Improving shuttle truck operations at VDL ETG Almelo

Bachelor thesis

van der Meer, A.I. (Ids)

20/11/2024

University of Twente

Faculty of Behavioral, Management, and Social Sciences

Bachelor of Science in Industrial Engineering and Management

Bachelor thesis Industrial Engineering and Management

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Author:

A.I. van der Meer (Ids)

s2399849

Date:

20 November 2024

Number of pages:

72

UNIVERSITY OF TWENTE.

University of Twente, Industrial Engineering and Management

PO Box 217, 7500 AE Enschede

Tel. +31(0)534899111

VDL ETG Almelo

Bornsestraat 345

7601 PB Almelo

University supervisors

Dr. I. Seyran Topan (Ipek)

Dr. E. Topan (Engin)

Company supervisors

K. Wiggers (Koen)

H. Slinger (Henk)

Management summary

This thesis was performed at VDL Enabling Technologies Group (ETG) Almelo, an industrial company based in the Netherlands. Throughout the years, VDL ETG Almelo has experienced big growth in personnel, demand, and turnover. Because of this, a central storage facility was rented from which the production locations can be supplied in the future. Production locations are between 2 - 6 Km away from the storage facility. Therefore, trucks constantly drive between locations to supply the production locations. After production orders a product, the norm, as defined by material handling, is to deliver products within 4 hours. However, VDL ETG Almelo experienced that this norm was not always achievable. Therefore this research started with the action problem: “Material handling cannot always deliver products/parts to production locations within the 4-hour time frame.” Following conversations with stakeholders and observations this resulted in the following main research question:

“How can the shuttle truck operations between storage and production be optimized to deliver products/parts within a 4-hour time frame?”

The first step in solving this research question involved a literature review, regarding the existing methods for improving material handling processes within industrial companies. Four approaches for improvement were studied: Business process reengineering (BPR), Lean, Six Sigma, and Total quality management (TQM). Following this, Lean methods for improving were reviewed to create a framework for improving processes.

Subsequently, to get a better understanding of the relevant operations, processes, and performances within VDL ETG Almelo, a current situation analysis was performed. This gives a better understanding of the product flows, truck routes, and all relevant material handling processes. Besides that, the reality of the action problem was measured using data provided by a Warehouse Management System (WMS). This highlighted the severity of the action problem, as the average product delivery is over 5,5 hours, and over 60% of products are delivered late.

Thirdly, the challenges and bottlenecks experienced within the shuttle truck operations were mapped. During this step, the goal was to seek problems, not necessarily looking at solutions yet. By finding these challenges and bottlenecks, solutions can eventually be formulated. Through observations and informal conversations, challenges and bottlenecks were found.

Afterwards, solutions were formulated to solve the challenges and bottlenecks and ultimately create improved shuttle truck operations. These solutions are divided into short-term, medium-term, and long-term solutions.

In the short-term it is suggested to implement three solutions:

- Changing the starting locations of trucks
- Improving communication with and by truck drivers
- Changing the picking order at the central storage facility.

In the medium-term, two solutions are suggested:

- Improving the visibility of products for transport at production locations
- continuously monitoring and improving performances via the use of a dashboard

In the long-term the following solution is proposed:

- Make use of a Transport Management System (TMS). The use of a TMS ensures better visibility of products and trucks, improves planning, provides additional data and offers alerts.

Finally, recommendations are given to VDL ETG Almelo. In the short-term, it is advised to implement the first three solutions and reconsider the norm of delivering within 4 hours. Adjusting the norm gives greater clarity and ensures more consistency. Implementing the three solutions reduces overall time and improves product visibility and communications. In the medium-term it is advised to implement the fourth and fifth solutions, improving visibility and being able to measure performances. By doing so, data-driven decisions can be made, and, through monthly meetings, continuous improvement can be ensured. In the long-term it is advised to make use of the TMS, giving improved tracking, visibility, and planning. Besides that, future research opportunities are given which can be looked at in the long-term.

Preface

Dear Reader,

This thesis ends my bachelor's degree in Industrial Engineering and Management at the University of Twente. Throughout this process, I received support, guidance, and encouragement from many people.

First, I would like to thank Koen Wiggers and Henk Slinger for supervising and helping me at VDL ETG Almelo. Besides that, I would like to thank the other members of the Supply Chain logistics team at VDL ETG Almelo. Throughout these months they created a supportive and friendly work environment.

Second, I want to thank Dr. I. Seyran, Topan (Ipek), from the University of Twente, whose feedback and expertise helped me a lot throughout the research. Besides that, I would like to thank Dr. E. Topan for being the second supervisor and providing final feedback.

Finally, I want to thank my family and friends for their constant support. Their encouragement helped me get through this process.

Thank you,

Ids van der Meer

30 October 2024

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List of abbreviations

ABBREVIATION	MEANING
ETG	Enabling Technologies Group
KPIS	Key Performance Indicators
MPSM	Managerial Problem-Solving Method
BPMN	Business Process Model and Notation
SLR	Systematic Literature Review
WMS	Warehouse Management System
FIFO	First in, First out
IQR	Interquartile Range
VSM	Value Stream Mapping
NVA	Non-Value Adding
NNVA	Necessary Non-Value Adding
VA	Value Adding
CSM	Current-State Map
PAM	Process Activity Mapping
FSM	Future-State Map
DMAIC	Define, Measure, Analyze, Improve, and Control.
BPR	Business Process Re-engineering
PDCA	Plan Do Check Act

1 Introduction

This research was conducted at VDL Enabling Technologies Group (ETG) Almelo, an industrial manufacturing company. This chapter addresses the introduction phase of the research, which, in Section 1.1, starts with a description of the company. Section 1.2 discusses the problem identification which is subdivided into: problem definition, action problem, problem cluster and core problem. Section 1.3 discusses the research questions needed to solve the core problem. Section 1.4 gives the problem-solving approach which is followed throughout the research. Finally, Section 1.5 contains the intended deliverables to VDL ETG Almelo at the end of the research.

1.1 Description of the company

VDL ETG Almelo is a part of VDL Groep, which is an international industrial family company founded in 1953. The company has over 15000 employees, spread over 100 operating companies located in 19 different countries. They manufacture a large variety of industrial products, differentiating from parts to advanced finished products. The activities of VDL Groep can be summarized into the 'five worlds of VDL': Hightech, Mobility, Energy, Infratech and Foodtech (VDL Groep, n.d.).

VDL ETG has 9 offices located in 5 different countries, it is a 'tier-one contract manufacturing partner', with customers who are 'Original Equipment Manufacturing' companies. The focus within VDL ETG lies on 6 different markets: Semiconductor, Solar, Medical, Science & Technology, Mechanization and Analytical (VDL ETG, n.d.).

VDL ETG Almelo has over 1400 employees and focuses on products with high complexity and low volume. Customers are leading companies with high-quality production and users of advanced production lines. Services provided consist of precision machining, sheet metal work, assembly within clean rooms, and the development of customized high-tech equipment. Figure 1.1 visualizes the DNA of VLD ETG Almelo.

Figure 1.1 DNA VDL ETG Almelo (VDL ETG Almelo, n.d., p. 1)

1.2 Problem identification

The problem identification is divided into 4 sub-sections. Firstly, the problem definition is discussed. Afterwards, the action problem is defined, and using this a problem cluster is created. Finally, using the previous parts, the core problem is defined.

Problem definition

VDL ETG Almelo is a fast-growing company within VDL Groep. Because of this, a central storage facility is rented from which the production locations can be supplied in the future. The storage facility is located at Columbus (XL business park in Almelo), and the production locations are located at the Bornsestraat and Darwin in Almelo. Within this research, the central storage facility is referred to as Columbus. Besides these three locations, there are several other (smaller) locations, for the time being, these are not mentioned as they currently are of less relevance. The distance from Columbus to Darwin is 2.2km and the distance from Columbus to Bornsestraat is 5.5km. In Figure 1.2, the distances between production and storage are visualized. In this figure, Columbus is portrayed with a warehouse symbol, Bornsestraat and Darwin are portrayed with factory symbols. Currently, shuttle trucks drive between these locations to deliver products/parts. This research started with VDL ETG Almelo identifying that they consider the Shuttle truck operations as not optimized. During this research, Shuttle truck operation can be considered as all operations needed for a product to move between Columbus (Storage) and Production; order picking, loading/unloading, (Internal) transport. At the moment, there is a time schedule for when the trucks drive between locations. However, this time schedule is not yet motivated by extensive research. The use of the capacity of the trucks is not always optimized. For example, at certain times a truck drives with 18 Euro pallets although the truck has a capacity of 33 Euro pallets. In other cases, the truck has reached full capacity although products/parts are supposed to be delivered with it.

Figure 1.2 Distances between production and storage.

Action problem

An action problem can be described as the following: "A discrepancy between norm and reality, as perceived by the problem owner'' (Heerkens & van Winden, 2017). This would suggest that there should be a certain norm at which the shuttle trucks should operate. To create an action problem, the norm is not always achievable, creating a less preferred reality.

After conversations with relevant stakeholders in material handling, the norm of the action problem was defined as follows; the norm of the shuttle trucks should be to always deliver the products/parts within 4 hours after production orders them. Based on the information provided by stakeholders it is known that in reality, this is not always the case, products are not always delivered within 4 hours. This could cause problems for production. For instance, when production expects part X to be delivered before 12:00 (they ordered the product at 08:00), they schedule the use of this part from 12:00. However, the shuttle truck is not always able to deliver before 12:00 which could result in a halted production. So, we define the following action problem:

“Material handling cannot always deliver products/parts to production locations within the 4-hour time frame.”

Hence, the norm should be to always deliver products/parts within 4 hours after ordering by production, however in reality this is not always the case. Currently, the reality of the action problem is based only on conversations with stakeholders, in Chapter 3, the action problem is further elaborated on. This focuses on measuring the reality of the action problem using data. Besides that, it also researches whether production has the same norm as material handling.

Problem cluster

The problem cluster started with the action problem as defined in the section regarding the action problem. Figure 1.3 gives a view of this action problem and its connections. The action problem is in the center of the cluster and leads to the main concern; not always being able to attain the preferred customer service level. From conversations with stakeholders at VDL ETG Almelo, 2 potential core problems that lead to the action problem were defined. Firstly, “The shuttle truck operations between production and storage are not optimized”. This leads to the shuttle trucks driving without full capacity, shuttle trucks being unavailable when needed, and shuttle trucks being full when products need to be transported. The former could lead to unnecessary fuel and employee costs.

Secondly, “Production inventory planning is not always optimized” is considered a potential core problem. Because of this, products are ordered using Just-in-Time production. Because there is no regular schedule, the demand for products/parts has a lot of variability. For instance, on Monday morning production could need 100 products and on Monday afternoon only 20. Therefore, products/parts cannot always be delivered within the 4-hour time frame.

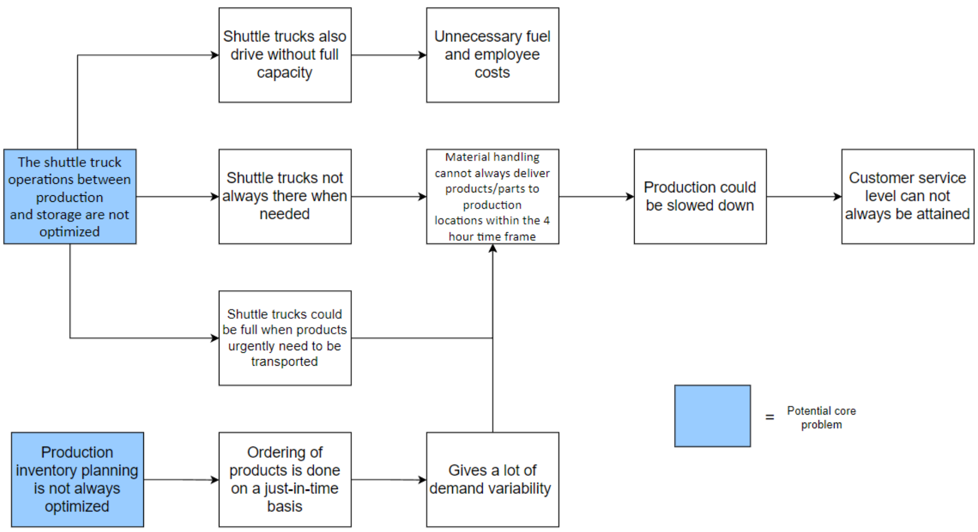


Figure 1.3 Problem Cluster

Core problem

When looking at the problem cluster, the root cause of the problems is considered the core problem. Given the problem cluster, there are 2 potential core problems. This research tackles the following core problem: "The shuttle truck operations between production and storage are not optimized". This core problem is chosen because it can directly change the action problem.

1.3 Research questions

There is one main research question which needs to be answered to solve the action problem within VDL ETG Almelo. This research question is:

"How can the shuttle truck operations between storage and production be optimized to deliver products/parts within a 4-hour time frame?"

To answer this research question, the following sub-research questions are formulated:

1. What existing methods are there to improve material handling processes within industrial companies?
2. How are the shuttle truck operations between storage and productions currently arranged at VDL ETG Almelo?
3. What are the challenges and bottlenecks experienced within the current shuttle truck operations?
4. What are possible solutions for the improvement of the challenges and bottlenecks within the shuttle truck operations and how can they be implemented?
5. What are the conclusions and recommendations given to VDL ETG Almelo based on the research?

In Chapter 1.4, the problem-solving approach, evaluates these research questions, explaining where they are answered and why they are relevant. Within the chapters, 'sub'- sub-research questions can be formulated to help solve the research questions.

1.4 Problem-solving approach

The main goal of the research is to solve the main research question. Therefore, a problem-solving approach is designed to ultimately tackle the main research question. This problem-solving approach consists of 6 chapters, starting with the introduction chapter, which defines the problem. Afterwards, 5 more chapters are given, each answering one of the five sub-research questions. This results in the following structure:

1. Problem identification

First, the problem must be defined. This has already been defined in the first part of chapter 1. Therefore, this is not further elaborated on

2. Literature review

In Chapter 2, the first research question is answered: "What existing methods are there to improve material handling processes within industrial companies?". This research question is answered via literature research, following the systematic literature review (SLR) protocol. Answering this research question helps in identifying strategies for improving material handling processes. Using these strategies, solutions can eventually be formed and be based on a theoretical framework.

3. Analyzing the current situation

In Chapter 3, the second sub-research question is answered: “How are the shuttle truck operations between storage and production currently arranged at VDL ETG Almelo?” After answering this research question, the current situation at VDL ETG Almelo is visualized. Analyzing the current situation also involves measuring the reality of the action problem, to evaluate the severity of the problem.

4. Analyzing the action problem

In Chapter 4, the third research question is answered: “What are the challenges and bottlenecks experienced within the current shuttle truck operations”. The goal of this step is to divide the action problem into different challenges/bottlenecks. By doing this, the action problem can be turned into smaller, easier-to-solve, problems.

5. Formulating solutions and proposing ways of implementation

In chapter 5, the fourth research question is answered: “What are possible solutions for the improvement of the challenges and bottlenecks within the shuttle truck operations and how can they be implemented?”, which ultimately gives solutions to the main research question. After having performed the necessary literature research in step 3, this step consists of generating possible solutions for optimized shuttle truck operations and proposing ways of implementation. It uses the divided problems from step 4 and generates solutions for each problem.

6. Conclusions and recommendations

Finally, the sixth chapter answers the fifth sub-research question: “What are the conclusions and recommendations given to VDL ETG Almelo based on the research?” Besides that, this chapter discusses the limitations of the research, gives possibilities for future research, and finally mentions the contribution to theory and practice.

1.5 Deliverables

The following deliverables are defined:

- The first deliverable is a more in-depth view of the current situation regarding the shuttle truck operations. This includes flowcharts of all the processes in which the shuttle truck operations are involved. Besides that, it includes the current truck capacities and routing. Measuring the action problem gives VDL a better view of how they are currently operating. Therefore, this is also included as a deliverable.
- The second deliverable is the solutions to the action problem. Afterwards, recommendations for implementation are given. Besides that, topics for future research are delivered, which include problems encountered that are not solved in this thesis but could in the future be interesting to look at for VDL ETG Almelo.
- Finally, the entire report is delivered. By delivering this, VDL ETG Almelo can base its changes on the research obtained in this report.

2 Literature

This section provides the theoretical framework of the research, answering the first sub-research question:

“What existing methods are there to improve material handling processes within industrial companies?”.

This chapter starts by introducing four approaches for improvement in Section 2.1. Afterwards, Section 2.2 provides the methods derived from the theoretical implications. Section 2.3 describes how the methods within this chapter are used within the research. Finally, Section 2.4 gives a summary of chapter 2.

2.1 Four approaches for improvement

Slack et al. (2013) describe four approaches for improvement: Business process reengineering (BPR), Lean, Six Sigma, and Total quality management (TQM). Although there are more than these four approaches, these are the most used for improvement. Figure 2.1 places the four approaches on a grid, differentiating the approaches from rapid to gradual change and varying emphasis on solutions and an emphasis on methods. BPR focuses on more rapid changes whereas lean and TQM focus on gradual (more continuous) changes. Six Sigma does not necessarily distinguish rapid- or gradual changes, the approach can be used for either large or smaller changes. Six Sigma and TQM focus on methods, whereas Lean and BPR make less distinction between the what or how to do it. In the next sections, all four approaches are explained more in-depth.

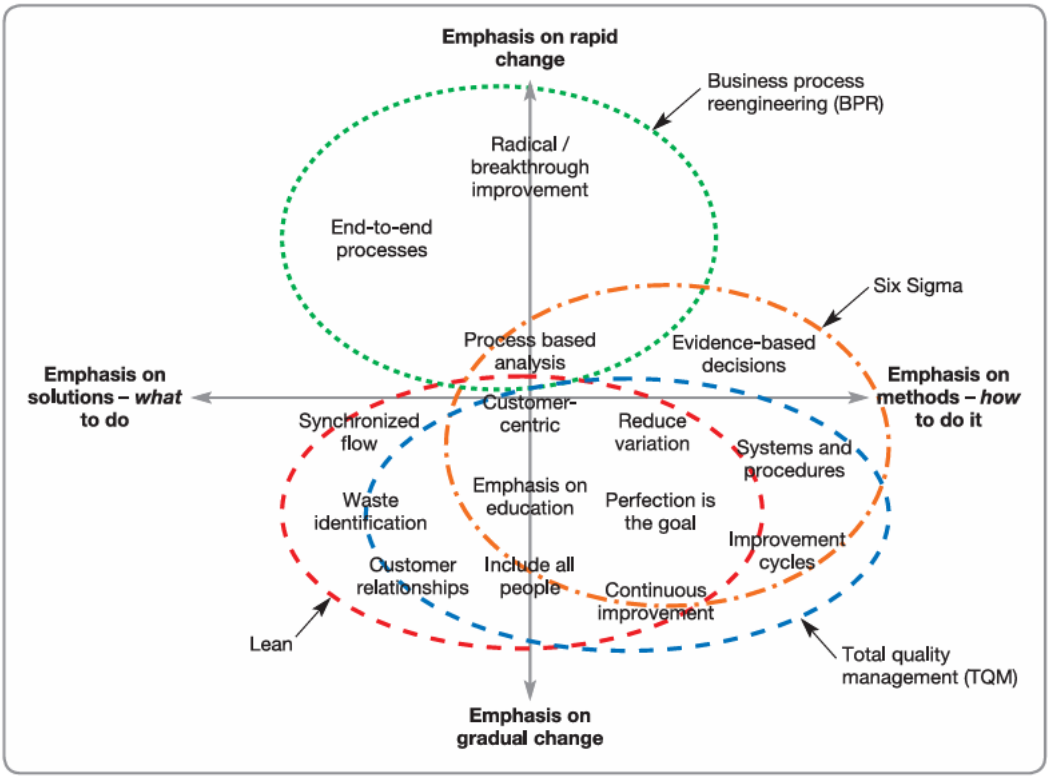


Figure 2.1 Four approaches for improvement (Slack et al., 2013, p 597)

2.1.1 Lean (Synchronization)

This section provides the theory behind lean synchronization. “Synchronization means that the flow of items that constitute services and products always deliver exactly what customers want, in exact quantities, exactly when needed, and exactly where required. Lean synchronization is to do all this at the lowest possible cost” (Slack et al., 2013). This sector describes the origin of lean, Muda, Mura, Muri, and the eight types of waste.

The origin of lean

The origin of lean lies in the Toyota Production System (TPS). “The principal objective of the TPS was to produce many models in small quantities” Ohno (1988). This principle was the opposite of mass production in the United States. To achieve the TPS objective, waste had to be minimized, and the flow of materials and information had to be optimized. In the next section types of waste and their causes are described.

Muda, Mura, Muri

Muda is the Japanese word for waste and refers to activities that do not have added value for the customer. These wastes can be divided into Non-value adding (NVA) and Necessary non-value adding (NNVA) Ohno (1988).

Mura is the ‘lack of consistency’ which leads to occasional overburdening of staff or equipment. Examples can be an uneven production flow causing operators to rush and then pause, creating a very inconsistent work pace. Ohno (1988).

Muri means absurd or unreasonable requirements for operators and machines which results in poor performance. This leads to overburdening of staff and/or equipment because they are not able to achieve the ludicrous standards. Ohno (1988). For example, if an order picker has to drive 100 meters from production to warehouse which takes 1 minute. It cannot be expected that 100 products per hour will be picked by this operator.

Eight types of waste

Muda, Mura, and Muri can be considered causes of waste, Toyota has identified seven types of waste. However, an eight type of waste namely ‘skills’ was added to create the ‘TIMWOODS’-model. This model consists of the following eight types of waste, as given by Ejsmont en Gładysz (2020);

1. Transportation

Waste in transportation consists of movements of products, tools, inventory, etc. which are further than absolutely necessary. For instance, large distances between operations, results in a waste of time by the movement of products between these operations.

2. Inventory

Excess inventory is considered a waste, having more inventory than necessary for keeping up the workflow. Excess inventory can, among other things, result in an increase in holding costs, product defects, and damaged materials.

3. Motion

Motion waste consists of the unnecessary movement of employees within operations. For instance, having to move between workstations or reaching to get materials.

4. Waiting

Waste of waiting is the time lost because people or machinery are waiting before they can continue. For instance, in an assembly line if one operator has to wait on the previous operator before he/she can start.

5. Overproduction

Producing more than necessary leads to excess supply and high storage costs.

6. Overprocessing

Overprocessing refers to putting in more work, adding more components, or achieving a higher quality than what customers require. For instance, delivering a machine that can weigh products up to 10000kg when the customers only require weighing up to 1000kg.

7. Defects

Products or services that do not meet quality standards which leads to repairs or waste of materials.

8. Skills

Skills is later introduced and is a waste of human potential, not utilizing the full potential of employees. If not engaging with employees it is hard to improve processes or operations.

Identifying and eliminating waste results in improved performance of business with better quality, reduced costs and time better spent.

2.1.2 Business process re-engineering

"Business process re-engineering (BPR) is the philosophy that recommends the redesign of processes to fulfil defined external customer needs" (Slack et al., 2013). When compared to Six Sigma and Lean the major difference is that BPR prefers more radical changes. Zaini en Saad (2019) define a 6-step approach BPR uses to optimize operations and be more efficient;

1. Identify the vision and aims
2. Identify the business process
3. Understand and assess the process
4. Information technology
5. Prototyping process
6. Implementation

2.1.3 Six sigma

"Six sigma, an approach first popularized by Motorola, seeks to get total customer satisfaction by delivering when promised, with no defects, with no early-life failures, and when a product does not fail excessively in service." (Slack et al., 2013). To solve problems, six sigma used the DMAIC method. De Mast en Lokkerbol (2012) describes the DMAIC which is visualized in Figure 2.2. In short, DMAIC is Define, Measure, Analyze, Improve, and Control.

Define: problem selection and benefit analysis
D1. Identify and map relevant processes
D2. Identify stakeholders
D3. Determine and prioritize customer needs and requirements
D4. Make a business case for the project

Measure: translation of the problem into a measurable form, and measurement of the current situation; refined definition of objectives
M1. Select one or more CTQs
M2. Determine operational definitions for CTQs and requirements
M3. Validate measurement systems of the CTQs
M4. Assess the current process capability
M5. Define objectives

Analyze: identification of influence factors and causes that determine the CTQs' behavior
A1. Identify potential influence factors
A2. Select the vital few influence factors

Improve: design and implementation of adjustments to the process to improve the performance of the CTQs
I1. Quantify relationships between Xs and CTQs
I2. Design actions to modify the process or settings of influence factors in such a way that the CTQs are optimized
I3. Conduct pilot test of improvement actions

Control: empirical verification of the project's results and adjustment of the process management and control system in order that improvements are sustainable
C1. Determine the new process capability
C2. Implement control plans

Figure 2.2 DMAIC (De Mast en Lokkerbol, 2012, p. 605)

2.1.4 Total quality management

'TQM consists of organization-wide efforts and an integrated system of principles, methods, and best practices to install and make a permanent climate in which an organization continuously improves its ability to deliver high-quality products and services to customers (Kiran, 2016). Total in TQM means that the whole organization can be considered stakeholders and all levels and functions can be involved. Quality, Kiran (2016) describes five principal approaches to define quality; transcendent, product-based, user-based, manufacturing-based, and value-based. Managing consists of the procedure of managing, with steps such as plan, do, check, act, lead, etcetera. To get to a certain quality, one of the methods used within TQM to improve processes or products is PDCA.

PDCA

PDCA is a four-step technique which essentially consists of; plan, do, check, and act. The plan part of the cycle consists of the identification and analyzes of a problem, taking into account quality requirements. Do involves the implementation of a plan, usually testing ideas for improvement. The next step is to check which measures how effective the solutions or proposed improvements are. Results are compared to expected quality requirements and define whether it needs additional improvement. Finally, the proposed plans will be acted upon, the improvements can be implemented on a larger scale. If the initial plans did not have a significant enough difference from the initial state, the cycle can be adjusted. (Kiran, 2016)

2.2 Methods

This section provides methods derived from the theoretical implications.

Value stream mapping

"Value stream mapping is an invaluable tool that helps us grasp our current condition and identify improvement opportunities" (Dennis, 2017).

VSM gives a visualization of all the actions/processes required for a product or service to end up at the customer. Hence, the focus lies on the entire process rather than sub-processes. Activities can be categorized into 3 types; value-adding (VA), NVA, and NNVA. VA are activities that customers consider of value and are therefore activities they are willing to pay for. For instance, in the design of a clothing item, customers are willing to pay for a design they perceive as nice. NVA and NNVA, as earlier mentioned, are part of Muda and are therefore considered waste. They are not of value to the customer and should therefore be eliminated. NVA are activities that are both not of value and also not necessarily needed whereas NNVA are necessary activities. An example of an NVA activity is the movement of parts from production to a quality check area. An example of a NNVA is a quality inspection, although it does not directly add value to a product, it is required to ensure the product meets certain safety and quality standards. Developing a future state in which the 'Muda' is eliminated where possible, starts with the development of a current-state map (CSM). Using process activity mapping (PAM) a future-state map (FSM) can be created. Amrina et al. (2020) describe a roadmap for solving problems using VSM, this roadmap is visualized in Figure 2.3. Using field observations, the CSM can be created which can be used to identify and analyze waste by using PAM. Finally, improvements can be made to create the final FSM. The next sections describes the steps more in-depth.

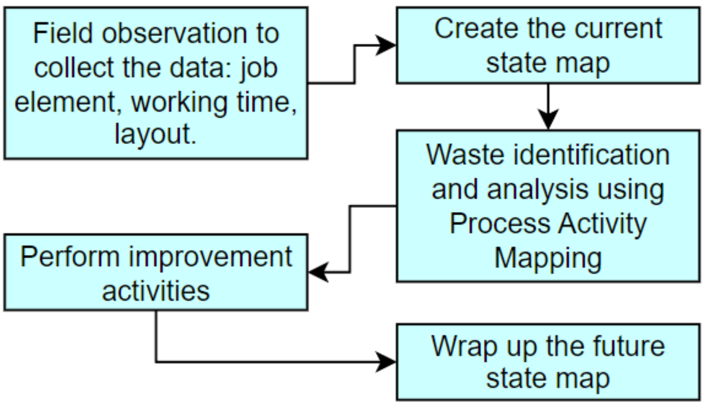


Figure 2.3 Value stream Steps (based on Amrina et al. ,2020, page 1542)

Current state mapping explained

Rother and Shook (1999) created a roadmap to creating a CSM, which gives a step-by-step approach for the creation of a CSM. VSM symbols are portrayed in Figure 2.4. They are categorized in information- and material flow. The creation of a CSM starts by visualizing the needs of the customer. The customer is visualized by a 'factory' icon, as seen in Figure 2.5. Data boxes are used to visualize the requirements/needs of the customer, units per time period, and type of shipment. The next step is to visualize the processes needed to get the finished product from door-to-door. This will result in several processes which can be further defined by a data box. Relevant data per process can be cycle time, value-added time, lead time, number of employees etcetera. Afterwards, the supplier is visualized in a similar way as the customer. Information flows are added to the map space to visualize how communication is performed. Finally, a timeline is added which portrays the time a single product takes to make it from door-to door. Figure 2.5. gives an example of a current- state map.

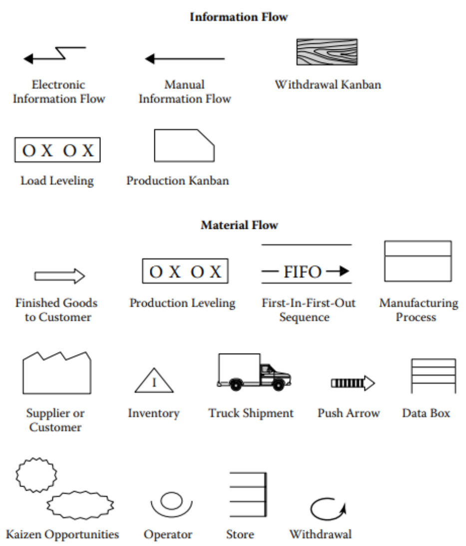


Figure 2.4 Value stream mapping symbols (Dennis, 2017, p. 115).

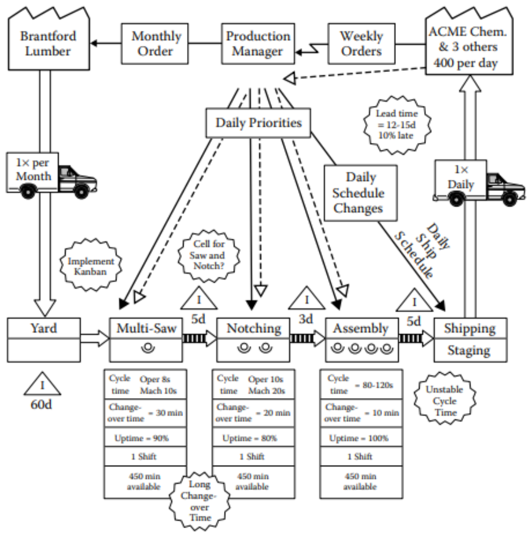


Figure 2.5 Current-state map example (Dennis, 2017, p. 116).

Kaizen

The definition of Kaizen, as given by Dennis (2017, p. 208): "A small incremental improvement." To get to a future state map, improvements will need to be made. Kaizen is associated with Muda as it seeks to decrease the Muda. Following the Kaizen approach would eventually lead to multiple incremental and smaller changes, which over time can have considerable effects. Hence, this approach does not need abrupt and/or big changes. To get to these small improvements, usually teams will be used. However, kaizen can also be used as an individual researcher. Kaizen suggests that a team or individual should have an "idea log" which tracks processes or activities that appear to be inefficient. Once in a certain time period, for instance, a month, the idea log will be used to identify the areas with waste. Looking at the idea log, changes can be thought of to reduce waste. Looking at Figure 2.4, possible kaizen opportunities are highlighted in the current state map. For instance, unstable cycle time or long changeover time at certain processes. Finally, plans will be made to implement the changes and achieve a future, improved, state. Changes can be implemented using a value stream plan, which will be explained later on.

Gemba

To create an "idea log", one will have to get into the 'Gemba'. Gemba can be translated as the real place, usually meaning the work floor or other locations where work is done. Womack (2013) states that when you want to understand work, and/or want to lead or want to learn, one must go on a Gemba walk. Besides that, Womack (2013) describes several experiences where observing the Gemba, and going on a Gemba walk, leads to noticing the problems within workflows. Hence, observing the processes firsthand will help create the idea log.

Process activity mapping explained

A PAM analyzes all different steps in a process based on flow, distance, time, operators, and VA/NVA/NNVA. The different steps are the different processes which the product has to follow to end at the customer. Flow consists of; operation, transportation, inspection, delay, or storage. Distance is the distance a product has to travel during the process. Time is the time a product takes within each step which can be merged to see the combined time of multiple steps. #operator gives the number of operators and their function. Finally, VA/NVA/NNVA describes the different types of value types of the activity. An example of a PAM is given in Table 2.1.

Table 2.1 Process activity map example (based on Amrine et al., 2020, p. 1543)

Step	Flow	Distance (meters)	Time (min)	Time when merged (min)	#operators	VA/NVA/NNVA
Transport of hamburger to grill	T	10m	1	-	1	NNVA
Grilling hamburger	O	0m	8	-	1	VA

Future state map

The end goal of value stream mapping is to eliminate waste and reach an improved future state. The FSM uses the same symbols and design as the CSM. Figure 2.6 gives an example of a future state, which is the future state of the example given in Figure 2.4. Kaizen opportunities in the CSM were used to get to this future state. For example, the CSM described the possibility of getting a combined cell for sawing and notching. The implementation of this combined cell reduced the long changeover time between the initial sawing and notching cells. Improving and implementing a combination of the kaizen opportunities leads to the FSM.

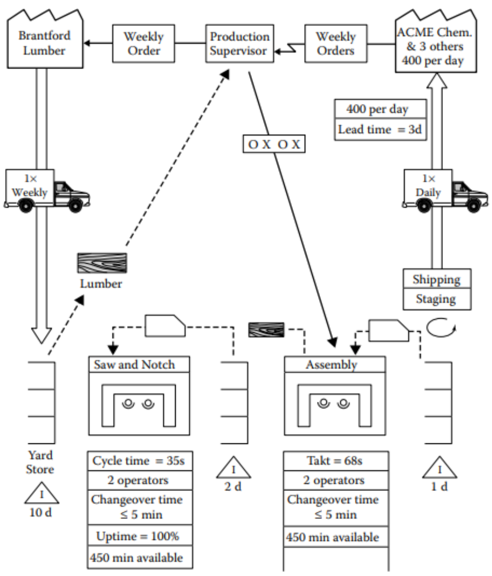


Figure 2.4 Future-state map example (Dennis, 2017, p. 117).

Value stream plan

In the previous steps, improvement opportunities and their solutions are obtained. This step proposes ways of implementing the improvements using a value stream plan. Value stream mapping focuses on the entire process rather than individual processes. However, when implementing it will mostly not be possible to apply all changes at the same time. Therefore, implementation is usually done in steps. Table 2.2 gives an example of a value stream plan, which divides several objectives over a time period. This example uses the plan layout of rother and shook.

Table 2.2 Value stream plan example (based on Rother and Shook, 1999, p. 100)

Where	**Objectives**	**Goal (measurable)**	**Implementation schedule (weeks)**							
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Saw/notch	Combining saw and notch cell	Changeover time <5 min								
Production	Implement kanban	Changeover time < 5min								
Delivery	Reduce lead time	Lead time < 5 days								

2.3 Use of the improvement techniques within this research

This research uses the methods described in this chapter to work towards improved shuttle truck operations and create an environment of continuous improvement. The way of thinking and tackling problems within the four approaches of improvement is used. Current state mapping, In combination with the process activity map, is used to visualize the current conditions. Using this, the research is further scoped, and decisions on where to observe can be made. Using the Gemba walk, challenges and bottlenecks are observed. Using Kaizen, conversations with stakeholders, and the idea log, solutions are formed to relevant problems. A value stream plan, or implementation plan, is created to get a clear idea of when to implement what.

2.4 Chapter Summary

This chapter gives the literature which works as a backbone for this research. It started by introducing four approaches for improvement: Business process reengineering (BPR), Lean, Six Sigma, and Total quality management (TQM). Each approach was discussed and with it their distinctive way of thinking. Following this, specific methods for improvement were discussed, including Value Stream Mapping (VSM), Kaizen, Gemba, and Process Activity Mapping (PAM). These methods offer ways to identify waste, map current states, and get towards an improved future state. By applying these improvement techniques, this research seeks to not only optimize the current situation but also create an environment of continuous improvement.

3 Current situation

This chapter describes the current situation at VDL ETG Almelo and with it answers the second research question:

"How are the shuttle truck operations between storage and productions currently arranged at VDL ETG Almelo?"

This chapter starts by addressing data collection methods to determine the current situation at VDL ETG Almelo. Afterwards, these methods are applied, and the current situation is described. Section 3.1 gives the data collection methods, describing the following: types of research and data, observational methods, survey methods, and the Warehouse Management System (WMS). Afterwards, these methods are applied, starting with Section 3.2 which gives documentation as provided by VDL ETG Almelo. Then, Section 3.3 gives flowcharts of the relevant operations. Subsequently, Section 3.4 provides the norm and reality of the action problem, based on data and perceptions from production personnel. Finally, Section 3.5 gives a summary of this chapter.

3.1 Data collection methods

This section gives the data collection methods, describing the following: types of research and data, observational methods, survey methods, and the Warehouse Management System.

3.1.1 Types of research and data

This section discusses two types of research, qualitative and quantitative. Besides that, it describes two data types: primary and secondary data.

Qualitative- and quantitative research

When collecting and analyzing data, research can be divided into qualitative- and quantitative research. Qualitative research is mainly expressed in words whereas quantitative research is expressed in numbers and/or graphs. Qualitative research is used to get a better understanding of things whereas quantitative research is used to test things. Qualitative- and quantitative research can be combined to form mixed-method research (Sandelowski, 2000). This research initially uses mixed-method research to get a clearer view of the relevant processes within VDL. Qualitative research is performed to get a better understanding of the processes within VDL. This consists of observations, surveys, and conversations with relevant stakeholders. Quantitative research is used to measure the processes within VDL. This consists of analyzing data provided by the warehouse management system (WMS). Using a mixed method ensures that the 'who, what, why, and how' are answered (Noble Predictive Insights, 2024). When using only quantitative research for instance the 'why' certain things occur will most likely not be answered.

Primary and secondary data

During this research, both primary and secondary data are used. Primary data is data, which is collected by the researcher, and secondary data is data that has already been documented by secondary sources (Rabianski, 2003). During this research, secondary data is used to gather information about how VDL ETG Almelo currently documents its shuttle truck operations. Besides that, the data collection during this research mainly consists of primary data. For instance;

observations, surveys, and WMS data. These three data collection methods are further elaborated on in this section.

3.1.2 Observational methods

This section describes the observational methods and how they are used in practice.

Observational methods

To obtain information regarding the current situation, the processes need to be observed. Hussain (n.d.) describes three types of observational methods; Participant observation, Naturalistic observation, and Controlled observation.

Observations can be overt or covert. Overt observations are observations where the participants know they are being observed. Covert observations are the opposite, participants are not aware that they are being observed. During this research, all observations are overt, and participants are made aware of when and why they are being observed. Besides that, this research follows a naturalistic approach. Hence, when observing, an overt naturalistic approach will be used. (Lee, 2022)

Firstly, the relevant processes are observed and analyzed. To get a better visualization of these processes, flowcharts are used. In later stages, overt naturalistic observations are used to look for possible activities that can be improved.

Observational methods in practice

During the research, two main ways of observing are performed to gather information. The two ways of observing are; observing by joining the truck driver in his process and observing at the work floor at Columbus. During these observations, logs are used to keep track of the obtained data. These logs can be found in Appendix A. Essentially, the logs are used to keep track of arrival/departure times, unloading/loading times, and transport times. Besides that, logs have an additional comments section which is used to write down observations. The primary goal of these observations is to determine the challenges and bottlenecks which are faced with regard to the action problem. During these observations informal conversations are held with truck drivers and logistics personnel are held. These conversations do not follow a structured manner but are useful to gain insights from employees who experience the operations daily.

3.1.3 Surveys

“A survey is a systematic method for gathering information from entities for the purpose of constructing quantitative descriptors of the attributes of the larger population of which the entities are members” (Groves, 2004). In this research, surveys are used to gather information from production. Within VDL ETG Almelo there are over 80 employees who can order products for production. To get an understanding of their perceptions with regard to the action problem a survey was held with a selected sample group. Production can be divided into 6 subdivisions; Parts/Plaat, Projects, Systems 1 (DUV), Systems 1 (SRS), Systems (EUV), and Systems 2. The sample group consists of at least 1 employee per production department to ensure all departments are considered. The goal of sampling was to ensure the participants were relevant stakeholders. This ensures the participants are knowledgeable regarding the situation and make use of the shuttle truck operations. Because of this, the sample size is relatively small, mostly only one participant per department. However, within departments, employees discussed the answers. Besides that, one department was not able to gather results within the time of this research. Hence, 5 filled-in surveys were gathered. The surveys consisted of a 6-question survey, given (via personal e-mail contact) to each participant. The entire survey, filled in by a participant, can be found in Appendix B. The survey has 2 purposes; measuring the action problem and gathering additional information. Firstly, measuring the action problem is done via the first and second questions. These questions intend to measure the norm and reality of the action problem and ultimately determine whether a discrepancy is noticed. The questions are formatted in a manner that ensures the results are quantitative, which can be used to measure the action problem. Besides that, 4 additional questions are asked to get more information regarding the thought process of production planners and their views of the ordering process. The results of this survey are given in Section 3.4.

3.1.4 Warehouse Management System

VDL ETG Almelo uses two different systems; Enterprise Resource Planning (ERP) and WMS. Production planners use an ERP system called Baan, for warehouse management Jungheinrich WMS is used. Throughout this research, WMS can be used to measure the performance of the shuttle truck operations. When production requires products, they send in an order request using Baan, which will directly be visible in WMS. During the transport of products, scanning points are used to keep track of the products' location in WMS. Using these systems, quantitative research can be performed to measure the action problem. Currently, the 'reality' of the action problem is based on feelings perceived by Stakeholders within material handling. Using primary data, these feelings can be based on numbers rather than gut-feeling.

WMS keeps track of the data which can be found using so-called 'journals'. Data within these journals can be extracted to Excel after which performances can be measured. To get a view of what can be seen in WMS, one product is visualized. This product has #LD 60208528 and was ordered in Baan initially with order number 240625083255, which means it was ordered on the 25th of June 2024 at 08:32:55. Table 3.1 gives all relevant data which is available in WMS. This is gathered by back tracing, so started looking at an arrived product at production. Pickers receive all LD Numbers that need to be picked, in this case, 40094319 and 40094320, they pick them and change the LD number to one Goal/Pick LD. This will be the LD Number used for the rest of the movements. For the different scanning locations, different times are stored. Using these times, compared to each other and the order time, measurements can be made.

Table 3.1 WMS Data LD 60208528

#	Time	Operation	LD Nr	Goal/Pick LD	Location	Goal location	Order number
1	25.06.2024 12:52:41 PM	Moving	60208528	-	PNDL-MAG2	HH-H-003	-
2	25.06.2024 10:54:20 AM	Moving	60208528	-	WH2-PB05	PNDL-MAG2	-
3	25.06.2024 09:49:20 AM	Moving	60208528	-	Terminal 109	WH2-PB05	-
4	25.06.2024 09:42:22 AM	Picking	40094319	60208528	2N-032-11	HH-H-003	240625083255
4	25.06.2024 09:40:11 AM	Picking	40094320	60208528	2N-092-10	HH-H-033	240625083255

Figure 3.1 portrays the data flows within WMS, at the order start the goal location and order number are given. Once the pickers receive the order number, they can also see the Original LD, they pick the products and create one, new, LD. Afterward, the product is brought to the Pendel location and the Location is updated in WMS. Then, the product is moved to the Pendel truck and again the location is updated. Finally, the product arrives at the goal location and the location is updated once more. Throughout this process, time updates are given which can be evaluated.

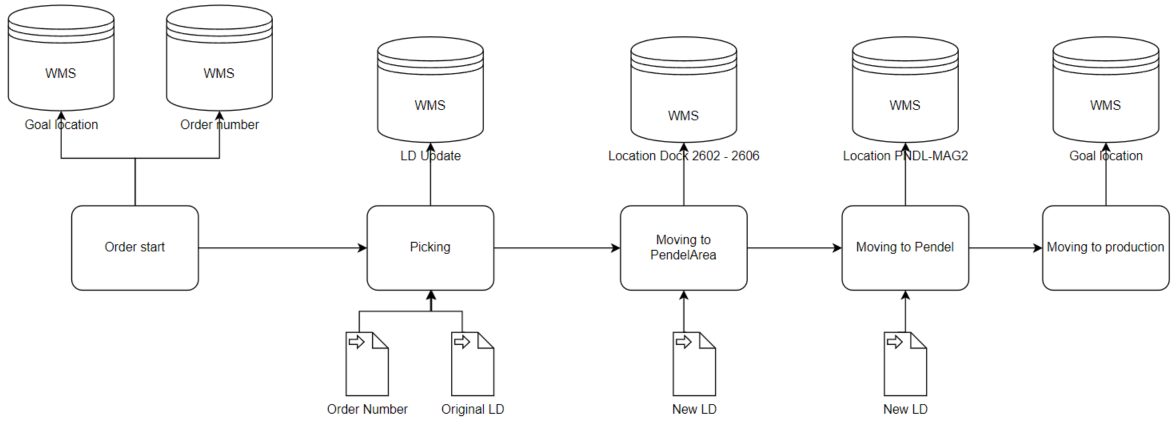


Figure 3.1 WMS Data flow

To measure the action problem, more than one data point needs to be evaluated. Therefore, data regarding the past 6 weeks is extracted and can be evaluated. To evaluate them, an excel file is created. This excel started with 4 different sheets, all with extracted data. When looking at Table 3.1, the 1st 2nd and 3rd rows all have one excel sheet of data, the last 2 rows share an excel sheet. The 1st sheet has all products that arrived at production, the 2nd sheet has all products that arrived at the Pendel and the 3rd sheet has all products that arrived at the Pendel area. Finally, the last sheet gives all picked products. All these excel sheets have one common denominator which is the Pick LD. Picking, for instance, does not only consider products which end up in the shuttle truck. Therefore, the Pick LD when the product arrives at production (from the Pendel) is used to analyze the data. Considering that at all locations the time is updated, an average throughput time can be calculated. Given all this data, several new sheets are formulated. All steps and their respective throughput times are calculated on different sheets. This gives the following sheets;

- Order → production (calculates the throughput time from the moment production planners order a product until it arrives at production)
- Order → Picking (calculates the time it takes before order pickers pick products after receiving an order from production planners)
- Picking → Dock (calculates the time it takes to pick a product and bring it to the pendel area (Dock))
- Dock → Pendel (calculates the time it takes before a product is placed into the truck after being placed at the dock)
- Pendel → Production (calculates the time it takes for a product to move from the truck to the correct production location)

By doing this, all steps within the process can be evaluated. The main takeaway will be the average times which gives an insight into whether material handling realizes their norm. Of all sub-processes, this average time will be the only calculation made. However, Order time -> production is further elaborated since this gives a view of the entire process.

3.2 Documentation as provided by VDL ETG Almelo

VDL ETG Almelo has some documentation regarding the shuttle truck operation, which is be summarized in this section. This section is divided into three sub-sections: "trucks, routes and distances," schedule and other observations. This is merely documentation from VDL ETG Almelo which is summarized in this section. However, this does not 100% reflect the current situation. This documentation is public for stakeholders and is something production planners can use to get a view of the trucking operations.

Trucks, routes, and distances.

VDL ETG Almelo currently has 6 different means of transport, their routes are given in Table 3.2.

Table 3.2 Truck capacities and routes.

Truck name	Capacity	Function	Route	Route #
Bolk trailer	33 Euro pallets	Transport big parts	1 – 2 – 3 – 1	1
Looms conditioned trailer	33 Euro pallets	Transport big parts	1 – 2 – 3 – 1	1
Transporter bakwagen	18 Euro pallets	Transport small parts	1 – 2 – 3 – 4 – 5 – 1	2
Looms conditioned trailer EXE Bamo	1 EXE Bamo	Transport EXE Bamo	3 – 1	3
Looms conditioned trailer Duv Bamo	4 DUV Bamo's	Transport DUV Bamo	2 – 1	4
Volkswagen Crafter	4 Euro pallets	Urgent transport	No specific routing	5

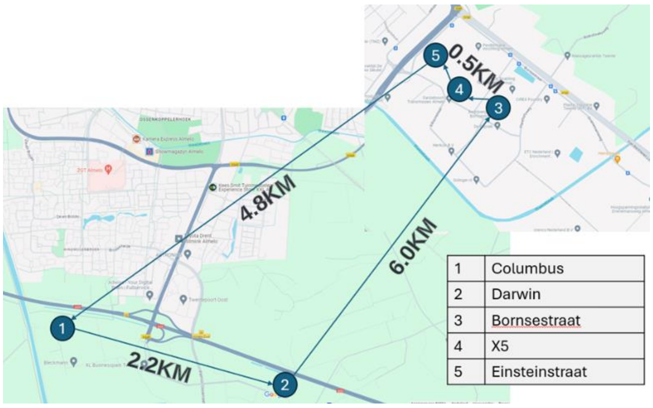


Figure 3.2 Distances between locations

Distances

Table 3.3 gives the distances between locations, as shown in Figure 3.2. Distances may vary slightly based on docking locations.

Table 3.3 Distances between locations

	Columbus	Darwin	Bornsestraat	X5	Einsteinstraat
Columbus		2.2Km	5.2Km	5.5Km	4.8Km
Darwin	2.2Km		6.0Km	5.8Km	5.8Km
Bornsestraat	5.2Km	6.0Km		0.1Km	0.5Km
X5	5.5Km	5.8Km	0.1Km		0.4Km
Einsteinstraat	4.8Km	5.8Km	0.5Km	0.4Km	

Schedule

Bolk trailer and Looms conditioned trailer follow the same route, all other means of transport have unique routes. Hence, there are 5 different routes with different time schedules. Currently, route 1 is the route the Bolk trailer and Looms conditioned trailer follow. Route 2 is the route the transporter follows. These 2 are the routes which are currently following a schedule. However, this schedule is indicative only and will therefore not be included. Mainly the trucks arrive at their starting point and follow the routes throughout the day.

3.3 Flowcharts

This section gives the flowcharts of the operations relevant to this research. In Section 3.3.1 it starts by describing the product flow throughout Columbus. Afterwards, the sub-processes are defined in Section 3.3.2, which are: Picking at Columbus, Pendel in (Columbus), trucks' perspective, and internal transport at production locations.

3.3.1 Product flow throughout Columbus

Business Process Modeling and Notation (BPMN) is a tool used to map product flows within a company. This BPMN, shown in Figure 3.3, gives the flow of products from Columbus to production with the inclusion of the WMS. However, this does not involve all processes, this does not include products that are given to the shuttle truck on retour for instance. The main focus of this BPMN is to show how a product moves through Columbus and the shuttle truck before arriving at the production locations. The Columbus location is divided into four subdivisions: Plaat, Storage, Pendel area, and Pendel.

The process starts at production, who send a picking order to Columbus. At the storage at Columbus, the picking order has been received and will be picked. To pick, WMS is used to get the correct locations. This WMS will also be updated to show the new location of the product. At location Columbus there is a relatively small production area which processes sheet metal. Therefore, the first decision-making process starts, the product has to go to either "Plaat" or "Pendel." Sheet metal work will be referred to as "Plaat" and shuttle truck operations will be referred to as "Pendel." If products go to Plaat, the BPMN ends. If products have to go to Pendel, they are brought to the Pendel area.

From WMS order pickers know what the end location of the product is (which production location), using this, products will be brought to the correct Pendel lane. Again, the WMS will be informed about the updated product location. When a Pendel truck arrives, the next decision-making process starts. Firstly, not all trucks go to the correct location so if the truck does not go to the correct location, the product has to wait for the next Pendel truck. If the truck does go to the correct location, the second decision starts. This decision involves whether or not there is enough space in the truck, if the truck is full the product has to wait for the next Pendel truck. If the truck does have space, the product will be loaded into the truck. At this point, the WMS will be updated to show the new product location.

The Pendel truck follows its route and all products are delivered to the correct production location. When arriving at the production locations, products are unloaded.

Finally, production receives the products and updates the product location in WMS one last time. This ends the BPMN.

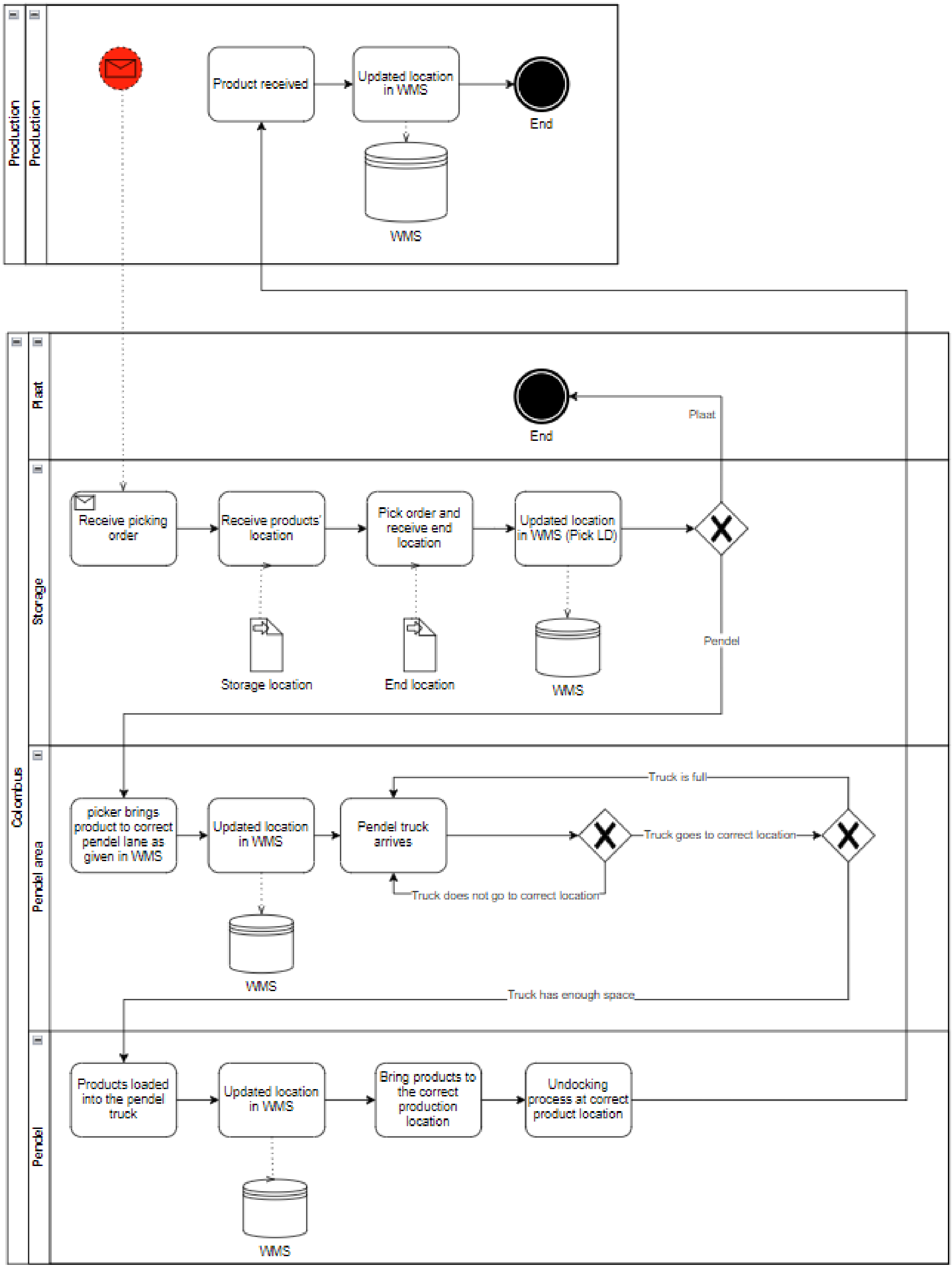


Figure 3.3 BPMN regarding product flow through the shuttle truck operations

3.3.2 Sub-processes

Within the shuttle truck operations, several sub-processes are required to get the product from the warehouse to production. To get a clearer view of these processes, flowcharts are used to visualize them. The following sub-processes are explained; picking at Columbus, Pendel in, trucks' perspective, and internal transport at production locations.

Picking at Columbus

At Columbus the process starts with picking the product(s), the entire picking process is displayed in Figure 3.4. Every order picker has its own WMS scanner which is used to track the process in WMS and see what to pick and where it is located. Pickers start by opening "werkinstructie" which is work instructions. Afterwards, they select a pick order with GoalArea 3000 (Production locations), get a new PickLD (starting with 6) and start picking the product(s). Once picked all the products in the pick order are registered on one PickLd. Afterwards, delivery to the PendelArea starts, usually, this is done directly after picking the product(s) and by the same operator. The operator scans the PickLD, after which the Goallocation will be shown, pickers bring to the Pendelarea and based on this Goallocation a docking area is chosen. Once the product(s) are in the correct lane, the docking location will be scanned and the picker can start the same process again. Throughout this process, products are picked on a First in, First out (FIFO) basis. However, at times there will be products marked as "urgent" which will be picked as soon as possible.

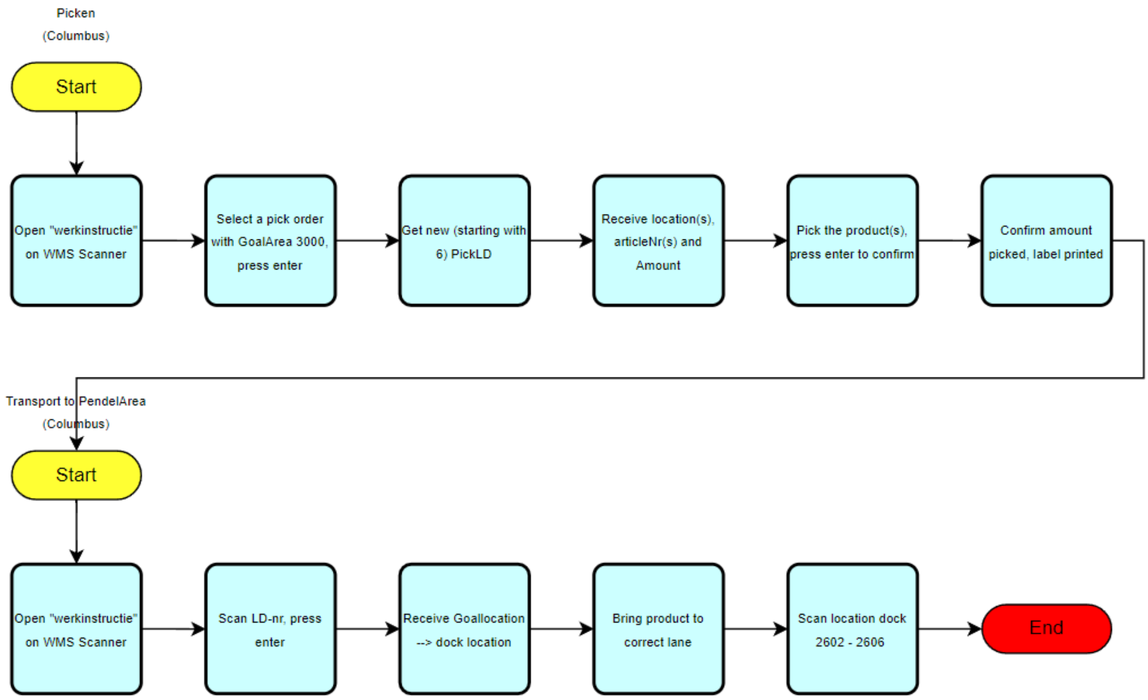


Figure 3.4 Picking (Columbus)

Pendel in (Columbus)

At the PendelArea, products are placed inside the trucks. The operator on sight scans the products in the lanes and loads the trucks. While doing this the products will be scanned to location "PNDL-MAG2". Mainly this will be done on a lane per lane basis. Every lane consists of products meant for the same production locations. Hence, a lane will be emptied in the truck, if afterwards there is still space inside the truck, products from another lane will be loaded. The choice of which lane to start from will be FIFO. However, because there are multiple lanes, not all products will be loaded FIFO. This process is displayed in Figure 3.5

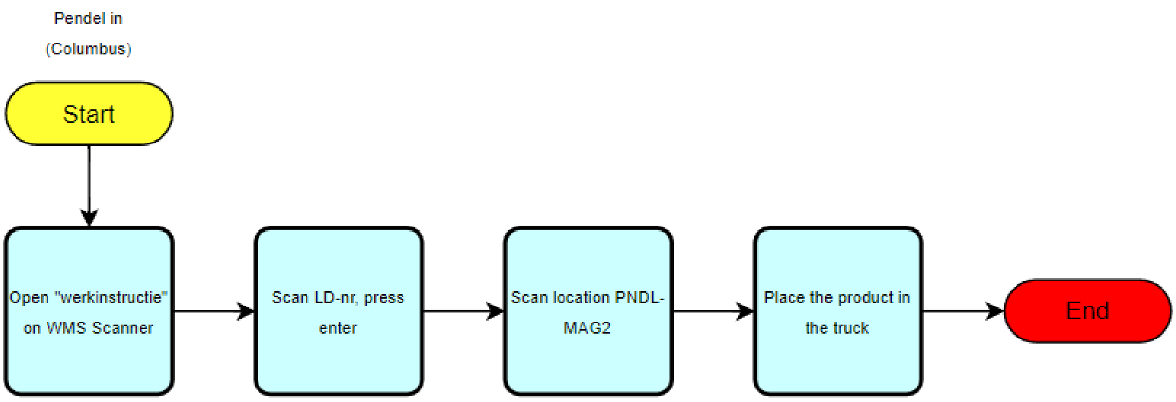


Figure 3.5 Pendel In (Columbus)

Trucks' perspective

The next sub-process is the trucking process, which for Bolk/Looms trucks starts at Columbus. When they arrive, they either have a load or not. If they do have a load, they will dock at "Goederenontvangst" where the truck will be unloaded. If they come in empty, or after they are unloaded, they will go to the PendelArea. In some cases, this will be inside to load the truck from the side, otherwise they will dock. They wait until the truck is loaded, verify which location(s) to drive to and start driving. Once arrived at the production locations, the truck will be unloaded and/or loaded. Afterwards, they either need to go to a 2nd production location or go back to Columbus. In the first case, they unload/load at a 2nd production location. In the latter case they drive back to Columbus and the process starts all over again. This process is visualized in figure 3.6.

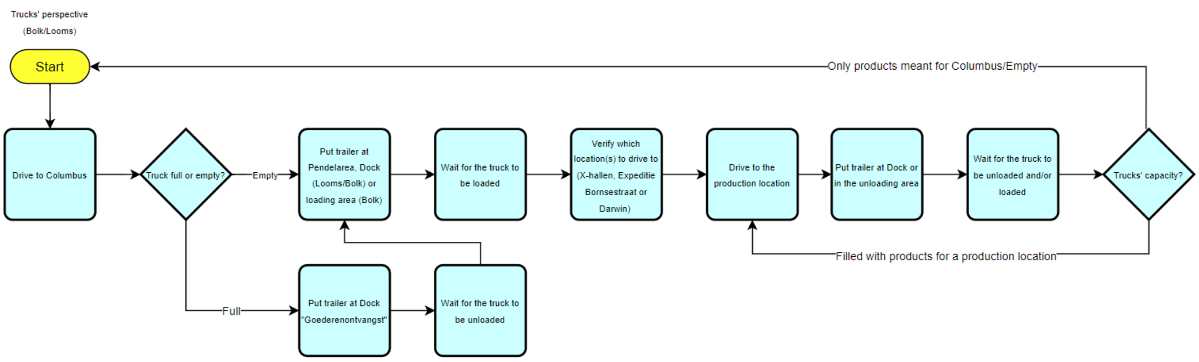


Figure 3.6 Trucks' flowchart

Internal transport at production locations

Finally, to get products from the truck to the final goal location, internal transport is used, visualization of this process is given in Figure 3.7. At the production locations, using a WMS scanner, the PickLd is scanned and a goal location should be provided. If not provided, a troubleshooter should be able to provide it. Finally, products are brought to the correct GoalLocation and will be scanned as such.

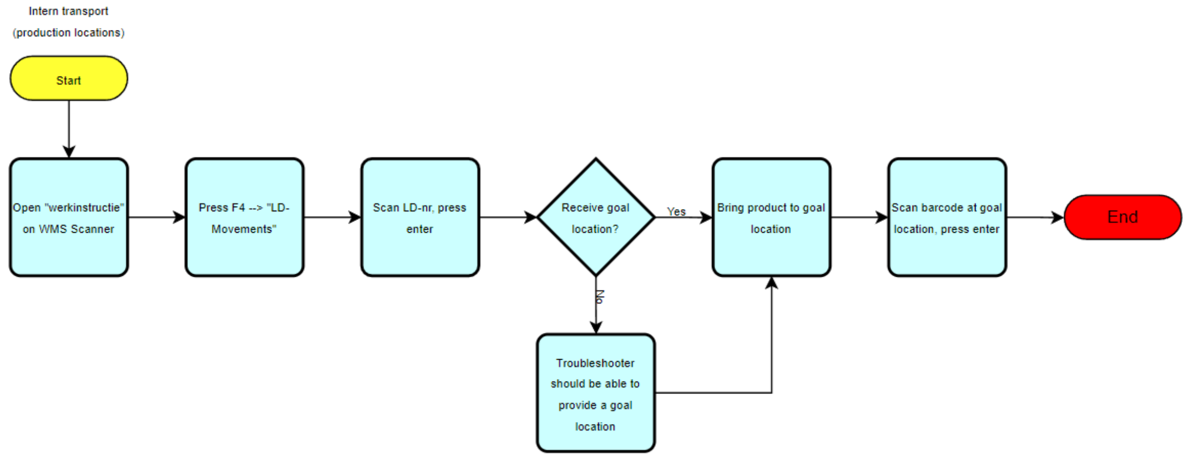


Figure 3.7 Intern transport (production locations)

3.4 Measuring the Action problem

This section will describes how the action problem is measured. By doing this, the research can be evaluated at the end. This section is separated into three sub-sections. Section 3.4.1 describes the norm and reality of the action problem as perceived by production. Section 3.4.2 measures the action problem using WMS. Afterwards, overall conclusions regarding the action problem are given.

3.4.1 The action problem as perceived by production

The action problem is defined as follows; "Material handling cannot always deliver products/parts to production locations within the 4-hour time frame." Hence, the norm should be to deliver products within a 4-hour time frame. However, this is the norm as perceived and given by material handling, it is not yet known whether production has the same norm. As mentioned in Section 3.1, surveys are given to stakeholders from production to get a clearer understanding of their perceptions of the norm. The first two questions are relevant to the action problem and are discussed in this section. The first question is the following: "When ordering a product for the shuttle truck, within what time frame do you expect the product to be delivered?". This question is asked to get an idea of the norm as perceived by the production planners. The results of this question are given in Table 3.4. After the 2nd question, the results are evaluated.

Table 3.4 norm as expected by production

Production	Expectation/norm
Projects	At most 2 days, urgent product within the next 4 hours.
Parts/Plaat	-
Systems 1 – DUV	Expectation is to deliver within a day, ordering in the morning, and delivering at the latest the next morning. (preferably at the end of the same day)
Systems 1 – SRS	½ day, ordering in the morning, delivering the same day. Ordering in the afternoon, delivering the next morning.
Systems 1 – EUV	Expectation is to deliver within a day, ordering in the morning, and delivering at the latest the next morning. (preferably at the end of the same day)
Systems 2	Expectation is to deliver within a day, ordering in the morning, and delivering at the latest the next morning. (preferably at the end of the same day)

The second question is the following: “I receive the ordered products within the expected time frame”. This question has 5 possible answers, scaling from 1 – 5, from totally disagree to fully agree. Where totally disagree is less than 20% of products and fully agree is more than 80% of products. The survey gives an optional comments text box in which additional comments can be provided. The goal of this question is to verify whether production planners experience many delays in receiving orders. The results of this question are given in Table 3.5.

Table 3.5 reality as estimated by production

Production	Reality
Projects	Estimated that around 80% of products are delivered within the expected time window.
Parts/Plaat	-
Systems 1 – DUV	Estimated the 60-80% of the products are delivered within the expected time window.
Systems 1 – SRS	Estimated that 60-80% of the products are received within the expected time window.
Systems 1 – EUV	Estimated that 40-60% of the products are received within the expected time window.
Systems 2	Estimated that 40-60% of the products are received within the expected time window.

When looking at the results, it can be seen that the projects department has the most flexible norm when it comes to non-urgent products. Besides that, they consider the norm to be achievable in about 80% of the time. Production planners from Systems 1/2 preferably receive their products within the next part of the day, ordering in the morning delivery before the end of the workday (16:00). Orders placed at the end of the day should preferably be delivered before the end of the next morning (12:00). A standard VDL ETG Almelo consists of 8 work hours (8.45 including breaks). Hence, it varies what the preferred norm is when measured in hours, however, if taken as an average Systems 1/2 prefer their products to be delivered within 5/6 hours. However, the reality as perceived by production planners is that only in 40-60% (Systems 1 – EUV, Systems 2) or 60-80% (Systems 1 – DUV/SRS) the products arrive on time. Systems 1/Systems 2 are responsible for about 80% of production and with it product flow. It can be concluded that production planners consider that an action problem exists, as they all feel over 20% of products are not delivered within the required time frame.

3.4.2 The reality of the action problem as measured using WMS

In Section 3.1, WMS and its way of collecting data is explained. This section will use that information to measure the reality of the action problem. It starts with average times for sub-processes. Afterwards, more in-depth calculations are made to measure the performance of the entire shuttle truck process. Finally, it is evaluated whether there is a discrepancy between the norm and reality, an evaluation of whether the action problem exists.

Sub processes

First of all, looking at all "calculation" sheets, different average times can be viewed. Data was collected from 17/06/2024 – 26/07/2024 which is a 6-week time period. During this period, the average times were calculated, these averages are displayed in Table 3.6. Order -> Production which gives the throughput of the entire process is further elaborated and will be discussed later on.

Table 3.6 Average throughput times

	Order -> Picking	Picking -> Dock	Dock -> Pendel	Pendel -> Production
Average time	02:10:56	00:02:10	02:09:27	02:04:43

These averages were calculated as follows, taking Order -> Picking as an example. Firstly, a table is created in excel with the first column being PickLD. Secondly, dates and times from ordering and picking are collected using lookup functions and are added to the table. The difference is calculated between ordering date and picking data, if the difference is more than 1 workday, it will be considered an outlier. According to Smiti (2020), outliers are observations that deviate so much from other observations that it is more likely they are affected by a different behavior. The difference in time between all other data points is calculated considering 7 am to 4 pm workdays. Hence, if products are ordered at 04:24:15 pm, time starts being calculated from 7 am the next day. The difference between order time and picking time is calculated, and using Excel the averages are calculated. Following this same procedure for all processes ultimately resulted in the averages as portrayed in Table 3.6.

Entire process

The first steps for calculating the entire process are the same as the procedure used for the sub-processes. This resulted in a table with all throughput times from order to production. Afterwards, outliers are calculated using Tukey's fences, which uses the interquartile range (IQR) to create fences. Observation outside of these fences will be considered outliers. The IQR is calculated using the first and third quartiles (Q1 and Q3). Q1 is the 25th percentile which is the median of the “lower half of the data”. Q3 is the 75th percentile which is the median of the “upper half of the data”. Q1 and Q3 are calculated using excel functions. The IQR can be calculated by Q3 – Q1. Finally, lower and upper limits are calculated, these will serve as the so-called “fences”. The lower limit is Q1 – 1,5* IQR and the upper limit is Q3 + 1,5 * IQR (Schwertman & De Silva, 2007). All values outside of these limits will be considered outliers and will not be taken into account when calculating averages. Table 3.7 gives the values calculated which can be used to determine outliers.

Table 3.7 Tukey's fences

Q1	03:22:50
Q3	07:29:30
IQR	04:06:41
Lower Limit	00:00:00
Upper Limit	13:39:31

After eliminating the outliers, the average is calculated using the average function in excel. These averages are divided into averages per day and a total average. Resulting in Table 3.8.

Table 3.8 Average throughput time entire process

	Total	Monday	Tuesday	Wednesday	Thursday	Friday
Average time	05:30:05	05:12:39	05:49:29	06:30:02	05:01:11	04:58:08
#Datapoints	705	157	148	137	158	105
#> 4 hours	448	90	111	103	93	59
%> 4 hours	63,55%	57,32%	75,00%	75,18%	58,86%	56,19%

Table 3.8 gives the average time taken for products from the moment of ordering till arriving at production. Besides that, it gives a view of the number of products that take over 4 hours to arrive at production.

Frequencies of delivery within certain time frames are given in Figure 3.8. The delivery times are binned with 1-hour time frames, starting at 0-1 hour and up until 13-14 hours. The goal of this frequency table is to see how many products are delivered within a certain time frame. Table 3.8 mentions that over 63.55% are delivered late, however, it does not know how late. In this frequency table, it can be seen that products take well over 4 hours to be delivered.

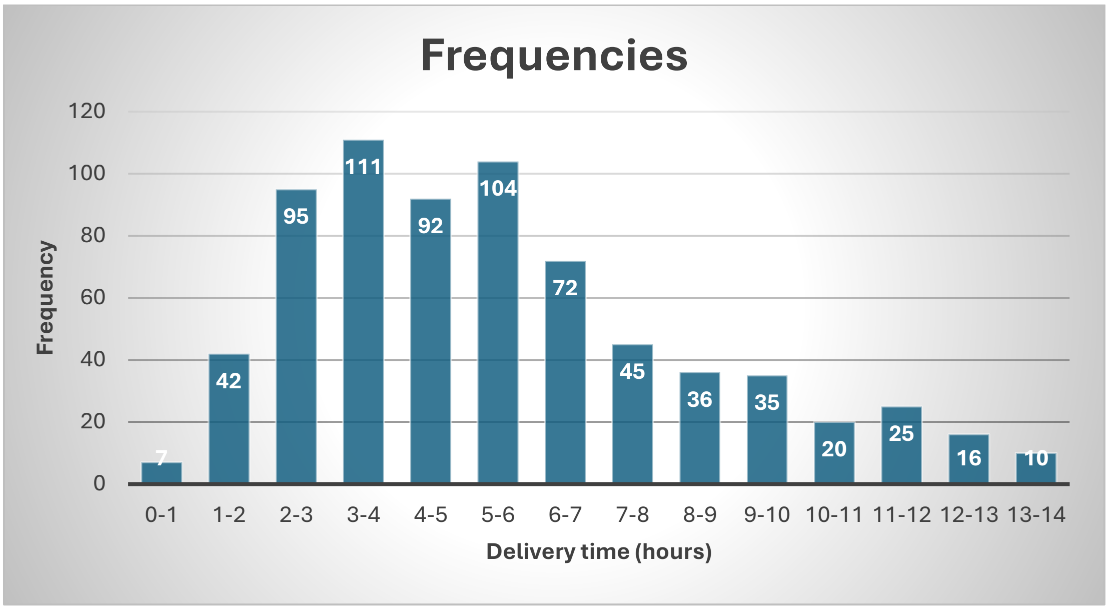


Figure 3.8 Frequencies of delivery time

Goal location

Besides comparing the difference per day, the averages are also compared based on goal location. Different production locations have different needs and therefore this comparison is made. Looking at the averages per production location could provide insight into whether delivering to certain production locations takes significantly longer. Besides that, it creates new clusters as not all shuttle trucks deliver products to all locations. By comparing the averages based on goal locations, approximate average times from trucks can be given. There are several different goal locations, during the 6 week time period not all goal locations were visited. However, thirty-one goal locations were visited resulting in Table 3.10. The goal locations are divided into five groups, which are the 5 main docking locations; locations marked in Yellow are located at Darwin, Blue is expedition Bornsestraat, Purple is Plantshofweg, grey is Einsteinstraat, and Green is X-locations Bornsestraat. From all locations, the average throughput times for the several processes are given. Besides that, the count is given to show how many products arrive at the several locations.

Table 3.9 Averages compared by goal location

Goallocation	Total	Order_Pick	Dock_Pendel	Pendel_Production	Count	Count>Goal Time	PercentageLate
D20A-A	08:04:52	01:16:27	06:12:21	00:28:52	1	1	100,00%
D40A-F	06:12:04	01:37:05	03:13:19	01:42:40	62	43	69,35%
D40B-B	03:48:59	00:50:01	03:15:20	02:13:35	7	2	28,57%
D50A-A	04:48:13	01:04:46	02:35:44	01:12:11	9	6	66,67%
D40B-E	04:44:54	00:27:30	03:33:43	00:47:23	13	8	61,54%
H1-B-001	08:12:40	01:03:54	05:22:12	01:12:26	3	2	66,67%
H2-A-001	04:38:02	00:06:22	02:43:07	01:46:32	3	2	66,67%
H2-B-001	06:17:12	02:47:23	01:32:53	01:58:41	17	9	52,94%
H5-A-001	05:38:31	02:56:22	01:41:16	01:56:56	36	14	38,89%
H5-Q-001	06:33:16	02:33:59	02:23:35	02:24:26	6	4	66,67%
HH-C-001	07:44:11	03:43:29	01:36:06	03:07:01	57	42	73,68%
HH-E-002	03:50:21	02:33:30	01:27:22	03:46:03	3	1	33,33%
HH-F-002	04:17:42	00:58:00	03:19:00	00:00:26	1	1	100,00%
HH-F-004	08:35:18	00:23:42	02:30:31	05:40:26	1	1	100,00%
HH-H-002	07:45:22	00:15:29	06:45:33	01:43:47	1	1	100,00%
HH-H-003	06:15:58	01:48:01	02:04:46	02:36:54	195	148	75,90%
M2-A-001	02:32:02	00:42:21	00:53:07	01:26:09	2	0	0,00%
M4-A-001	07:32:54	01:50:51	03:57:01	02:13:44	37	27	72,97%
M4-D-001	07:34:32	07:08:58	03:10:51	02:32:25	6	2	33,33%
M4-E-001	06:43:14	03:09:31	03:06:40	01:52:36	23	12	52,17%
M4-F-001	09:46:44	08:32:46	01:56:05	00:40:44	5	3	60,00%
M4-Q-001	09:08:03	00:14:46	06:23:23	02:29:40	1	1	100,00%
P10B-A	11:34:36	06:02:41	01:04:35	03:41:13	3	2	66,67%
X1-A-001	05:32:09	02:20:53	01:36:24	01:50:27	128	63	49,22%
X2-A-001	05:18:31	01:33:03	02:03:39	01:43:55	17	11	64,71%
X3-A-001	03:52:53	00:55:14	01:44:48	01:27:14	89	35	39,33%
X3-A-002	04:18:33	01:18:35	02:02:29	01:50:24	10	5	50,00%
X3-B-001	03:01:20	00:51:58	01:26:57	01:27:54	9	3	33,33%
X3-E-001	04:41:45	01:14:17	01:33:39	01:51:54	19	10	52,63%
X40B-A	06:03:13	03:50:00	02:09:43	01:42:09	14	9	64,29%
X4-A-001	03:57:07	01:01:15	00:42:33	02:42:27	4	3	75,00%

Conclusions from WMS

Material handling set the norm for delivery of products at 4 hours, looking at Table 3.8 it can be seen that the average time taken is about 5,5 hours. Besides that, over 60% of products take over 4 hours to arrive at production. Considering that the goal should be an average of under 4 hours and all products delivered within 4 hours, it is clear a discrepancy between norm and reality exists. Figure 3.8 gives the frequency of delivery within certain time windows. Looking at this table it is clear that the most frequent delivery time is between 3-4 hours, which is within the norm. However, it can also be seen that products overall take too long to be delivered. Looking at these frequencies, taking into account the (more lenient) norm of approximately 5/6 hours of production planners, it can be seen that over 30% of products fall outside this time window. Hence, it can be concluded that the action problem exists. Finally, Tables 3.6, 3,8, and 3,10 can be used to scope the research.

3.5 Chapter Summary

This chapter describes the current situation at VDL ETG Almelo and answers the second research question. It started by giving the methods needed for collecting data. Different types of data and research are explained, methods for observing and surveying are given, and the warehouse management system and its possibilities are given.

Documentation, as provided by VDL ETG Almelo is discussed. This is documentation that production personnel use to get an idea of the shuttle truck operations. It describes the different trucks and their routes and functions. Besides that, distances between locations are given.

Afterwards, flowcharts of the operations relevant to this research are discussed. In Section 3.3.1 it started by describing the product flow throughout Columbus. Afterwards, the sub-processes were defined in Section 3.3.2, which are: Picking at Columbus, Pendel in (Columbus), trucks' perspective, and internal transport at production locations. By doing this, a better understanding of operations and processes is given.

Finally, Section 3.4 measures the reality of the action problem and compares it with the norm and perceived reality from production. Surveys held at different production locations reveal that the production norm is more lenient, delivery in the afternoon (when ordering in the morning), which usually allows 5-6 hours. However, the reality as perceived by production planners is that only in 40-60% (Systems 1 – EUV, Systems 2) or 60-80% (Systems 1 – DUV/SRS) do the products arrive on time. Using the data provided by WMS, it is revealed that in reality products take an average of 5,5 hours to be delivered, with over 60% of products exceeding the 4-hour norm. Several tables and graphs are given to dive further into the problem. Distinctions are made for each scan moment and the time in between to see where the problems lie. Besides that, a frequency table is created to give a better view of performances. While production planners might tolerate a more flexible delivery time of 5-6 hours, looking at the frequency table, the current performance falls short of both the strict 4-hour norm and the more lenient expectations.

4 Analyzing the action problem

This chapter will answer the third research question:

“What are the challenges and bottlenecks experienced within the current shuttle truck operations?”

It starts in Section 4.1 by drawing a current state map, using all data and information collected in Chapter 3. Afterwards, Section 4.2 will give the process activity map. Then, Section 4.3 discusses the observations made during the Gemba walk. Finally, section 4.4 summarizes the chapter.

4.1 Current state map

The current state map (CSM) visualized in Figure 4.1, portrays the products flowing from Columbus to Production. An enlarged map is given in Appendix C. The CSM is created through observation and WMS data. All steps needed for the product to get from Columbus to production are given: picking/creation of the PickLD, Transport to the Pendelarea, loading at Columbus, Pendel (truck), and unloading at production. Value-added time will be considered as the time taken for a product to move from Columbus to production without waiting. Hence, moving the product from the picking location to the Pendelarea has a value-added time of 2.5 minutes for instance. Overall, value-added time is 65 minutes whereas total throughput time is 321.5 minutes. Total throughput time is the average time taken for the product to move through the entire process. Looking at this, the most throughput time is generated while loading at Columbus and picking at Columbus. Because of this, it is decided to observe these locations when on the “Gemba walk”.

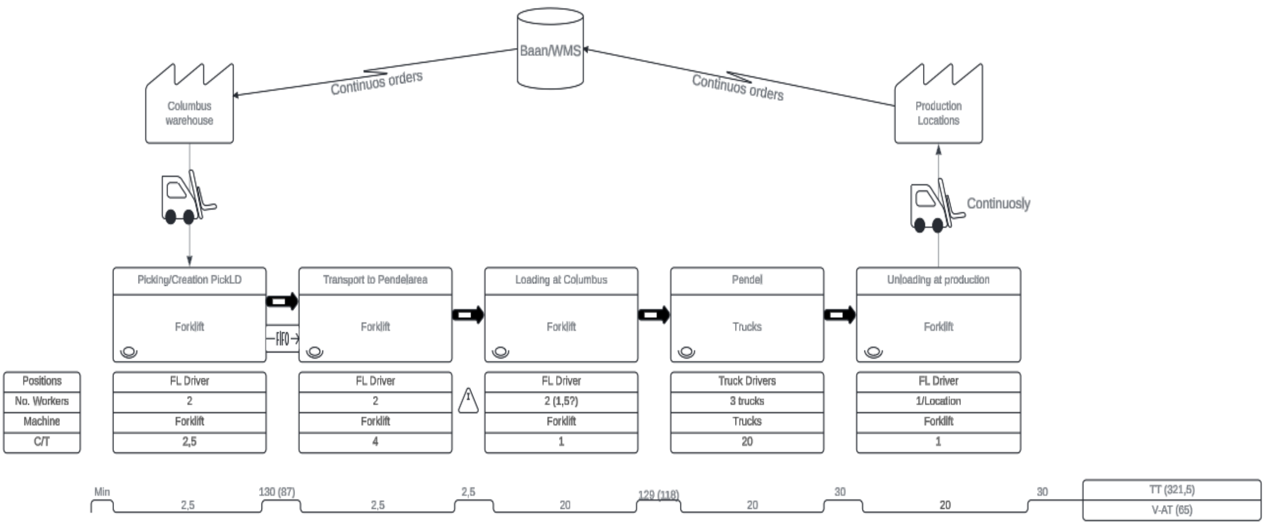


Figure 4.1 Current state map

4.2 Process activity mapping

The process activity map, given in Table 4.1, displays all steps in the trucking operations and their respective flow type, distances (if applicable), times, time when merged (if applicable), number of operators and finally Value added, non value added, and Necessary non value added

(VA/NVA/NNVA). Times are measured based on a weeklong observation, for some steps estimates of time taken are not possible. Times formatted as hh:mm:ss are times directly taken from the WMS calculations made in Chapter 2. Times formatted as XX min are based on observation. Following this table, it is concluded to observe the trucks and accompany them for a week. This decision has been made as most activities in the process map are observed when following the trucks.

Table 4.1 Process activity map

Step	Flow	Distance	Time	Time when merged	#operators	VA/NVA/NNVA
Waiting for the order to arrive in WMS (After miniload)	O	-	NB	02:10:56	-	(Currently N) NVA
Waiting for the picking process to start	O	-	NB		-	NVA
Picking order and creation of “Pick LD”	O	-	02:06		2 FL Drivers	VA
Transport from Pick location to Docking area	T	+- 50m	02:19	-	2 FL Drivers	VA
Waiting time before unloading starts	O	-	NB	-	-	NVA
Unloading time at Columbus	T	+-15m	20min	-	1 FL Driver	VA
Waiting time at the dock (Columbus) before starting the loading process	S	-	02:09:27	-	-	NVA
Loading process at Columbus	T	+- 15m	20min	02:04:43	1,5 FL Driver	VA
Transport between locations	T	+- 5km	15min		3 Truck drivers	VA
Waiting before unloading starts	O	-	NB		-	NVA
Unloading time pendel at Production	T	+- 10m	15min		1 FL Driver Per location	VA
Loading time pendel at Production*	T	+- 10m	15min		1 FL Driver Per location	VA
Waiting time before transport to goal location	S	-	-		-	NVA
Intern Transport of products at production locations	T	+- 50m	5min		-	VA
Loading time Pendel at Production *	T	+-10m	20min	-	1 FL Driver per location	VA

* Loading times pendel at production is added twice as it differs, the first one added is regarded when products are loaded at Production but the truck will visit another production locations afterwards. The second one is added when products are loaded and the next destination is Columbus.

4.3 Gemba walk (observations)

As mentioned in the literature section, observations need to be made on the Gemba (real place, the actual work floor) level to encounter problems, after which improvements can be thought of. Therefore, during this thesis, a couple of weeks were used to observe the processes. This consisted of driving along the trucks; observing the truck drivers, observing the loading/unloading at the warehouse and production locations, and observing the storage facility Columbus. These observations were done using an overt naturalistic approach. Appendix A gives logs which were used to track performances. This section describes the observations that were made, not yet looking at solutions but rather at problems. This resulted in the following observations:

1. **Coping with demand variability**

Demand has a relatively high variability, for instance, on Monday morning production can require 35 pallets whereas they require 75 on Monday afternoon. This thesis does not seek to reduce this variability but coping with the variability can be discussed. Reducing the variability is elaborated on in Section 6.4 (further research). Demand variability gives two main decision points at location Columbus:

1.1. What is currently done when there is over 100% load capacity when a truck arrives?

Figure 4.2 gives a visualization of the 'PendelArea' at Columbus, this visualization does not include all 'Lanes' but gives an idea of how the area is structured. Each lane is filled with products destined for certain production locations. All these lanes display a full truck capacity (Bolk/Looms) when filled to the red line (starting from the side of the white door). Hence, when a lane is filled from the white door to the red line (considering a perfectly packed lane) one truck can be filled. So, if one lane is filled over the red line or several lanes combine a total of over 100%, which products to load first? Not taking into account products with higher urgency, the main instigator for choosing currently is FIFO per lane. Hence, if multiple lanes are packed over 100%, the truck will be filled with products from the lane where the first product was placed. By doing this, not all products are delivered in FIFO order. If for instance a lane is filled with 20 pallets meant for Darwin at 10:00:00AM, afterwards 10 pallets are placed in a lane meant for X-Hallen at 11:00:00 and finally 10 pallets are placed in the Darwin Lane at 11:30:00. Currently products placed at 11:30:00 will most likely be loaded before the products placed at 11:00:00, which is not FIFO when looking at single products.

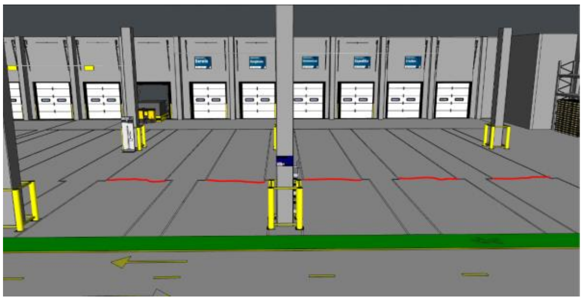


Figure 4.2 PendelLanes

1.2. What is currently done when a load is under a certain threshold of capacity?

If all lanes are empty and only one lane has about 20% for instance, what is currently done? For example, Bolk truck; the truck arrives at 11:45, is loaded at 11:55 (however only a load of 5 pallets), drive or not drive? In this instance, it was decided to wait and drive at 13:00, instead of at 11:55. This did include a break of 30 minutes, still 35 minutes later departed considering the 30-minute break. In this case, no new products were loaded as no new products were brought to the PendelArea. So, the truck delivers the same products but 35 work minutes later. Because of this, among other things, the truck drove 4 times where it could have driven 5 times. Decisions regarding this, same for +100% situation, are usually made by Columbus personnel (Forklift driver). These decisions are mainly based on gut feelings rather than a certain play-/decision book.

2. Large amount of congestion at production locations

Loading/unloading at all locations, except for loading at Columbus, is usually done by 1 operator. Therefore, if two trucks arrive at a location at the same time they will have to wait before the other trucks are unloaded/loaded. Besides that, not all locations have multiple docks which means they not only have to wait for the unloading/loading process but also the docking process. Every minute where a truck is waiting is a minute of non-value-added time, therefore congestion should be minimized. Currently, the standard for the two bigger trucks (Bolk/Looms) is to start at Columbus. While driving with the Bolk truck for 5 days, on average, the truck had to wait 41 minutes each day for other trucks (or +- 10 minutes every route).

3. Communication between truck drivers and on-site personnel is not optimized

Effective communication can play a big role in many different processes. First of all, truck drivers' communication with other employees (Forklift drivers etc.) is not always optimal. For instance, a Bolk driver arrives at the (closed) dock and decides to dock his truck at 09:20 AM. Only after 50 minutes did the driver decide to take a look at whether his truck was being unloaded, which was not the case. Although it is normal practice to dock at a closed dock, not communicating your arrival should not be the standard. Currently, drivers are not always aware of their tasks, which should not only include driving the truck but also communication when arriving, whether they will return or not. At the same time, it is important for other (VDL ETG ALMELO) personnel to communicate with the drivers when their trucks are filled and what locations they are supposed to drive to.

Currently, which might also be impossible without losing time waiting to drive, no clear schedule is made. Because of this, personnel is not always ready when trucks arrive. For instance, at X-hallen some of the unloading/loading process needs to be done by 'big forklift'. However, this forklift is not always at the location when a truck arrives. This truck, and the operator using it, also tend to drive between locations (expeditie Bornsestraat and other side of the X-hallen, non-unloading side). Currently, this means that trucks have to wait for the operator to return without a possible form of contact.

4. Following a fixed route

Initially, this thesis stated, in the section regarding Documentation from VDL, that all trucks follow a fixed route. However, the reality is that drivers tend to only drive where they have products to deliver. Hence, if a driver has products for X-hallen, he will drive to X-hallen and back to Columbus. In this case, Darwin and/or Bornsestraat Expeditie will not be visited. Mainly Darwin is not visited on every route which led to uncertainty at production locations whether a truck will arrive and if so when it will arrive. If Bolk/Looms have 0 products for Darwin, driving back to Columbus via Darwin takes approximately 20 minutes. This time will need to be driven with or without there being products at Darwin. Therefore, it is often chosen to not drive to Darwin.

5. **Unloading Bolk truck from the side**

When the Bolk truck unloads its truck from the side, which is sometimes needed because of the size of the products, the side of the truck needs to be opened. However, this is a process that takes up to 5 minutes, if done correctly, because of the +- 25 'clips' (As seen in Figure 4.3) that need to be opened or closed.

Figure 4.3 Bolk trailer

6. **The Dock at X-hallen is too steep for the Bolk trailer**

Currently, the dock at X-hallen is too steep for Bolk trailers. Therefore, at X-hallen Bolk trucks are not able to dock their truck and can only unload from the side. When unloading a bulk of pallets, loading from the side is a process which takes significantly more time than loading at the dock.

7. **Data points within WMS**

Currently, products are scanned at several locations, however, products are not yet scanned when leaving the trucks. After leaving the trucks, it takes internal transport to GoalLocation before the products are scanned and the change is made visible in WMS. Hence, between loading the truck and arriving at the Goallocation, no scans are made. Therefore, at times products can be lost without knowing where they are and where it went wrong.

8. **Visibility of products from production locations**

Most production personnel only have access to Baan, which they use to order products that need to be transported. However, they do not have access to WMS and are not able to see where their products are themselves. If for instance, one wants to know whether a product is already scanned to the Pendel, they are not able to see this.

4.4 Chapter Summary

This chapter addressed the challenges and bottlenecks in the current shuttle truck operations. Through the creation of a current state map and process activity map, it was decided to observe the trucks by driving with them and observing at the storage facility Columbus. Following these observations, or Gemba walk, several challenges and bottlenecks were found:

1. Coping with demand variability

Describes the decisions currently made and challenges experienced when demand is either low or high.

2. Congestion at production locations

Describes the observations made while driving with the trucks, where trucks are waiting for other trucks 45 minutes daily.

3. Communication between truck drivers and on-site personnel is not optimized

Communication is key, however, not always optimized within the shuttle truck operations.

4. Not always following a fixed route

Trucks do not always follow a fixed route and therefore at times do not visit all locations. Because of this, uncertainty at production locations is created and routing might not always be optimized

5. Unloading Bolk truck from the side

Unloading from the side requires opening 25+ clips which is an unnecessary time-consuming practice.

6. The steep Dock at the X-hallen

The dock at X-hallen can not be entered by the trucks because of its steepness. This results in additional unloading- and loading times.

7. Data points within WMS

Not every transport is displayed in WMS, which can result in lost products as it makes it more difficult to estimate product locations.

8. Visibility of products from production locations

Production personnel are not able to see where products are, leading to uncertainty when products will arrive.

5 Solution Approach

This section seeks to give the solutions approach and with it answer the 4th sub-research question:

"What are possible solutions for improvement of the challenges and bottlenecks within the shuttle truck operations?"

Section 5.1 introduces all possible solutions and divides them into short-term, medium-term, and long-term fixes. Afterwards, Section 5.2 elaborates on all short-term solutions, Section 5.2 elaborates on the medium-term solutions, and Section 5.4 discusses the long-term solutions. Section 5.6 formulates an implementation plan. Finally, Section 5.6 summarizes the chapter.

5.1 Possible solutions

This section introduces all possible solutions for VDL ETG Almelo to achieve an optimized shuttle truck operation. The following six solutions are given;

1. Changing the starting locations of the trucks (short-term)
2. Improved communication with and by truck drivers (short-term)
3. Changing the picking order at Columbus (short-term)
4. Improving visibility of products for transport at Darwin (medium-term)
5. Continuously monitoring and improving performances (medium-term)
6. Use of a Transport Management System (TMS) (long-term)

These solutions are listed in order of implementation speed, where solution 1 can be implemented the fastest, ending with the solution requiring the longest implementation. In the next three sections, these solutions are elaborated on. The first three solutions are discussed in the short-term solutions section, the 4th and 5th solutions are addressed in the medium-term section, and finally, the last solution is discussed in Section 5.4. Each section describes which observations made in Chapter 4 are addressed. However, not all observations are addressed with a solution in this chapter. These are the following:

1. Unloading Bolk truck from the side

Although this is considered a problem, VLD ETG Almelo is already working on a new trailer. This new trailer will have an automated system to open the side of the truck. Therefore, establishing additional solutions for this problem is not of interest.

2. The dock at X-hallen is too steep for the Bolk trailer

Currently, the dock at X-hallen is too steep for Bolk trucks. However, with the inclusion of the new trailer, it is expected that this problem will be solved.

3. Data points within WMS

This observation is made and is further elaborated on within future research, Section 6.4

5.2 Short-term solutions

This section discusses the first three solutions, which are all considered short-term fixes as they can all be implemented within two weeks.

5.2.1 Changing the starting locations of the trucks

The solution in short: Bolk and Looms should start their day at opposite locations.

Observations addressed: Large amount of congestion at production locations

Congestion is difficult to predict and can always happen because of the high variability of trucking times. However, because Bolk and Looms start at the same location, the number of congestions is unnecessarily high. Bolk and Looms drive approximately 4-5 times a day, so about 1,5 hours for each route. When starting together at Columbus, as is currently done, Bolk and Looms mainly arrive at Columbus at the same times throughout the day. While driving with the Bolk truck for 5 days, on average, the truck had to wait 41 minutes each day for other trucks (or +- 10 minutes every route). These observations were only performed for Bolk trucks, however, all other trucks have similar waiting times. Although not necessarily backed up with data, during the observation it was observed that other trucks also had to wait. Besides that, during informal conversations with truck drivers, it is frequently mentioned that there are long waiting times.

To get less congestion, an early fix will be that;

Bolk/Looms should start at Expeditie Bornsestraat, with the 2nd location (if not already at 100% after Expeditie Bornsestraat) being X-hallen and afterwards going to Columbus. Looms should start at Columbus with 2nd location being X-hallen/Expeditie (Based on importance, usually in the morning X-hallen.)

Time saved using these starting locations will be estimated at +- 5 minutes every route. (20-25 minutes daily)

Following a standard schedule, congestion can be minimized even further. However, because of the relatively high variability in trucking times (+- 45 minutes difference between max and min), this would reduce the total amount of trips per day. Trucks can only constantly follow a schedule if it takes into account the maximum time taken per trip as a basis for the schedule. However, following a standard schedule does help with visibility and gives a clearer view for all locations when trucks will arrive. For instance, Table 5.1 gives an example of a schedule for the Bolk truck. This schedule takes into account an approximate trip time of 01:45 when only visiting Bornsestraat and an approximate trip time of 02:15 when visiting Darwin as well. The benefit of using schedules like these is the added clarity of when and where trucks arrive. However, while observing trucks were able to drive 5 times daily. To be able to follow a schedule that drives 5 times a day, loading/unloading, time taken to drive, and waiting times all need to be minimized during each trip.

Table 5.1 Example schedule for Bolk

Location	Arrival Times	Departure times
Columbus	07:30; 09:15; 11:30; 13:45; 16:00.	08:15; 10:00; 12:45; 14:30
Darwin	10:10; 14:40	10:30; 15:00
Bornsestraat	08:25; 10:40; 12:55; 15:10	09:00; 11:15; 13:30; 15:45

Expected benefit:

1. Reduction in congestion

5.2.2 Improved communication with and by truck drivers

The solution in short: Truck drivers should report arrival inside at all locations

Observations addressed: Communication between truck drivers and on-site personnel is not optimized.

Truck drivers need more structure and training concerning communication and their day-to-day tasks. The outsourced companies provide a lot of different truck drivers who are not always up to date with their required tasks. Quick instructions to new drivers and a continuous evaluation should ensure a flawless performance. The latter is elaborated on later, proposing ways of evaluating the truck drivers and their performances. Figure 5.1 gives the day-to-day tasks of truck drivers, with the main 'new' inclusion that truck drivers must always report themselves inside. By doing this, personnel on site are more aware that trucks have arrived and can easily communicate with the driver where to go next. It is hard to express how much time can be saved following this solution. However, it does annul anomalies where truck drivers failed to report themselves costing over an hour for a trip. Besides that, it makes it easier to communicate where to go next. Finally, it increases safety as trucks cannot leave while the truck is still being loaded.

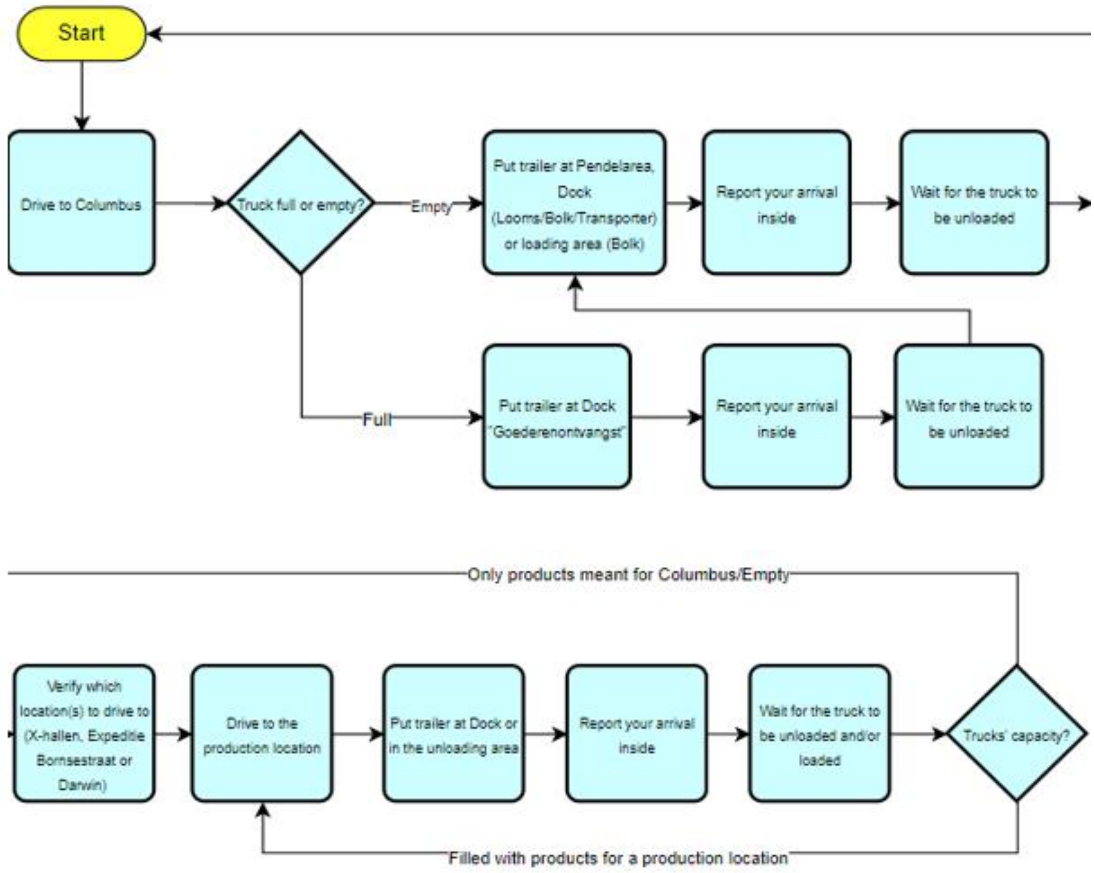


Figure 5.1 Trucks' new workflow

Expected benefits:

1. Reduction in unnecessary waiting times when personnel is not aware of the arrival of a truck
2. Better communication on which location to go to next

5.2.3 Changing the picking order at Columbus

The solution in short: The picking order should be a combination of FIFO- and 'lane-' picking

Observations addressed: Coping with demand variability

A combination of FIFO (First-In-First-Out) and 'lane picking' can optimize the capacities which the trucks drive with, departing from Columbus. While FIFO ensures older products are picked first, lane picking allows for flexibility in high-demand situations. If a truck is arriving soon and certain lanes are not full, lane picking can fill the truck efficiently without necessarily taking into account FIFO. Besides that, if for instance a truck arrives and departs for Darwin, 'lane picking' ensures that all products currently in the system for Darwin are picked. By doing this, all products for Darwin will be inside the truck.

Four situations are addressed to get a view of when FIFO is useful and when 'lane picking' is useful. All situations are displayed in Table 5.2. It is to be noted that in all these situations, it is known that a truck will arrive shortly. For instance, when a truck is unloading at Columbus. In situation 1, all lanes are filled to the red line and are therefore exactly the capacity of one truck (100%). Therefore, if a truck would arrive, it would load one lane and depart. In this situation, the products can remain being picked FIFO.
In situation 2, Darwin is filled for 40% and the other lanes are filled for 20% (giving a total of 80%). In this case, FIFO picking remains.
In situation 3, Darwin's lane has a capacity of 80% and Expeditie Bornsestraat has a capacity of 30%. Hence, not all products currently on the lanes can be transported with the next truck. Therefore, it is advised to 'lane pick' for Darwin, to make sure all products currently in the system with end location Darwin are picked and ready for the next transport. Besides that, if a truck is filled for 80% usually the 20% left will not be loaded. (if that means driving to an extra location) Therefore, quickly filling the Darwin lane makes sure the truck departs fully loaded.
Finally, in situation 4, Darwin's lane is filled, therefore it is more useful to consider picking products for other lanes first as the next truck will depart for Darwin and take all products with it.

Table 5.2 Examples of picking order

	Situation 1	Situation 2	Situation 3	Situation 4
Darwin	100%	40%	90%	100%
Bornsestraat Expedititie	100%	20%	20%	70%
Bornsestraat X-hallen	100%	20%	0%	0%
Picking method	FIFO	FIFO	Lane	Lane

Hence, the main picking procedure remains to pick FIFO. However, when a truck arrives, 'lane picking' can ensure that trucks leave with more capacity and that all products currently in the system for a certain location are picked. This is mainly useful for location Darwin, as this location is usually not always visited. So, when it is visited this method makes sure that all products, in the system with end location Darwin, are in the truck.

Expected benefits:

1. Optimized capacity utilization
2. Less waiting time at the 'PendelArea' for products to Darwin

5.3 Medium-term solutions

This section discusses 4th and 5th solutions that require more implementation time, they will need a month before full implementation is possible.

5.3.1 Improving the visibility of products ready for transport at Darwin

The solution in short: Visibility of products ready for transport at Darwin should be improved by implementing a camera at the outgoing products lane.

Observations addressed: Following a fixed route

Currently, there is little to no visibility at Darwin (or other locations) concerning the number of products for transport. Darwin has two lanes, one for incoming products and one for outgoing products. Visualizing, or knowing how many products are in, the lane for incoming products is not of much importance as it are products already delivered by the trucks. Hence, these products will no longer be important for shuttle truck transport. However, it could be valuable to know whether there are products in the outgoing products lane and what these products are. If Bolk/Looms have 0 products for Darwin, driving back to Columbus via Darwin takes approximately 20 minutes. This time will need to be driven with or without there being products at Darwin. However, if one were to visualize whether there are products at Darwin, this detour can be skipped. Placing a camera above the "outgoing products lane" gives other locations the option to see whether products are at Darwin.

Expected benefits:

1. Reduction in unnecessary trips to Darwin
2. Reduced waiting times for products at Darwin

5.3.2 Continuously monitoring and improving performances

The solution in short: Implementation of a dashboard with key performance indicators, to continuously improve operations based on data-driven decision-making.

Observations addressed: none directly, however, it ensures continuous improvement and discovery of bottlenecks in the future.

During this research, a warehouse management system (WMS) in combination with Excel was used to measure the performance of the operations. The goal should be to create a dashboard in the future which continuously updates and measures performances. Relevant KPIs for WMS can be:

- Average time taken for products to be delivered
- The number of products delivered late
- Percentage of products delivered late

All these KPIs can be further elaborated on for each production location or starting dock. Besides that, the graphs provided in the thesis should be able to be updated continuously. For instance, the frequency table, shows the frequencies of deliveries within a certain time frame. Currently, these are displayed in numbers, in the future these can also be displayed as percentages.
Besides that, depending on TMS information, additional KPIs can be measured. These can be:

- Number of trips per truck
- Idle time per truck (at each location)

An example dashboard is given in Figure 5.2, this example uses tables and figures used throughout this report.

Besides that, to measure more effectively, an extra WMS data point should be included. Currently, all steps within the process are tracked except for 'PendelUit'. Products that are moved from the truck at production locations are not tracked, they are only scanned when they arrive at the goal location within the production locations. When the products leave the trucks, performances can be tracked and evaluated better by adding an extra scan point. To measure whether scans are done all the time, an additional KPI will be included. This KPI is the number of products fully scanned, using the data from WMS it can be easily seen whether the products have been scanned at all scan locations.

Monthly meetings can be used to evaluate the performances and see where improvements can/should be made. If for instance after months of tracking data, it is visible that certain locations or trucks perform less than expected, questions need to be asked. Besides that, during these meetings, on-site personnel (or spokespersons for each location) need to be present. Currently, there is not enough communication between on-site personnel and material handling concerning possible improvements. Planning a monthly meeting should ensure that their ideas can be heard.

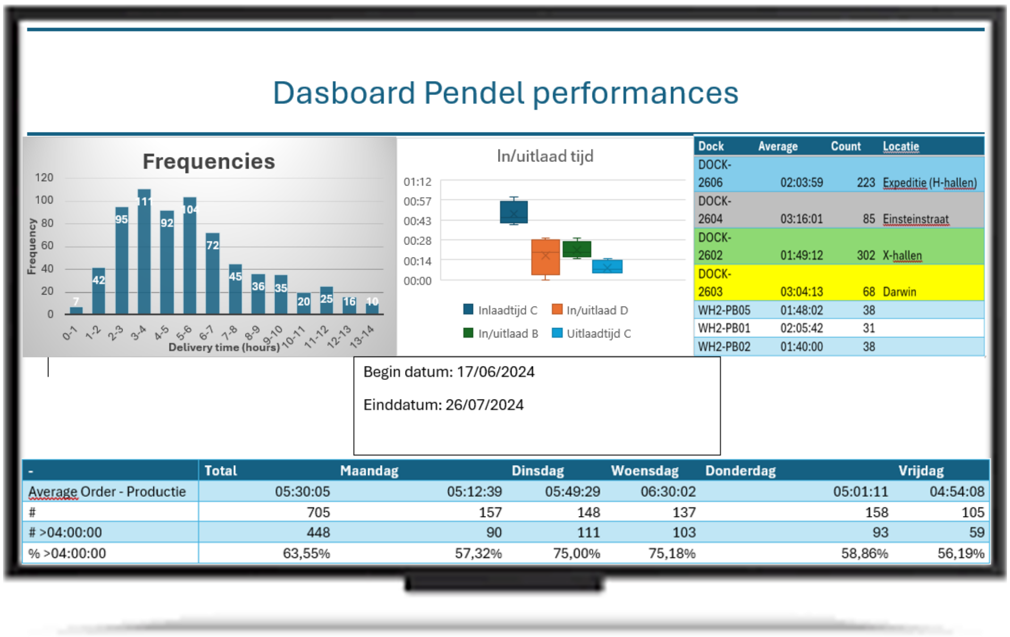


Figure 5.2 Basic Dashboard Example

Hence, by implementing a dashboard, VDL ETG Almelo can constantly track their performances. Using this, it is easier for the company to see whether they perform as they should. If not, using a dashboard they can locate where the problem lies. Besides that, using monthly meetings they can work towards an environment that continuously improves when necessary. Overall, this solution does not necessarily seek to immediately reduce the time of the whole shuttle truck operation. However, in time it can be used to measure performances and continuously improve them.

Expected benefits:

1. Improved clarity of performances by the shuttle truck operations
2. Data-based decision making
3. Continuous improvement

5.4 Use of a Transport Management System (TMS)

The solution in short: using a transport management system to follow the trucks

Observations addressed: Coping with demand variability, Following a fixed route, Communication between truck drivers and on-site personnel is not optimized, Large amount of congestion at production locations**,** and visibility of products from production locations.

This section describes the final solution, the use of a transport management system. This solution requires the longest implementation time. To improve visibility and efficiency in trucking operations, a Transport Management System (TMS) can be used. TMS offers an online platform that provides real-time insight into the location and activities of trucks. It gives better visualization data such as truck positions, and idle times at locations. Besides that, it can make planning based on historical data. Additionally, TMS can integrate with existing software, like ERP and WMS systems. SAP. (n.d.).

TMS providers

Several companies in the Netherlands offer TMS solutions, including Sensolus, AddSecure, and Tcommtelematics. By doing this, extra information regarding the use of the systems and benefits were found. The latter two companies were contacted via phone, both communicating with a sales executive. Hence, this information is collected via informal conversation. After getting insights from these companies, the following quick insights were gathered:

- **Sensolus** gives a cost-effective solution (€1150 for 5 trackers and a one-year subscription). Trackers can be easily transferred between trucks without requiring installation, but this has to be done manually each day. The system offers visibility into truck locations, geofencing, idle times, and transition counts between key zones, such as warehouses and production sites. (Benjamin, 2024)

- **AddSecure** offers a more advanced system, starting at €200/month for 5 trucks, with a one-time setup fee of €1500. The system features GPS tracking, geofencing, and start/stop reports, with an implementation time of 30-45 days. It also provides a more structured approach to planning and routing, which is normally used for larger logistics operations. (more trucks and longer distances)

- **Tcommtelematics** provides a solution starting at €8-25 per truck per month, with a one-time installation cost of €400 per unit. Similar to AddSecure, it offers real-time location tracking and geofencing but at a lower monthly rate depending on the selected package.

Each of these companies can provide valuable data to improve logistics by monitoring how long trucks spend at each location, optimizing time management, and identifying potential bottlenecks in transport operations.

Visualization at production locations

Using a TMS should make it easier at all locations to know when trucks arrive, and where they currently are. A basic visualization of this is given in Figure 5.3. When fully implemented, the visualization can/will be more elaborate. It can show how long it takes for the trucks to arrive, how much they are carrying and what locations they are going to visit. Because the locations are always aware when trucks arrive, they can plan better and make sure they are ready. Earlier it was mentioned that picking order can be adapted. This can easier be done if it is known exactly when trucks arrive. Besides that, at production locations, on-site personnel will be ready directly.

Figure 5.3 Basic tracking visualization

Integration of TMS with WMS

TMS and WMS can be combined to optimize the shuttle trucking operations. Using the WMS it will be known at which locations products are. Using the TMS planning can be coordinated which tells the trucks where to go. For instance, if Darwin has zero products in their outgoing lane, TMS makes sure this location is only visited when there are products to be delivered. Besides that, if VDL ETG Almelo were to get less variable demand, TMS could make a planning based on historical data. However, currently, demand is hard to predict and following standard schedules is difficult.

Using TMS to continuously improve

As earlier mentioned, it is advised to create a dashboard which measures performance. This dashboard can be filled with data collected from the TMS. Using the additional TMS data gives more visibility of the whole process.

Expected benefits:

1. Improved planning through a combination of WMS and TMS

2. Improved visibility of products and trucks
3. Additional data for measuring performances
4. Alerts to quickly notice when idle time is too long

5.5 Implementation plan

An implementation plan is created for VDL ETG Almelo to see which steps need to be made to implement the recommended solutions. The entire implementation plan can be found in Appendix D, this section will discuss the plan divided into short-term, mid-term, and long-term. For all implementations, the days taken are estimated. Besides that, start-days are an advice, it is currently not clear whether VLD ETG Almelo has the time to implement within these time windows.

Short-term

Figure 5.4 gives an implementation plan for the three short-term solutions. As can be seen in the figure, all three solutions can be implemented within a month. It is advised for all solutions to have a 5-day 'test' week, in this week performances are checked. By doing this, it can be ensured that the solutions are implemented properly and check whether they are effective.

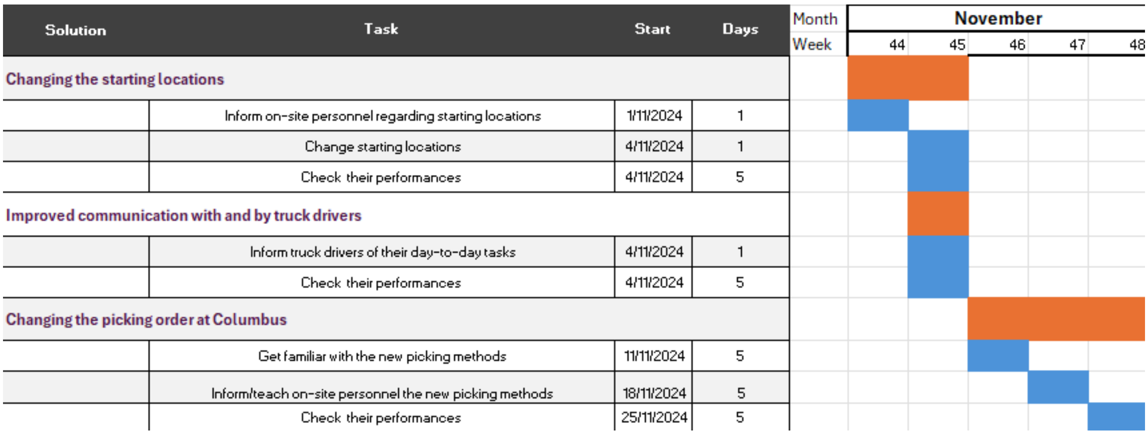
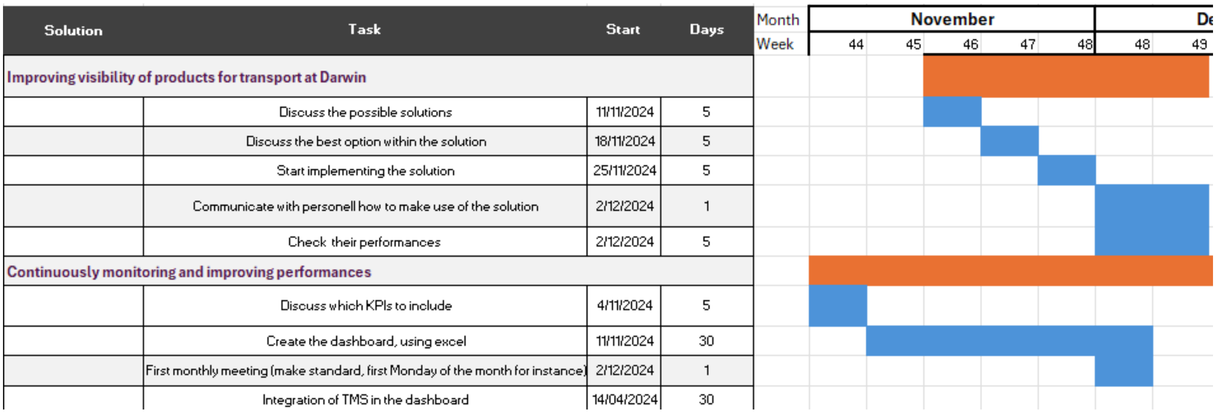


Figure 5.4 Short-term implementation plan

Medium-term

Figure 5.5 gives the medium-term implementation plan. In the medium-term, it is advised to implement the improved visibility at Darwin and start the creation of a dashboard. For improved visibility at Darwin, a meeting should be held with relevant stakeholders. In this meeting can be discussed what will be done to tackle the problem. Afterwards, the solutions should be implemented. Finally, personnel should be taught how to deal with the solutions and again performances should be checked. For the creation of the dashboard, a meeting should be held with the digitalization supply chain team, to discuss which KPIs to address and how to move forward. Following this meeting, the team can start the creation of the dashboard. In the latter stages, this dashboard can be integrated with data from TMS, which is only visible in the implementation plan in Appendix D. Besides that, monthly meetings should start to monitor performance, address possible issues, and work towards continuous improvement.

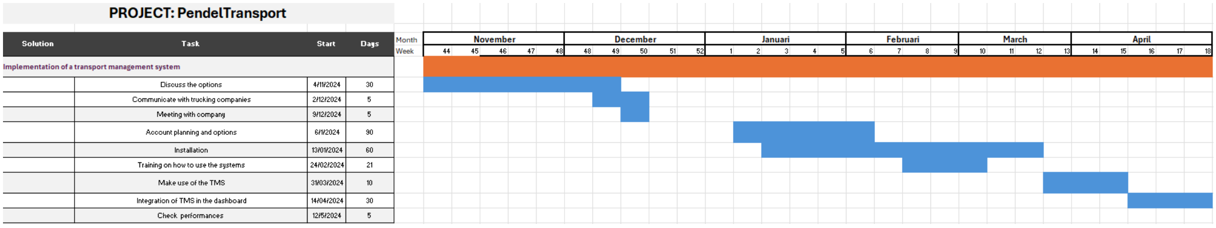


Solution	Task	Start	Days
Improving visibility of products for transport at Darwin			
	Discuss the possible solutions	11/11/2024	5
	Discuss the best option within the solution	18/11/2024	5
	Start implementing the solution	25/11/2024	5
	Communicate with personell how to make use of the solution	2/12/2024	1
	Check their performances	2/12/2024	5
Continuously monitoring and improving performances			
	Discuss which KPIs to include	4/11/2024	5
	Create the dashboard, using excel	11/11/2024	30
	First monthly meeting (make standard, first Monday of the month for instance)	2/12/2024	1
	Integration of TMS in the dashboard	14/04/2024	30

Figure 5.5 Medium-term implementation plan

Long-term

In the long-term, it is recommended to implement the transportation management system. The implementation steps and days taken are given in Figure 5.6, a more elaborate view is provided in Appendix D. TMS is the biggest implementation and requires the most time. Initially, it is advised to discuss all possible options, concerning TMS providers, and choose the most suitable. This needs to be communicated with the current trucking companies. For the implementation of a TMS, information given by a provider (AddSecure) is used, which is given in Appendix E. The overall time taken for implementation, once started, is 90 days. This is divided into account planning, installation, and training. Afterwards, the TMS can be used. Finally, the TMS can be integrated into the dashboard and overall performances can be checked.



PROJECT: PendelTransport

Solution	Task	Start	Days
Implementation of a transport management system			
	Discuss the options	4/11/2024	30
	Communicate with trucking companies	2/12/2024	5
	Meeting with company	9/12/2024	5
	Account planning and options	6/1/2024	90
	Installation	13/01/2024	60
	Training on how to use the systems	24/02/2024	21
	Make use of the TMS	31/03/2024	10
	Integration of TMS in the dashboard	14/04/2024	30
	Check performances	12/5/2024	5

Figure 5.6 Long-term Implementation plan

5.6 Chapter Summary

This chapter gives the possible solutions for VDL ETG Almelo, divided into long-term, medium-term, and long-term.

Short-term

Three short-term solutions are proposed:

1. **Changing the starting locations of the trucks:** Trucks will have different starting locations to decrease congestion by trucks. This adjustment is expected to reduce waiting times by 20-25 minutes for the Bolk and Looms trucks.
3. **Improved communication with and by truck drivers:** Improving communication with and by truck drivers, gives a reduction in unnecessary waiting times when personnel is not aware of the arrival of a truck and ensures better communication on which location to go to next.

2. **Changing the picking order at Columbus:** This solution combines FIFO and 'lane picking' where in different scenarios different picking strategies can be used. This solution ensures higher truck capacities and less waiting time for products to Darwin.

Implementation of these solutions is estimated to take between 1-2 weeks. Where in the final 5 days of each implementation it is advised to constantly check performances. By doing this, it is ensured that implementation is done properly, and changes are worthwhile.

Medium-term solutions

Two medium-term solutions are proposed:

1. **Improving visibility of products for transport at Darwin:** Improving visibility of products outgoing for location Darwin ensures that trucks don't drive to Darwin for unnecessary trips.
2. **Continuously monitoring and improving performances:** Introducing a dashboard to track KPIs such as average delivery times, late deliveries, and truck idle times will provide real-time data insights. Monthly evaluations of these KPIs will allow for continuous improvement in shuttle truck operations, being able to make decisions based on data.

The implementation time of these solutions is between 2 weeks and 2 months.

Long-term solutions

One long-term solution is proposed:

1. **Implementation of a Transport Management System (TMS):** Implementation of a TMS is the final solution and requires the longest implementation time. The implementation of a TMS ensures better visibility of products and trucks, improves planning, provides additional data and offers alerts.

The implementation time of this solution is 3-4 months. This estimate is given, taking into account, information provided by Addsecure.

6 Conclusion

This chapter gives the conclusion from this report. It starts with the recommendations of the research in Section 6.1. Afterwards, Section 6.2 gives the conclusions of the research. Section 6.3 gives the limitations encountered during the research. Section 6.4 proposes possibilities for future research. Finally, Section 6.5 describes how the research contributes to theory and practice.

6.1 Recommendations

This section provides the recommendation for VDL ETG Almelo. These recommendations are divided into short-term, medium-term, and long-term recommendations.

Recommendations for the short-term are the following:

Implementation of the first three solutions

The first three provided solutions can all be implemented on a short-term basis. These three solutions can be implemented without investments or major changes to day-to-day operations. Hence, Bolk and Looms should start at different locations to minimize daily congestion. Communication with truck drivers should be improved by constantly reporting themselves inside. By doing this it is ensured that idle time through poor communication no longer occurs and communication on where to go next becomes clearer. Finally, ensuring a combination of lane picking and FIFO increases trucks' capacity and decreases dock time for Darwin products.

Reconsider the norm

There may be a need to reconsider the given norm of delivering within 4 hours. In casual conversations with production personnel, it was clear that they prefer more clarity. Hence, they prefer 100% of products to be delivered within 5 hours over a 70% delivery rate within 4 hours. Where in the latter case the 30% delivered late can take 6/7 or even more hours to be delivered. Initially altering the norm to 5 hours and communicating this with all relevant stakeholders is advised. Section 6.1.3. will further discuss this and give recommendations for setting the norm based on the dashboard.

Recommendations for the medium-term are the following:

Implementation of the 4th and 5th solution

In the mid-term, solutions 4 and 5 should be implemented. Increasing the visibility to make sure unnecessary trips to Darwin no longer occur. Besides that, when there are products at Darwin, it will be easier to see what type of truck is needed. Implementation of the dashboard should be started in the short-term but will be finished in the mid-term. Whereas using the dashboard will be more towards the long-term, as data needs to be collected first. However, it is recommended to make sure during the mid-term the dashboard is up and running. Besides that, a first (monthly) meeting needs to be planned to work towards an environment of continuous improvement.

Recommendations for the long-term are the following:

Implementation of the 6th solution

In the long-term, it is recommended to have implemented the transport management system. The TMS should be integrated with the WMS. By doing so, tracking trucks will be easier, planning can be made, and data regarding performances can be collected.

Continuous improvement

Using the dashboard, in combination with data from WMS and TMS, it is recommended to continuously monitor performances. Monthly meetings should be held with relevant stakeholders and performances should be discussed. Besides that, based on the dashboard and performances, production stakeholders can be better informed.

Future research

The final recommendation is to look at the future research section, Section 6.4. This section gives additional ideas for research which can help optimize performances.

6.2 Conclusions

This section will discuss the conclusion of this report which is divided based on the research questions, ending with the main research question:

"How can the shuttle truck operations between storage and production be optimized to deliver products/parts within a 4-hour time frame?"

To answer this research question, the following sub-research questions were formulated:

1. **What existing methods are there to improve material handling processes within industrial companies?**

This research question was answered via literature research, focusing on four improvement techniques; Lean, Six Sigma, Business Process Reengineering (BPR), and Total Quality Management (TQM). BPR focus on rapid changes, while Lean and TQM focus on more gradual and continuous improvement. Six Sigma can be applied to both rapid and gradual changes.

2. **How are the shuttle truck operations between storage and productions currently arranged at VDL ETG Almelo?**

This research question was answered via observation and data collection/analysis. This research describes the operations needed for a product to flow from storage to production locations. Starting with an order from production, order pickers use a Warehouse Management System (WMS) to gather products needed for transport. Afterwards, these products are transported to the correct lane in the Pendelarea. Several trucks are used to constantly transport the products between the different locations. Once delivered and unloaded at the production locations, products are delivered to the goal location. Within this process, products are tracked within WMS and scanned via hand scanners. The norm provided by Material handling is to achieve this process within 4 hours. Hence, within 4 hours after production orders a product, it should be delivered at the goal location. However, using data collection methods, the reality tells us that this process takes over 5,5 hours on average. Besides that, over 63% of products take over 4 hours to be delivered.

3. **What are the challenges and bottlenecks experienced within the current shuttle truck operations?**

This research question was answered via observations and informal conversations. Two ways of observing were performed, driving with trucks and observing at the storage location of Columbus. Following these observations, several challenges and bottlenecks were experienced. These were later used to see which operations and processes could be improved on and therefore needed solutions/improvements.

4. **What are possible solutions for the improvement of the challenges and bottlenecks within the shuttle truck operations and how can they be implemented?**

This research question gives the possible solutions for VDL ETG Almelo, divided into long-term, medium-term, and long-term solutions. Three short-term solutions are proposed: Changing the starting locations of the trucks, Improved communication with and by truck drivers, and changing the picking order at Columbus. These short-term solutions offer a reduction in congestion, improve communication and increase capacity while lowering waiting times for products for Darwin.
Two medium-term solutions are proposed: Improving visibility of products for transport at Darwin and Continuously monitoring and improving performances. Introducing a dashboard to track KPIs such as average delivery times, late deliveries, and truck idle times will provide real-time data insights. Monthly evaluations of these KPIs will allow for continuous improvement in shuttle truck operations, being able to make decisions based on data. Besides that, the improved visibility at Darwin eliminates the waste from unnecessary trips.
One long-term solution is proposed: Implementation of a Transport Management System (TMS). Implementation of a TMS is the final solution and requires the longest implementation time. The implementation of a TMS ensures better visibility of products and trucks, improves planning, provides additional data and offers alerts.

5. **What are the conclusions and recommendations given to VDL ETG Almelo based on the research?**

This is the final sub-research question and proposes short-term, medium-term, and long-term recommendations based on the solutions. It is advised to implement the solutions following the 4th research question. Besides that, it is advised to reconsider the norm in the short-term and indicate this to all relevant stakeholders. In the long-term this can be altered following the performances measured using the dashboard. Finally, future research, given in Section 6.4, can be used to get additional insights and improvements.

All 5 sub-research questions are answered, which leads to answering the main research question;

"How can the shuttle truck operations between storage and production be optimized to deliver products/parts within a 4-hour time frame?"

This research question can essentially be answered by summarizing the sub-research questions. The main research question was divided into 5 sub-research questions, which are answered within this section. Hence, the shuttle truck operations can be optimized by implementing the solutions and following the recommendations and implementation plan.

6.3 Limitations

Throughout the research, there were several limitations: the amount of data, the limitation of time and with it the limitation of testing the results.

Amount of data

One of the main limitations was the short duration of data available for analysis. With only six weeks of data (when measuring the performance), the sample size was limited. Besides that, part of this data was collected during a holiday period, which tends to show a lower demand than during regular operational weeks. This affects the reliability of the data since the demand fluctuations during non-holiday weeks likely vary, leading to less accurate insights into overall performance.

Limitation of time

The limited time taken for this research can also be considered a limitation. Due to time constraints, it was not feasible to fully implement and test the proposed solutions in practice. Therefore, it can currently not be seen whether the proposed solutions will have a positive effect, and if so, how impactful they are.

6.4 Future research

This section gives possible options for future research problems within VLD ETG Almelo. These can be discussed and solved internally; however, they can also be new bachelor's or master's assignments. There are three possibilities for future research observed while at VLD ETG Almelo, they are the following:

- **Minimizing or predicting demand variability**

Within VDL ETG Almelo there are several different departments and it is estimated that over 70 employees can order products from the warehouse. Currently, these employees have no communication and order products without predicting demand. Hence, when they order products they need it as soon as possible. Within this system, products are never ordered in advance for instance. Therefore, demand variability is relatively high, for instance, 50 products on Monday and 200 products on Tuesday. Therefore, it is advised to have a look at ways to minimize or predict this variability.

- **Creation of the dashboard**

This research advises about the creation of a dashboard, using the created Excel and possible KPIs. However, the creation of the dashboard itself lies outside the scope of this research. Within VLD ETG Almelo there are employees with a background in IT and Supply chain, they can create a dashboard. However, it can also be considered to offload this workload and have a bachelor's degree student create this dashboard.

- **Optimizing the warehouse management system**

VDL ETG Almelo currently has a warehouse management system that tracks its products. However, this system does currently not track all movements. For instance, movements from production locations to the warehouse are not always tracked. Besides that, it was observed that during this research over 50% were not fully scanned throughout the whole process. Hence, it is advised to have a look at the WMS and its possibilities. In a perfect scenario, all product locations are always visible, and each product is scanned at every movement.

6.5 Contribution to theory and practice

This section addresses the contribution of this research with regards to theoretical- and practical contribution. On a theoretical basis, this research contributes by giving a case study on applying Lean tools to identify waste and find bottlenecks. This research formulated solutions by using a theoretical framework. Following the same methods in similar case studies can help in future research.

On a practical basis, this research has contributed to the company of VDL ETG Almelo. These practical contributions are found in Chapter 6, where the solutions and implementations are given. Besides that, the entire research is of practical use for VLD ETG Almelo.

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Appendix

Appendix A – Observation logs

Rit	1. Aankomst Beginlocatie (Tijd + locatie)	2. Hoe vol is trailer bij vertrek vanaf beginlocatie? (Procentuele inschatting)	3. Vertrek beginlocatie (Tijd)	4. Aankomst 2e locatie (Tijd + locatie)	5. Hoeveel afgeleverd bij 2e locatie (Procentuele inschatting)	6. Hoe vol is trailer bij vertrek vanaf 2e locatie (procentuele inschatting)	7. Vertrek 2e locatie (Tijd)	8. Aankomst 3e locatie (Tijd + locatie)	9. Hoeveel afgeleverd bij 3e locatie (Procentuele inschatting)	10. Hoe vol is trailer bij vertrek vanaf 3e locatie (procentuele inschatting)	11. Vertrek 3e locatie (Tijd)	12. Opmerkingen
1												

Truck	Arrival time	Capacity when arriving	Time unloaded	Time loaded	Capacity when departing	Time departed	Comments

Appendix B - Survey for production

Verwachtingen rondom het afroepen van producten via de pendel.

Intro: Mijn naam is Ids van der Meer en voor mijn bachelor opdracht voor de UT doe ik onderzoek bij VDL. De focus van deze opdracht ligt bij het pendelverkeer tussen Columbus en de diverse productielocaties. Om een beeld te krijgen van het afroepen van producten via de pendel heb ik een aantal vragen opgesteld. Alvast bedankt voor het antwoorden!

Productielocatie: SRS (Hal X1, X2 en X3)
Rol binnen deze locatie: Realisatie Manager

1. Wanneer je een product/onderdeel afroept dat via de pendel geleverd moet worden, binnen welk tijdsbestek **verwacht** je het product/onderdeel geleverd te krijgen?

1 dagdeel (4 uur). S'ochtends afroepen is in de middag geleverd. S'middags afroepen wordt dag erna in de ochtend geleverd.

2. Ik krijg de producten die ik afroep binnen dit verwachtte tijdsbestek. (Graag een inschatting maken)
   - ○ Volledig mee oneens (<20% van de producten komen binnen dit tijdsbestek)
   - ○ Oneens (20 - 40% van de producten komen binnen dit tijdsbestek)
   - ○ Neutraal (40 - 60% van de producten komen binnen dit tijdsbestek)
   - ○ **Eens** (60 – 80% van de producten komen binnen dit tijdsbestek)
   - ○ Helemaal mee eens (>80% van de producten komen binnen dit tijdsbestek)

Eventuele opmerkingen over deze vraag

Eens; wil nog wel eens voorkomen dat er door ruimtegebruik of capaciteitsgebrek een onderdeel toch later wordt geleverd.

3. Wanneer ik een product afroep heb ik er zicht op wanneer het ongeveer geleverd gaat worden. (Graag invullen/markeren wat het meest toepasselijk is)

- ○ **Volledig mee oneens** (Ik heb geen idee en ik weet het echt pas als het geleverd wordt)
- ○ Oneens (Ik kan een slechte inschatting maken, het zal meestal 2/2.5 uur verschillen)
- ○ Neutraal (Ik kan een beetje een inschatting maken, het zal hooguit 1/1.5 uur verschillen)
- ○ Eens (Ik kan een beetje een inschatting maken, het zal hooguit 30/45 minuten verschillen)
- ○ Helemaal mee eens (Ik weet precies wanneer het product wordt geleverd, het zal hooguit 15 minuten verschillen)

Eventuele opmerkingen over deze vraag

Kan wel enigszins een inschatting maken, maar dat komt doordat mijn inschatting rond de 4 uur ligt.

4. Wanneer ik een product afroep heeft productie dit direct na levering nodig. (Graag invullen/markeren wat het meest toepasselijk is)

- ○ Volledig mee oneens (Het product wordt nooit de week van levering al gebruikt)
- ○ Oneens (Het product wordt nooit de dag van levering al gebruikt)
- ○ Neutraal (Het verschilt, in ongeveer 50% van de gevallen zal het product op de dag van levering gebruikt worden)
- ○ Eens (Het product wordt binnen een tijdsbestek van 3 uur na levering gebruikt)
- ○ **Helemaal mee eens (Het product wordt direct na levering gebruikt)**

Eventuele opmerkingen over deze vraag

Binnen spare en repair roepen we alleen wat af als we het direct nodig hebben op de vloer. We creëren geen buffers.

5. Ik houd er rekening mee dat er meerdere mensen producten via de pendel afroepen en probeer dit daarom van tevoren af te stemmen. Met als doel een bepaalde “pendel planning” zodat niet toevallig de gehele productie tegelijk producten afroept.

- ○ **Volledig mee oneens (Er is geen overleg tussen productie personeel dat afroept in de vorm van een “pendel planning”)**
- ○ Oneens
- ○ Neutraal (Af en toe zal er een keer overlegd worden zodat niet al het pendel vervoer tegelijk afgeroepen wordt.)
- ○ Eens
- ○ Helemaal mee eens (Hier wordt dagelijks over overlegd)

Eventuele opmerkingen over deze vraag

Monteur doet de melding bij onze runner en die roept het dan ter plekke meteen af. Hiermee wordt geen rekening gehouden met het

6. Ik weet vandaag al wat ik volgende week op de pendel wil hebben.

- ○ Volledig mee oneens (Ik weet het pas 5 uur voordat ik het product nodig heb)
- ○ **Oneens** (Ik weet s ’ochtends wat ik die dag nodig heb)
- ○ Neutraal (Ik weet vandaag wat ik morgen nodig heb)
- ○ Eens (Ik weet wat ik de rest van deze week nodig heb)
- ○ Helemaal mee eens (Ik weet precies wat ik deze en volgende week nodig heb)

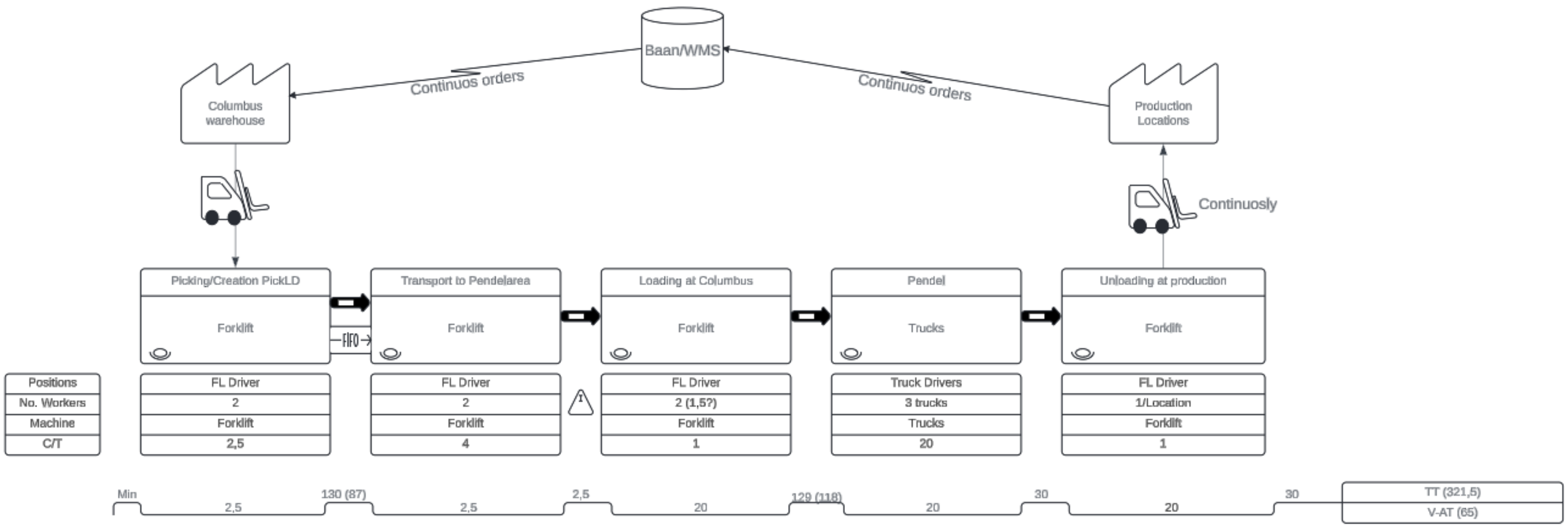
Eventuele opmerkingen over deze vraag

Dat ligt geheel aan de producten die we dan moeten maken. Dit is binnen een spare en repair omgeving erg verschillend.

Eventuele opmerkingen

Alvast bedankt voor het invullen! Mochten er vragen zijn kunnen die altijd gesteld worden! (Ids.van.der.meer@vdletg.com)

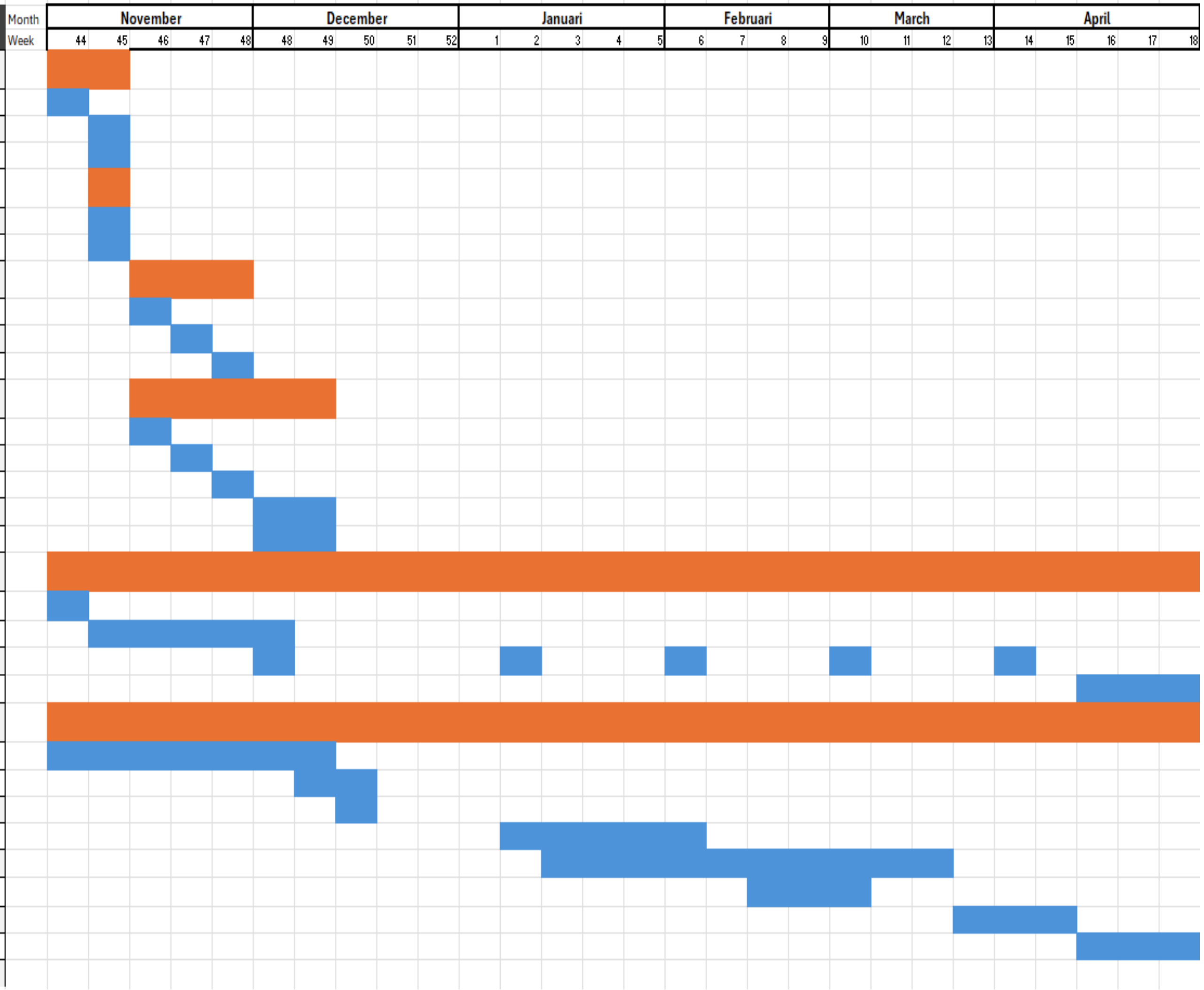
Appendix C - Value stream map



Appendix D - Implementation plan

PROJECT: PendelTransport

Solution	Task	Start	Days
Changing the starting locations			
	Inform on-site personnel regarding starting locations	1/11/2024	1
	Change starting locations	4/11/2024	1
	Check their performances	4/11/2024	5
Improved communication with and by truck drivers			
	Inform truck drivers of their day-to-day tasks	4/11/2024	1
	Check their performances	4/11/2024	5
Changing the picking order at Columbus			
	Get familiar with the new picking methods	11/11/2024	5
	Inform/teach on-site personnel the new picking methods	18/11/2024	5
	Check their performances	25/11/2024	5
Improving visibility of products for transport at Darwin			
	Discuss the possible solutions	11/11/2024	5
	Discuss the best option within the solution	18/11/2024	5
	Start implementing the solution	25/11/2024	5
	Communicate with personell how to make use of the solution	2/12/2024	1
	Check their performances	2/12/2024	5
Continuously monitoring and improving performances			
	Discuss which KPIs to include	4/11/2024	5
	Create the dashboard, using excel	11/11/2024	30
	First monthly meeting (make standard, first Monday of the month for instanc	2/12/2024	1
	Integration of TMS in the dashboard	14/04/2024	30
Implementation of a transport management system			
	Discuss the options	4/11/2024	30
	Communicate with trucking companies	2/12/2024	5
	Meeting with company	9/12/2024	5
	Account planning and options	6/1/2024	90
	Installation	13/01/2024	60
	Training on how to use the systems	24/02/2024	21
	Make use of the TMS	31/03/2024	10
	Integration of TMS in the dashboard	14/04/2024	30
	Check performances	12/5/2024	5



Appendix E - AddSecure implementation plan