the format
         S1.Cells(LastRowProductivitySegments + 1, 1).NumberFormat = "dd/mm/yyyy"
     'If the date was already in there, do nothing
     End If

     'Reset the inproductivitysheet for the next date
     InProductivitySegmentsSheet = 0
Next i


End Sub
```

To generate the output of the unloading segment in the 'Productivity segments' sheet, VBA is used. Figure 59 shows the GenerateOutputUnloading macro, including code and explanation (green text/sentence starting with quotation mark). The output of unloading is equal to the total output, so it is derived from the total output column in the 'Productivity' sheet. At the end of the code, VBA calls all other output segment macros, which means that they are automatically run when generating the output of the unloading segment. Besides that, it calls the GenerateTeamProductivitySegments and GenerateIndividualProductivitySegments macros so that the team and individual productivities of the segments are updated automatically.

Figure 59: Macro GenerateOutputUnloading (VBA) of Productivity segments sheet

```
Sub GenerateOutputUnloading()
'Productivity segments sheet

'Generate the unloading output in the productivity segments sheet

Dim LastRowProductivitySegments, LastRowProductivity, DateToCheck, j, i As Long
'Set the worksheets to be used
Dim S1 As Worksheet
Set S1 = Sheets("Productivity")
Dim S2 As Worksheet
Set S2 = Sheets("Productivity segments")

'Determine last row of productivity and productivity segments sheet
LastRowProductivitySegments = S2.Cells(Rows.Count, 1).End(xlUp).Row
LastRowProductivity = S1.Cells(Rows.Count, 1).End(xlUp).Row

'Loop through productivity segments sheet
For i = 2 To LastRowProductivitySegments
    'Determine the date to check
    DateToCheck = S2.Cells(i, 1)
    'Loop through productivity sheet
    For j = 2 To LastRowProductivity
        'If the dates are equal
        If DateToCheck = S1.Cells(j, 1) Then
            'Determine and fill in the output
            S2.Cells(i, 2) = S1.Cells(j, 2)
            'Exit loop
            Exit For
        'If the dates are not equal, do nothing
        End If
    Next j
Next i

'Let the other output segments run immediately
Call GenerateOutputLoadingGeneralCargo
Call GenerateOutputLoadingRouteCargo
Call GenerateOutputScanning
Call GenerateOutputFallOut
'Update the team and individual productivities of the segments
Call GenerateTeamProductivitySegments
Call GenerateIndividualProductivitySegments
End Sub
```

To generate the output of the loading general cargo segment in the 'Productivity segments' sheet, VBA is used. The GenerateOutputUnloading macro automatically runs this macro. Figure 60 shows the GenerateOutputLoadingGeneralCargo macro, including code and explanation (green text/sentence starting with quotation mark). The output of the loading general cargo is derived from the 'Output' sheet. It is the sum of the quantity of the general cargo pallets on a specific date. The same is done for the output of the loading route cargo segment but then focusing on the route cargo pallets. Figure 61 shows the GenerateOutputLoadingRouteCargo macro, including code and explanation (green text/sentence starting with quotation mark).

Figure 60: Macro GenerateOutputLoadingGeneralCargo (VBA) of Productivity segments sheet

```
Sub GenerateOutputLoadingGeneralCargo()
'Productivity segments sheet

'Generate output loading general cargo

Dim LastRowProductivitySegments, LastRowOutput, j, i As Long
Dim Output As Double
Dim DateToCheck As Date
'Set the worksheets to be used
Dim S1 As Worksheet
Set S1 = Sheets("Output")
Dim S2 As Worksheet
Set S2 = Sheets("Productivity segments")

'Determine last row of productivity sheet
LastRowProductivitySegments = S2.Cells(Rows.Count, 1).End(xlUp).Row

'Loop through productivity segments sheet
For i = 2 To LastRowProductivitySegments
    'Reset output
    Output = 0
    'Set the date to check from output sheet
    DateToCheck = S2.Cells(i, 1)
    'Determine last row of ouput sheet
    LastRowOutput = S1.Cells(Rows.Count, 1).End(xlUp).Row
    'Loop through output sheet
    For j = 2 To LastRowOutput
        'If the date in output sheet matches the date in productivity sheet
        If S1.Cells(j, 1) = DateToCheck Then
            'And if the shipment is general cargo
            If S1.Cells(j, 7) = "General" Then
                'Add quantity to output
                Output = Output + S1.Cells(j, 5)
            'If the shipment is not general cargo, do nothing
            End If
        'If the date does not match, do nothing
        End If
    Next j

    'Fill in output in productivity segments sheet
    S2.Cells(i, 3) = Output
Next i

End Sub
```

Figure 61: Macro GenerateOutputLoadingRouteCargo (VBA) of Productivity segments sheet

```
Sub GenerateOutputLoadingRouteCargo()
'Productivity segments sheet

'Generate output loading route cargo

Dim LastRowProductivitySegments, LastRowOutput, j, i As Long
Dim Output As Double
Dim DateToCheck As Date
'Set the worksheets to be used
Dim S1 As Worksheet
Set S1 = Sheets("Output")
Dim S2 As Worksheet
Set S2 = Sheets("Productivity segments")

'Determine the last row of productivity segments and output sheet
LastRowProductivitySegments = S2.Cells(Rows.Count, 1).End(xlUp).Row
LastRowOutput = S1.Cells(Rows.Count, 1).End(xlUp).Row

'Loop through productivity segments sheet
For i = 2 To LastRowProductivitySegments
    'Reset output
    Output = 0
    'Set the date to check in output sheet
    DateToCheck = S2.Cells(i, 1)

    'Loop through output sheet
    For j = 2 To LastRowOutput
        'If the date in output sheet matches the date in productivity sheet
        If S1.Cells(j, 1) = DateToCheck Then
            'And if the shipment is general cargo
            If S1.Cells(j, 7) = "Route" Then
                'Add quantity to output
                Output = Output + S1.Cells(j, 5)
            'If the shipment is not general cargo, do nothing
            End If
        'If the date does not match, do nothing
        End If
    Next j

    'Fill in the output in the productivity segments sheet
    S2.Cells(i, 4) = Output
Next i

End Sub
```

To generate the output of the scanning segment in the 'Productivity segments' sheet, VBA is used. The GenerateOutputUnloading macro automatically runs this macro. Figure 62 shows the GenerateOutputScanning macro, including code and explanation (green text/sentence starting with quotation mark). The output of the scanning segment is, just like the output of the unloading segment, equal to the total output.

Figure 62: Macro GenerateOutputScanning (VBA) of Productivity segments sheet

```
Sub GenerateOutputScanning()
'Productivity segments sheet

'Generate output scanning

Dim i, LastRow As Long

'Determine last row of unloading column
LastRow = Cells(Rows.Count, 2).End(xlUp).Row

'Loop through output unloading column
For i = 2 To LastRow
    'Ouput scanning = output unloading
    'Fill this in as output scanning in the productivity segments sheet
    Cells(i, 5) = Cells(i, 2)
Next i


End Sub
```

To generate the output of the fall-out segment in the 'Productivity segments' sheet, VBA is used. The GenerateOutputUnloading macro automatically runs this macro. Figure 63 shows the GenerateOutputFallOut macro, including code and explanation (green text/sentence starting with quotation mark). The output of the fall-out segment is equal to the total output, thus the output of the unloading segment, times the percentage of fall-out pallets derived from the 'Fall-out percentage' sheet. Appendix C.6 discusses this sheet.

Figure 63: Macro GenerateOutputFallOut (VBA) of Productivity segments sheet

```
Sub GenerateOutputFallOut()
'Productivity segments sheet

'Generate output fall-out

Dim i, j, LastRowProductivitySegments, LastRowFallOutPercentage As Long
Dim DateToCheck As Date
Dim S1 As Worksheet
Set S1 = Sheets("Productivity segments")
Dim S2 As Worksheet
Set S2 = Sheets("Fall-out percentage")

'Determine last row of the productivity segments and fallout percentage sheets
LastRowProductivitySegments = S1.Cells(Rows.Count, 1).End(xlUp).Row
LastRowFallOutPercentage = S2.Cells(Rows.Count, 1).End(xlUp).Row
```

```
'Loop through output fall-out column
For i = 2 To LastRowProductivitySegments
    'Determine the date to find the fall-out percentage for
    DateToCheck = S1.Cells(i, 1)

    'Loop through fall-out percentage sheet
    For j = 2 To LastRowFallOutPercentage
        'If the date to check is equal to the date in the fall-out percentage sheet
        If DateToCheck = S2.Cells(j, 1) Then
            'Ouput fall-out = output unloading * percentage of fall-out pallets
            'Fill this in as output fall-out in the productivity segments sheet
            S1.Cells(i, 6) = S1.Cells(i, 2) * S2.Cells(j, 4)
        End If
    Next j
Next i


End Sub
```

To generate the employee hours of each segment in the 'Productivity segments' sheet, VBA is used. Figure 64 shows the GenerateWorkedEmployeeHoursSegments macro, including code and explanation (green text/sentence starting with quotation mark). The employee hours are derived from the 'Employee hours segments' sheet. The code sums up the hours of the employees working on a specific date for each segment. At the end of the code, it calls the GenerateTeamProductivitySegments macro so that the team productivities of the segments are updated automatically.

Figure 64: Macro GenerateEmployeeHoursSegments (VBA) of Productivity segments sheet

```
Sub GenerateEmployeeHoursSegments()
'Productivity segments sheet

'Generate the employee hours of the segments

Dim i, j, LastRowProductivitySegments, LastRowEmployeeHoursSegments As Long
Dim HoursUnloading, HoursLoadingGeneral, HoursLoadingRoute, HoursScanning As Double
Dim HoursFallOut, HoursOther, HoursBreak As Double
Dim DateToCheck As Date
'Set worksheets to be used
Dim S1 As Worksheet
Set S1 = Sheets("Productivity segments")
Dim S2 As Worksheet
Set S2 = Sheets("Employee hours segments")

'Determine last row in productivity segments and employee hours segments column
LastRowProductivitySegments = S1.Cells(Rows.Count, 1).End(xlUp).Row
LastRowEmployeeHoursSegments = S2.Cells(Rows.Count, 1).End(xlUp).Row

'Loop through productivity segments sheet
For i = 2 To LastRowProductivitySegments
    'Determine the date to check
    DateToCheck = S1.Cells(i, 1)
    'Reset hours
    HoursUnloading = 0
    HoursLoadingGeneral = 0
    HoursLoadingRoute = 0
    HoursScanning = 0
    HoursFallOut = 0
    HoursOther = 0
    HoursBreak = 0
```

```
    'Loop through employee hours segments sheet
    For j = 2 To LastRowEmployeeHoursSegments
       'If the dates are equal
        If DateToCheck = S2.Cells(j, 1) Then
            'Then add the value to each segment
            HoursUnloading = HoursUnloading + S2.Cells(j, 7)
            HoursLoadingGeneral = HoursLoadingGeneral + S2.Cells(j, 8)
            HoursLoadingRoute = HoursLoadingRoute + S2.Cells(j, 9)
            HoursScanning = HoursScanning + S2.Cells(j, 10)
            HoursFallOut = HoursFallOut + S2.Cells(j, 11)
            HoursOther = HoursOther + S2.Cells(j, 12)
            HoursBreak = HoursBreak + S2.Cells(i, 13)
        'If the dates are not equal, do nothing
        End If
    Next j

    'Fill in the hours in the productivity segments sheet
    S1.Cells(i, 7) = HoursUnloading
    S1.Cells(i, 8) = HoursLoadingGeneral
    S1.Cells(i, 9) = HoursLoadingRoute
    S1.Cells(i, 10) = HoursScanning
    S1.Cells(i, 11) = HoursFallOut
    S1.Cells(i, 12) = HoursOther
    S1.Cells(i, 13) = HoursBreak
    S1.Cells(i, 14) = HoursUnloading + HoursLoadingGeneral + HoursLoadingRoute + HoursScanning + HoursFallOut + HoursOther
Next i

'Update the team productivities of the segments
Call GenerateTeamProductivitySegments

End Sub
```

To generate the team productivity of each segment in the 'Productivity segments' sheet, VBA is used. Figure 65 shows the GenerateTeamProductivitySegments macro, including code and explanation (green text/sentence starting with quotation mark). The team productivity of a segment is the output of the segment divided by the employee hours of the segment.

Figure 65: Macro GenerateTeamProductivitySegments (VBA) of Productivity segments sheet

```
Sub GenerateTeamProductivitySegments()
'Productivity segments sheet

'Generate team productivity of the segments

Dim i, LastRow As Long

'Determine last row of the productivity segments sheet
LastRow = Cells(Rows.Count, 1).End(xlUp).Row

'Loop through rows
For i = 2 To LastRow
    'Team productivity = output/employee hours
    'Fill this in as team productivity in the productivity segments sheet
    Cells(i, 15) = Cells(i, 2) / Cells(i, 7)
    Cells(i, 16) = Cells(i, 3) / Cells(i, 8)
    Cells(i, 17) = Cells(i, 4) / Cells(i, 9)
    Cells(i, 18) = Cells(i, 5) / Cells(i, 10)
    Cells(i, 19) = Cells(i, 6) / Cells(i, 11)
Next i

End Sub
```

To generate the number of employees of each segment in the 'Productivity segments' sheet, VBA is used. Figure 66 shows the GenerateNumberOfEmployeesSegments macro, including code and explanation (green text/sentence starting with quotation mark). The code counts the number of employees for a segment on a specific day by adding one to the count value of the segment each time it comes across an employee that worked on the specific date. At the end of the code, it calls the GenerateIndividualProductivitySegments macro so that the individual productivities of the segments are updated automatically.

Figure 66: Macro GenerateNumberOfEmployeesSegments (VBA) of Productivity segments sheet

```
Sub GenerateNumberOfEmployeesSegments()
'Productivity segments sheet

'Generate the number of employees of each segment

Dim i, j, LastRowProductivitySegments, LastRowEmployeeHoursSegments As Long
Dim CountUnloading, CountGeneral, CountRoute, CountScanning, CountFallOut As Long
Dim DateToCheck As Date
'Set worksheets to be used
Dim S1 As Worksheet
Set S1 = Sheets("Productivity segments")
Dim S2 As Worksheet
Set S2 = Sheets("Employee hours segments")

'Determine last row of productivity segments and employee hours sheet
LastRowProductivitySegments = S1.Cells(Rows.Count, 1).End(xlUp).Row
LastRowEmployeeHoursSegments = S2.Cells(Rows.Count, 1).End(xlUp).Row

'Loop through productivity segments sheet
For i = 2 To LastRowProductivitySegments
    'Determine the date to check
    DateToCheck = S1.Cells(i, 1)
    'Reset counts
    CountUnloading = 0
    CountGeneral = 0
    CountRoute = 0
    CountScanning = 0
    CountFallOut = 0

    'Loop through employee hours segments sheet
    For j = 2 To LastRowEmployeeHoursSegments
        'If date is equal
        If DateToCheck = S2.Cells(j, 1) Then
            'If the hours unloading cell is empty
            If S2.Cells(j, 7) = Empty Then 'Do nothing
            Else 'If the hours unloading cell is filled in, add one to countunloading
            CountUnloading = CountUnloading + 1
            End If

           'Do the same for the other hours
           If S2.Cells(j, 8) = Empty Then
           Else
           CountGeneral = CountGeneral + 1
           End If

           If S2.Cells(j, 9) = Empty Then
           Else
           CountRoute = CountRoute + 1
           End If
```

```
            If S2.Cells(j, 10) = Empty Then
            Else
            CountScanning = CountScanning + 1
            End If

            If S2.Cells(j, 11) = Empty Then
            Else
            CountFallOut = CountFallOut + 1
            End If
        'If date is not equal, do nothing
        End If
    Next j

    'Fill in the counts as number of employees for each segment in the productivity segments sheet
    S1.Cells(i, 20) = CountUnloading
    S1.Cells(i, 21) = CountGeneral
    S1.Cells(i, 22) = CountRoute
    S1.Cells(i, 23) = CountScanning
    S1.Cells(i, 24) = CountFallOut
Next i

'Update the individual productivities of the segments
Call GenerateIndividualProductivitySegments

End Sub
```

To generate the individual productivity of each segment in the 'Productivity segments' sheet, VBA is used. Figure 67 shows the GenerateIndividualProductivitySegments macro, including code and explanation (green text/sentence starting with quotation mark). The individual productivity of a segment is the output of the segment divided by the number of employees of the segment.

Figure 67: Macro GenerateIndividualProductivitySegments (VBA) of Productivity segments sheet

```
Sub GenerateIndividualProductivitySegments()
'Productivity segments sheet

'Generate the individual productivity of the segments
Dim i, LastRow As Long

'Ensure that the code runs through productivity segments sheet
With Sheets("Productivity segments")
    'Determine last row of productivity segments sheet
    LastRow = Cells(Rows.Count, 1).End(xlUp).Row
    'Loop through productivity segments sheet
    For i = 2 To LastRow
        'Calculate and fill in the individual productivity for all segments
        'Individual productivity = output/number of employees
        Cells(i, 25) = Cells(i, 2) / Cells(i, 20)
        Cells(i, 26) = Cells(i, 3) / Cells(i, 21)
        Cells(i, 27) = Cells(i, 4) / Cells(i, 22)
        Cells(i, 28) = Cells(i, 5) / Cells(i, 23)
        Cells(i, 29) = Cells(i, 6) / Cells(i, 24)
    Next i
End With

End Sub
```

Appendix C.6
Fall-out percentage sheet

The 'Fall-out percentage' sheet consists of the data for calculating the percentage of fall-out pallets per day. This data is only available for the 26th of May since it is the first day that HST TransMission saved this data. Figure 68 shows the 'Fall-out percentage' sheet. The data consist of the date (column A), number of pallets automatically assigned as route cargo (column B), number of fall-out pallets (column C), and percentage of fall-out pallets (column D). This data is manually derived from the planner of HST TransMission. The percentage of fall-out pallets is the number of fall-out pallets divided by the number of pallets automatically assigned as route cargo. Equation (46) depicts this.

$$D[number] = 1 / B[number] * C[number] \quad (46)$$

Figure 68: Fall-out percentage sheet of data set

	A	B	C	D	E	F
1	**Date**	**Number of pallets automatically assigned as route cargo**	**Number of fall-out pallets**	**Percentage of fall-out pallets**		
2	26/05/2021	615	109	17.72%		
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						

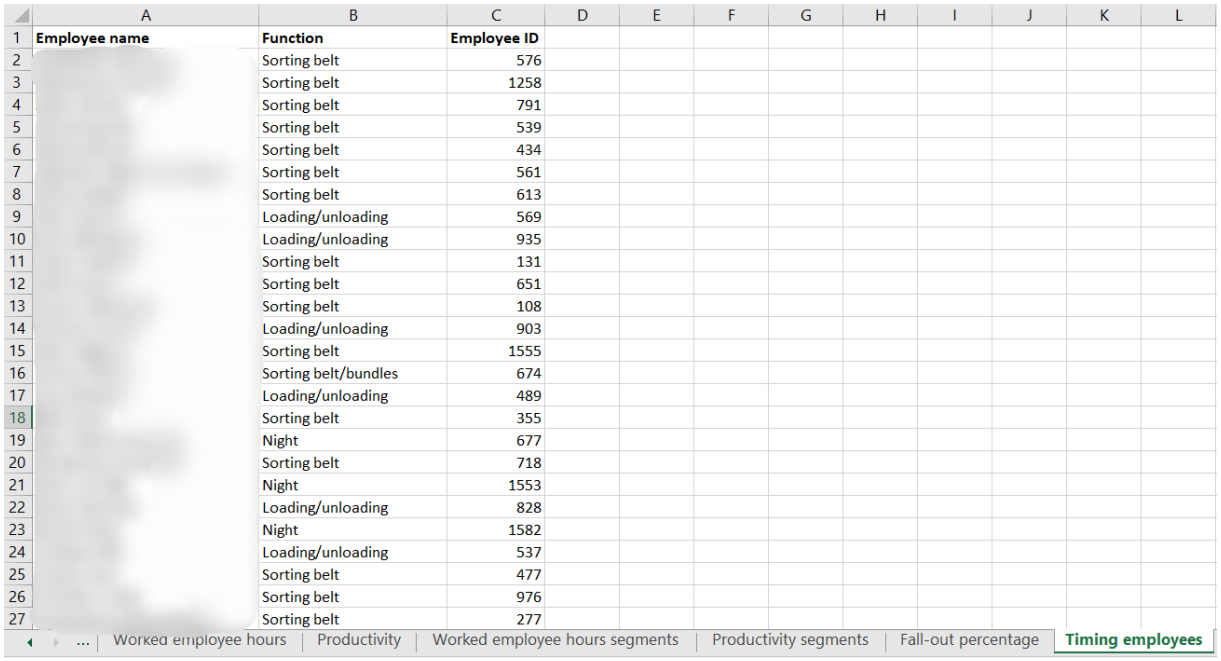
Output | Employee hours | Productivity | Employee hours segments | Productivity segments | **Fall-out percentage**

Appendix C.7
Employees sheets

The 'Timing employees' and 'HST employees' sheets consist of all employees who worked between the 1st of January 2019 until the 26th of May 2021. Figure 69 shows an excerpt of the 'Timing employees' sheet, and Figure 70 shows an excerpt of the 'HST employees' sheet. Both sheets consist of employee names (column A), functions (column B), and employee IDs (column C). The 'Timing employees' sheet focuses on the temporary employees employed via the employment agency Timing. In addition, the 'HST employees' sheet focuses on the permanent employees employed by HST TransMission itself. The function represents the activity that the employee is assigned to. Except for the employees working in other halls than the TransMission transport hall. Their function

represents the hall in which the employee works. The employee ID is an anonymous number to keep the privacy of the employees. Excel automatically generates the employee ID for each employee.

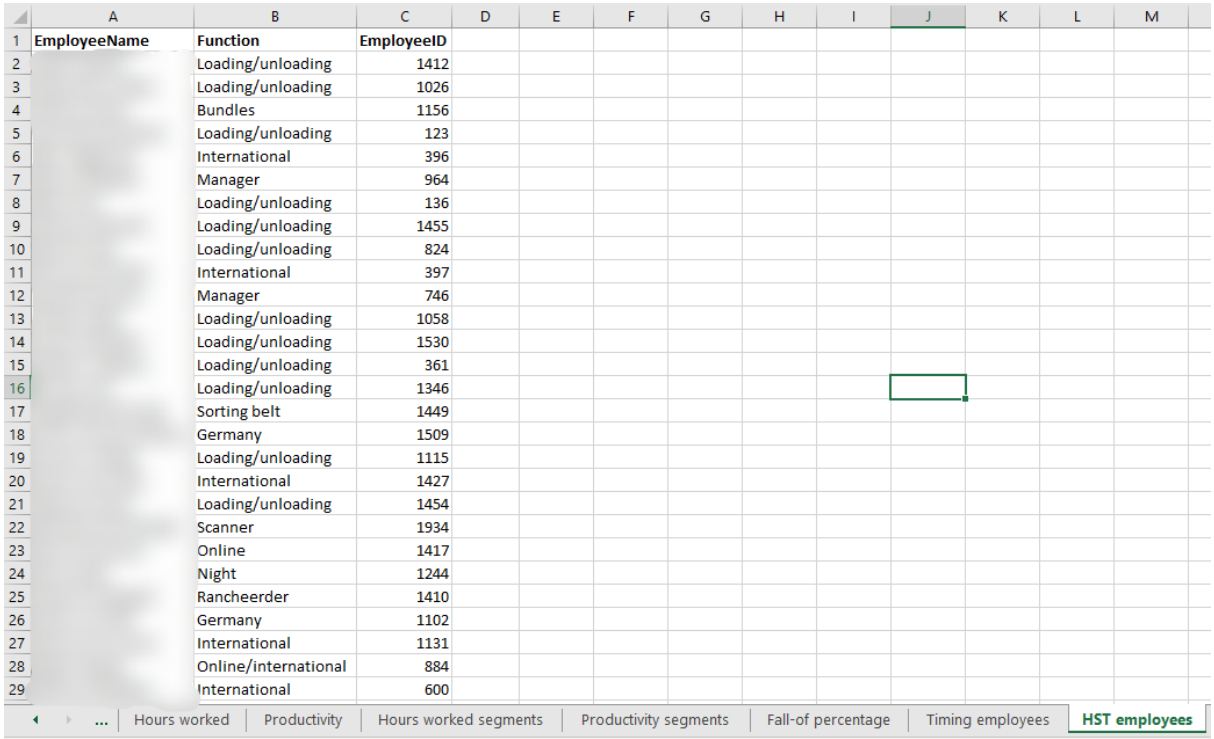
Figure 69: Timing employees sheet of data set



Employee name	Function	Employee ID
[redacted]	Sorting belt	576
	Sorting belt	1258
	Sorting belt	791
	Sorting belt	539
	Sorting belt	434
	Sorting belt	561
	Sorting belt	613
	Loading/unloading	569
	Loading/unloading	935
	Sorting belt	131
	Sorting belt	651
	Sorting belt	108
	Loading/unloading	903
	Sorting belt	1555
	Sorting belt/bundles	674
	Loading/unloading	489
	Sorting belt	355
	Night	677
	Sorting belt	718
	Night	1553
	Loading/unloading	828
	Night	1582
	Loading/unloading	537
	Sorting belt	477
	Sorting belt	976
	Sorting belt	277

... | Worked employee hours | Productivity | Worked employee hours segments | Productivity segments | Fall-out percentage | Timing employees

Figure 70: HST employees sheet of data set



EmployeeName	Function	EmployeeID
[redacted]	Loading/unloading	1412
	Loading/unloading	1026
	Bundles	1156
	Loading/unloading	123
	International	396
	Manager	964
	Loading/unloading	136
	Loading/unloading	1455
	Loading/unloading	824
	International	397
	Manager	746
	Loading/unloading	1058
	Loading/unloading	1530
	Loading/unloading	361
	Loading/unloading	1346
	Sorting belt	1449
	Germany	1509
	Loading/unloading	1115
	International	1427
	Loading/unloading	1454
	Scanner	1934
	Online	1417
	Night	1244
	Rancheerder	1410
	Germany	1102
	International	1131
	Online/international	884
	International	600

... | Hours worked | Productivity | Hours worked segments | Productivity segments | Fall-of percentage | Timing employees | HST employees

APPENDIX D

Segment productivity pages performance dashboard

Figure 71: Unloading productivity page performance dashboard

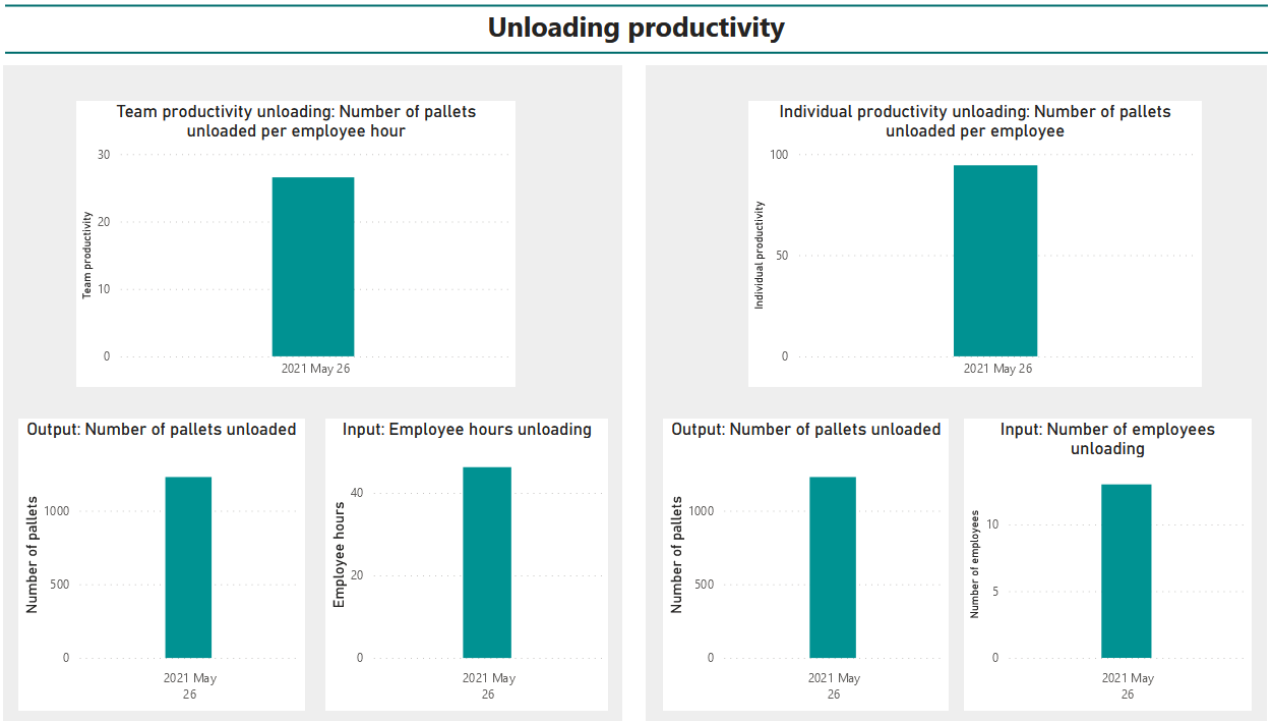


Figure 72: Loading general cargo productivity page performance dashboard

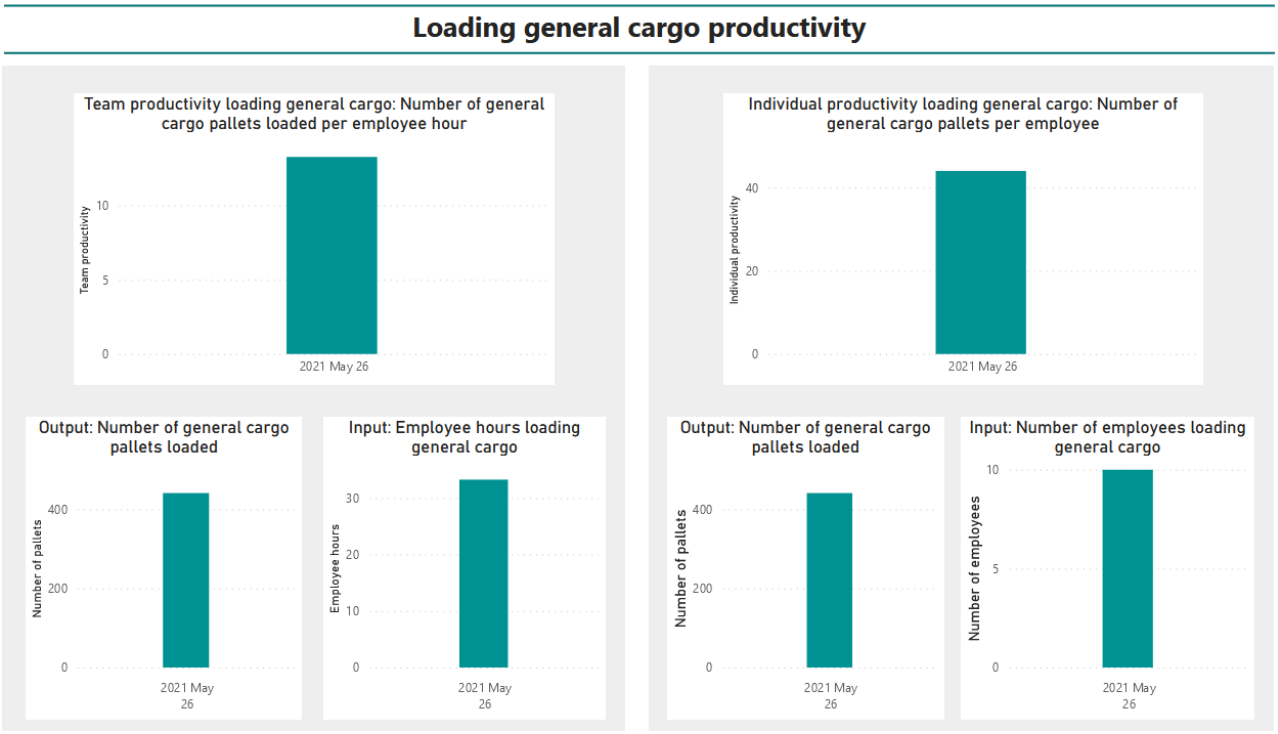


Figure 73: Loading route cargo productivity page performance dashboard

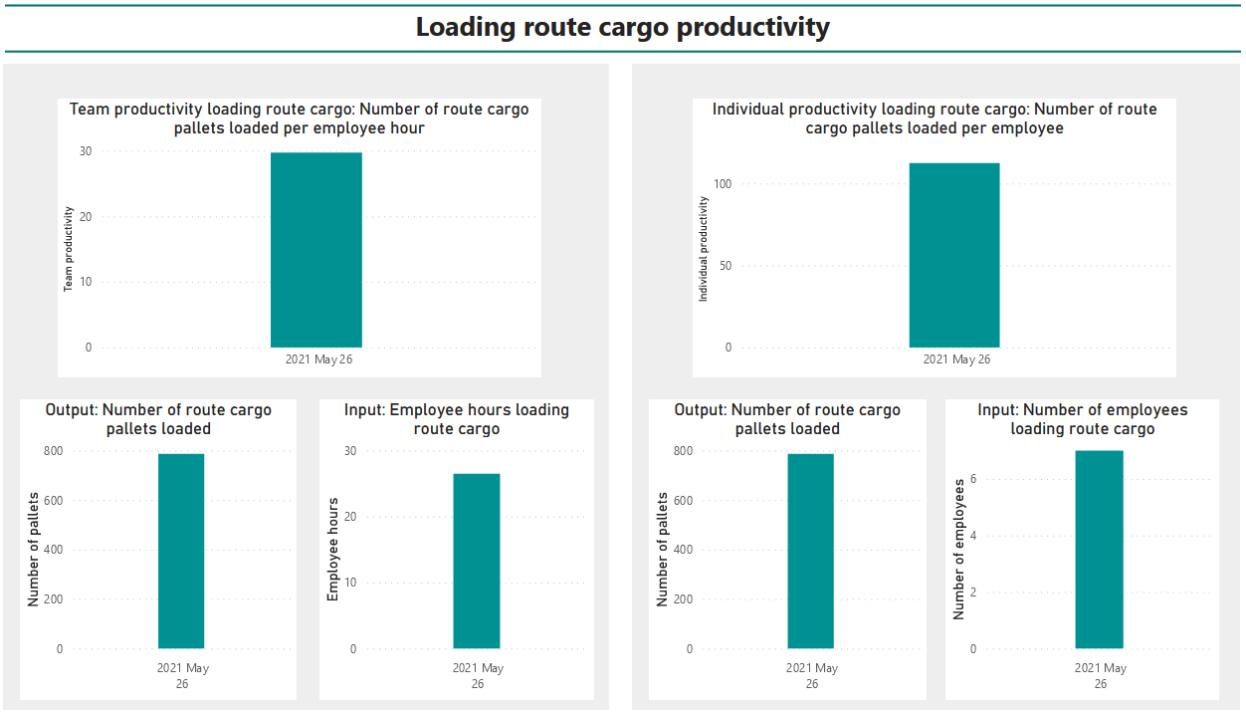


Figure 74: Scanning productivity page performance dashboard

Figure 75: Fall-out productivity page performance dashboard