Optimization of the use of Lean-Lifts at VMI HOLLAND

BACHELOR THESIS INDUSTRIAL ENGINEERING AND MANAGEMENT, UNIVERSITY OF TWENTE

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Bachelor Thesis Industrial Engineering and Management

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Preface

Dear reader,

In front of you, you find my research on the optimization of the use of Lean-Lifts at VMI Holland for the the purpose of graduating from my Bachelor Industrial Engineering and Management at the University of Twente. I conducted my research over a period of 5 months, from February until June, during which all of us experienced the strange times of COVID-19.

I would like to thank VMI Holland for allowing me to perform my thesis under their guidance. A special thanks goes out to the department of Supply Chain Innovation, for all of the feedback and information they provided me with over the past months. Most importantly, I would like to thank my supervisor Peter Ubels for all of his help, weekly skype calls and support. I am extremely grateful I was able to continue my assignment from home with the help of everyone involved.

Apart from that, I want to thank my first supervisor from the University of Twente, Peter Schuur, for his guidance and helpful feedback. Even though we were not able to enjoy our conversations face-to-face, I feel he made the experience all the more enjoyable. I would also like to thank my second supervisor, Ipek Seyran Topan. She provided me with very helpful feedback, that I will also continue to use for future reports.

Finally, I would like to thank my family, roommates and friends, who often provided me with the necessary guidance and/or distraction when needed. I especially would like to thank Carlijn, Sven and my mother for always providing useful feedback on my thesis whenever I asked for help.

I hope you enjoy reading my Bachelor Thesis!

Elles

Enschede, June 2020

MANAGEMENT SUMMARY

INTRODUCTION

This research takes place at VMI Holland. VMI is a globally operating company that produces manufacturing systems for the tire, rubber, can and care industry. At their headquarters in Epe, some of these machines are produced. This research focusses on the storage in Lean-Lifts of small parts that are needed for production. However, VMI is currently facing a problem with these Lean-Lifts, which is that their use is not fully optimized. Therefore, this research will answer the question: "What is a smart way to improve the use of Lean-Lifts at VMI Holland?"

PROBLEM DESCRIPTION

The fact that the Lean-Lifts are not fully optimized originates from several causes. First of all, the Lean-Lifts are located outside of the main warehouse in the Expedition department. Therefore, items have to be moved from the warehouse to the Lean-Lifts and vice versa. In addition, the items have to be stored intermediately after they have been picked from the Lean-Lifts before they can be shipped off to production. This increases the throughput time of the products, but moreover increases VMI's costs. Second of all, the Lean-Lifts are nearly 15 years old, which results in them being behind regarding technological innovation. New Lean-Lifts are faster and offer more features that could be beneficial to VMI's warehouse process. Finally, the software supplier and supplier of the Lean-Lifts are no longer working together, which makes it impossible to get software updates or change certain limitations to the current software.

APPROACH

First, the current situation is mapped in order to be able to compare it to any new situations. To map the current situation, it is observed and discussed with employees.

After sufficient insight into the current situation has been gained, multiple possible solutions are discussed. The solutions include moving the items from the Lean-Lift to shelving or a vertical carousel, but focus on the relocation of current Lean-Lifts and purchase of new Lean-Lifts, as these are the two preferred improvement methods by VMI.

These two methods are explored further, starting with the relocation of the Lean-Lifts. To gain insight into whether or not the move of the current Lean-Lifts is worthwhile, their value, costs of relocation and the resulting savings are weighed up, together with the feasibility of the logistics that come with the relocation.

The purchase of new Lean-Lifts is evaluated by first researching all new features that the Lean-Lifts have to offer for four market leading Lean-Lift suppliers. Furthermore, the technical specifications of the current Lean-Lifts and new Lean-Lifts are elaborated to gain insight into their performance. The utilization of the current Lean-Lifts in multiple scenarios is then used to determine the advised number of new Lean-Lifts to be purchased. Finally, all of this information is used to find the investment needed for the new Lean-Lifts as well as the savings that result from them, so that the payback period of Lean-Lifts can be determined.

CONCLUSION AND RECOMMENDATION

According to the findings, the purchase of new Lean-Lifts is a smart way of improving the use of Lean-Lifts at VMI Holland. The purchase solves all problems mentioned in the Problem Cluster: the current location, the software issues and the fact that the current Lean-Lifts are behind regarding technological innovation. Moreover, because of the new location and the new features the Vertical Lift Modules offer, the purchase of new Lean-Lifts allows for significant yearly savings compared to the current situation, that can be continued to be made over the Lifts' long life span. In addition, it shows that based on the expected future growth, the advised number of Lean-Lifts to be purchased amounts to 4. The payback period of the Lean-Lifts amounts to a little over 3 years, without adding additional features to the Lean-Lifts, this increases the savings and thus reduces the payback period. Concluding, the recommended approach for VMI is to invest in 4 new Lean-Lifts. If VMI decides to implement this recommendation, they should first decide on a supplier. During the course of the research, Hänel has shown to be the best fit, but the stakeholders should again consider whether Hänel offers all of the features VMI would like for their new Lean-Lifts. In the event that a supplier has been selected successfully, further research should be performed into the benefits and disadvantages of the several additional features that can be added to the standard VLMs, to find whether this investment would be worthwhile. When all of these aspects are clear, VMI can move forward with the purchase of new Lean-Lifts.

TABLE OF CONTENTS

1 INTRODUCTION

I, Elles de Rooij, perform my thesis researching optimization of the use of Lean-Lifts at VMI Holland for the purpose of graduating from my Bachelor Industrial Engineering and Management at the University of Twente.

This chapter provides an introduction into VMI Holland in Section 1.1, and shows the motivation for the research and the research questions in Section 1.2 and 1.3 respectively. In addition, Section 1.4 introduces the concept of Lean-Lifts needed to understand how they function as storage of small parts in a warehouse.

1.1 VMI HOLLAND

VMI, short for Veluwse Machine Industry, was founded in 1945 by Jan de Lange at the same spot VMI's headquarters are currently located, in Epe. The company started off helping to rebuild the Dutch railways after the Second World War. Over the years, the company moved into different businesses; first they started producing manufacturing systems for the tire and rubber industry. These were later followed by the can and care industry. Nowadays, VMI is a globally operating company with around 1600 employees and branches in 8 countries. Their production sites are located in the Netherlands, China and Poland. In addition, they have service centers in the USA, Russia, Germany, Malaysia and Brazil to be able to provide their customers around the world with their service. VMI's mission is "Making our customers more successful through innovative technology" (VMI Group, 2020). Through this innovative technology they have developed to be market leaders in the Tire, Can and Rubber industry. VMI's shares are wholly owned by the TKH Group. The TKH Group is a globally operating technology firm that focusses on, supports and creates high-end innovative technologies in the Telecom, Building and Industrial Solutions market segments (TKH Group, 2019).

1.2 MOTIVATION FOR RESEARCH

This Bachelor thesis looks into ways to improve the use of the Lean-Lifts at VMI Holland in Epe. A Lean-Lift is a type of machinery that stores and handles small parts in warehouses. Lean-Lifts, also known as Vertical Lift Modules, store parts vertically and collect the items that have to be picked by extracting the tray and bringing it to the picker. The Lean-Lifts are explained more elaborately in Section 1.4.

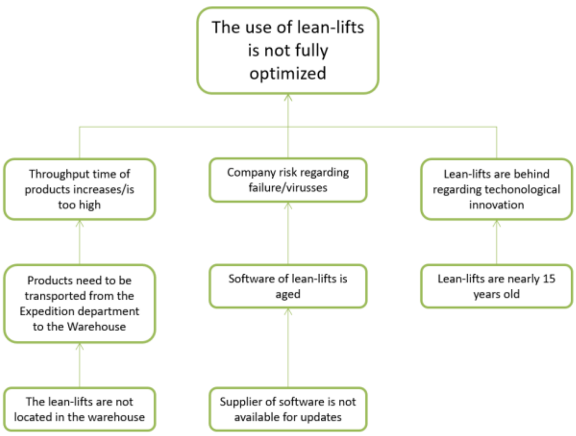

Figure 1-1: Problem Cluster

Currently VMI Holland has 4 Lean-Lifts located outside of their main warehouse. The Lean-Lifts are part of the inbound, storage and outbound system at VMI Holland and store small parts needed for the assembly of their machines. The details of the Lean-Lifts are elaborated in Section 2.2. Over the years, VMI has researched various ways to optimize these Lifts and use them to their full capabilities, sometimes in collaboration with students. During the course of various graduation assignments, they have found limitations to the current Lean-Lifts. These limitations are displayed in the Problem Cluster.

The limitations can be divided into three categories:

First of all, the location of the Lean-Lifts: the warehouse has moved several times over the course of the past 15 years. As a result, the main warehouse and the Lean-Lifts are no longer located in the same building. As shown in Figure 1-2, the Lean-Lifts are located in the Expedition department, the building across the road from the warehouse. Therefore, items that arrive to the warehouse have to be moved to the Lean-Lift to be stored, moved back to the warehouse after being picked from the Lean-Lift, stored in the warehouse in the shelving zone (RB), before being picked from the RB zone to be shipped off to assembly. This causes additional transport time and as a result the throughput time of materials/products also increases, the current system requires interim storage and multiple extra steps that need to be taken. This unnecessary interim storage and the accompanying actions also increase costs.

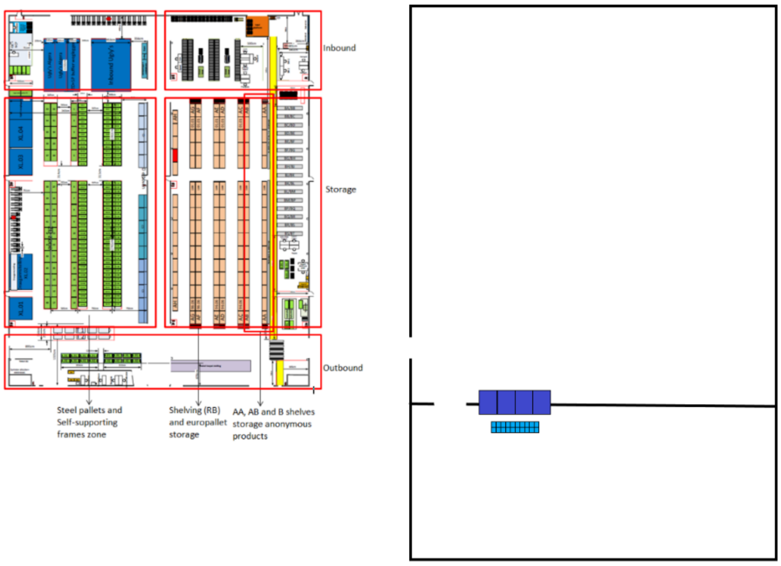

Figure 1-2: Schematic layout of warehouse and Expedition department

Secondly, the software-updates: The supplier of the lifts and the software licensing company, that created the software for the Lean-Lifts at the time, are not cooperating anymore. Therefore they are not easily available to update the software frequently, which led to the software aging overtime. This could possibly be a risk to the company. In addition, the software currently has multiple flaws that VMI is not able to fix independently. They would need an software update to take care of these problems, which is currently unavailable.

And finally, the age of the Lean-Lifts: The Lean-Lifts are nearly 15 years old. Currently, the Lean-Lifts' maximum picking capacity is limiting the picking process and it does not allow the expected future growth in production. Therefore, the Lean-Lifts could do with an update. Since the purchase of the Lean-Lifts, the technology has improved significantly. Likely, ease of use and picking speed have improved as a result. Apart from the Lifts themselves, the technology in the field of smart allocation of products and batch picking has also led to new insights. In combination with the fact that the software of the Lean-Lifts is currently rather aged, the Lean-Lifts are lacking regarding technological innovation.

As displayed in the Problem Cluster, the limitations show that the use of the Lean-Lifts is currently not fully optimized. VMI wants to look into two ways to optimize the current situation. First of all, they want to find out more about the possibilities of moving the current Lean-Lifts from the Expedition department, where they are currently located, to the warehouse. Secondly, they want to get insight into the pros and cons of purchasing new Lean-Lifts and placing these directly in the warehouse.

VMI thinks that new Lean-Lifts have potential and offer possibilities the current Lean-Lifts do not offer. They expect these to be:

- Space: By giving the new Lean-Lifts a different location to the current ones, using newer software and improved technology, they expect the Lean-Lifts to take up less space.
- Anonymous sourcing: If this would provide them with sales benefits, they would be able to purchase more products anonymously. Doing so would require more storage space, which currently is not available, since the maximum picking and storage capacity does not allow for such growth. The new Lean-Lifts might be able to offer this space and capacity.
- Process optimization: Currently products picked from the Lean-Lift are transported to the warehouse. There they are stored and picked again before being shipped off to production. A new Lift might be able to pick in the same sequence in which products should be shipped of, which would eliminate the transport to the warehouse, storing and picking. In an ideal situation this would allow VMI to pick up to 7 days later, which leads to the possibility of lower stock levels and thus lower costs.

1.3 Research questions

This section shows the research questions and the data gathering methods that were used to answer these questions. The research questions are divided into two parts: the main research question and the sub-questions.

Main research question

As displayed in the Problem Cluster, the use of the Lean-Lifts is currently not fully optimized. VMI has indicated that they want to get insight into ways to change this. More specifically, they want to find out whether either moving the current Lean-Lifts to the warehouse or purchasing new ones could be a viable way to solve the problem. As such, to provide VMI with insight into which decision would be the best approach to improve the use of the Lean-Lifts, the main research question of this Bachelor thesis is:

What is a smart way to improve the use of Lean-Lifts at VMI Holland?

Sub-questions

1. *What does the Lean-Lift process currently look like at VMI Holland? - Chapter 2*

In order to be able to make any recommendations regarding the use of the Lean-Lifts at VMI Holland, the current process should first be clear. The current situation can then be used to compare to any new situation that might be suggested throughout this Bachelor thesis. To gain insight into the current situation, data is gathered through observations at VMI, conversations with some of VMI's employees, and existing descriptions and maps of both the warehouse and the Expedition department, where the Lean-Lifts are located. The current situation is measured on a group of Key Performance Indicators (KPIs), set by VMI.

2. *What are possible ways to improve the use of the Lean-Lifts at VMI Holland? – Chapter 3*

To establish what is a smart way to improve the use of the Lean-Lifts at VMI, one should first explore the different options. This sub-question serves to provide VMI Holland with an insight into these different options, but focusses mostly on the two approaches VMI prefers: moving the current Lean-Lifts or purchasing new Lean-Lifts. In order to answer this question, a Systematic Literature is performed.

3. *What savings result from changing the location of the current Lean-Lifts to the warehouse? – Chapter 4*

One of the main limitations of the current Lean-Lift process is the location. Since the current Lean-Lifts are located outside of the warehouse in the expedition department, products that are placed in the Lean-Lifts have to be transported several times, and stored intermediately. This causes the products to spend unnecessary time in transport and in addition, results in unnecessary process steps. As such, to examine if it would be worthwhile placing the Lean-Lifts inside the warehouse, we need to find which savings would result from doing so. This information is gathered through conversations and brainstorm sessions with some of VMI's employees, in order to establish the accurate number. Furthermore, previous graduation assignments are reviewed, in order to ensure that the assumptions, regarding labour costs for example, remain the same through the different assignments.

4. *Is it worthwhile for VMI Holland to change the location of the 4 current Lean-Lifts? – Chapter 4*

VMI Holland has asked for an advisory report offering insight into two options: the move of the current Lean-Lifts and the purchase of new Lean-Lifts. Many aspects are involved in this decision making process, including costs, possible savings, an increase in productivity, et cetera. The possible savings become clear after answering sub-question 3, but the information regarding the other aspects is gathered through both discussions with the stakeholders, and offers by at least one Lean-Lift supplier. This sub-question serves to discuss these aspects and weigh them up against each other. After careful consideration, it will show whether the move of the 4 current Lean-Lifts is worthwhile.

5. *How would purchasing and implementing new Lean-Lifts improve the warehouse process at VMI? – Chapter 5*

In order to be able to make a decision regarding the purchase of new Lean-Lifts, it should be clear what they have to offer compared to the current Lean-Lifts. To gain insight in this matter, the following sub-question are defined:

a. What do new Lean-Lifts offer compared to the current Lean-Lifts?
   For the sake of gaining insight into the improvements of the new Lean-Lifts, their characteristics should be compared to the current Lean-Lifts. To do so, the brochures of the four market leading Lean-Lifts suppliers are evaluated. In addition, they are reviewed with respect to the problems that are indicated in the Problem Cluster.
b. How many new Lean-Lifts are needed without changing the current storage demands?
   In order to advise VMI on the purchase of new Lean-Lifts, it is important for them to know how many new Lean-Lifts should be purchased, should they choose to do so. A Lean-Lift is an investment and they cannot make a decision between the two options, moving the current Lean-Lifts or purchasing new ones, if they don't know the costs of the purchase of new Lean-Lifts. To determine the required number of Lean-Lifts, the utilization rates for various options are considered. These situations are supported by data of the current situation, and various calculations resulting from previous graduation assignments.

6. *What is the payback period of new Lean-Lifts at VMI Holland? – Chapter 5*

To ensure a full picture of all aspects that are involved in the purchase of new Lean-Lifts, it is important to look at their payback period. As VMI would have to make a rather large investment, they have to get a clear understanding of how long it will take for the Lean-Lifts to pay off their investment. Based on this payback period they will be able to determine whether or not the investment would be worthwhile. To calculate the payback period, the costs and savings have to be determined. The costs are based on an offer from one of the Lean-Lift suppliers. The savings are calculated based on conversations with VMI's employees and data from graduation assignments from the past.

7. *How do the answers of sub-questions 4 and 6 compare? In particular, what choice can be recommended? – Chapter 6 and 7*

This research question serves to provide VMI with a recommendation based on the pros and cons of both scenarios: moving the current Lean-Lifts or purchasing new Lean-Lifts. The recommendation is based on several aspects, varying from financial benefits and costs to efficiency, and follows directly from sub-questions 4 and 6, while also including several preferences expressed by the stakeholders. In addition, this recommendation helps to answer the main research question.

1.4 THEORETICAL PERSPECTIVE

This section elaborates on the theoretical perspective that is relevant to conduct and understand the research. First of all, the warehouse is briefly explained. Secondly, Lean-Lifts are discussed in more detail.

There are various different types of warehouses, like picking warehouses, sortation centres, and transhipment centres. The warehouse we consider at VMI is a picking warehouse. A picking warehouse can be picker-to-parts, which remains the most used strategy in today's warehousing systems (Richards, 2011). When a picker-to-parts system is used, the picker travels to the parts. In a picker-to-parts warehouse, static storage locations are visited by pickers, travelling within the warehouse aisles. This travelling usually amounts to a travel time which is about 50% of the total order processing time (Tompkins et al., 2010). An alternative, which minimizes the travel time, is the parts-to-picker strategy, in which the items (parts) are brought to the operator (picker) by an equipment. At VMI, the warehouse consists of picker-to-parts and parts-to-picker processes. In the case of this Bachelor thesis, I will focus on the parts-to-picker process, since my assignment researches Lean-Lifts, also known as Vertical Lift Modules (VLMs), which are a type of parts-to-picker machinery.

Figure 1-3: Lean-Lift

In a Lean-Lift, an insertion/extraction device is travelling vertically and extracts trays from shelves and brings them to the picker, putting them on the pick shelf (Dukic et al., 2015). In Figure 1-3 (*Hanel Lean-Lift [image]*) a VLM is displayed. The yellow arrows show the ways in which the tray can move along the Lean-Lift. According to Dukic et al. (2015), usual VLM systems have only one picking place.

Therefore they often use two, three or four units, to minimize the waiting times, as displayed in Figure 1-3. While one unit extracts the tray, the human order-picker can pick parts from the other Lean-Lift. When the picker is done picking, the Lift will extract another tray and the picker can pick from the other Lean-Lift. That way the picker does not have to wait for the VLM to extract a tray. However, recently some producers of Lean-Lifts offer solutions with two pick-places, named dual-tray VLMs, which would mean that multiple units to reduce waiting time might not be needed anymore. These dual-tray VLMs are discussed in more detail in Chapter 5. Lean-Lifts offer various benefits compared to traditional, static storage locations, like a reduction in travel time of pickers and the square meters they take up, but their applicability depends on several factors as mentioned by Calzavara et al. (2019), like usage of the warehouse, order size and space cost. In this Bachelor thesis, the Lean-Lifts' applicability for VMI Holland is briefly discussed in Chapter 3.

2 CURRENT SITUATION

This chapter describes the current situation in the warehouse and regarding the Lean-Lifts at VMI Holland. Section 2.1 discusses the current warehouse process. Section 2.2 describes the current Lean-Lifts and their characteristics. In Section 2.3, the Key Performance Indicators, that are used to measure the performance of the Lean-Lifts and their role in the warehouse, are explained and their current performance is evaluated.

2.1 WAREHOUSE PROCESS

As described in Section 1.4, VMI uses both parts-to-picker and picker-to-parts processes. This section discusses the main warehouse, which uses a picker-to-parts system.

All parts are delivered to VMI's main warehouse. When these parts are delivered, they are carefully unpackaged and sorted. Depending on their size and whether or not the parts have a defined location, it is determined where they should be moved and stored. Small parts are stored using shelving, slightly larger parts up to 1.2 meters are stored on europallet racks, parts larger than 1.2 meters are stored on a steel pallet and parts exceeding 1.8 meters are placed on self-supporting frames. Almost all parts stored at these locations are project related, which means they are purchased on demand. VMI also purchases some products anonymously, which means that they are not linked to a particular project. These anonymous products are either placed on shelving destined for anonymous products, moved to the Lean-Lifts outside the warehouse, or when larger stored on europallet racks or steel pallets. A floor map of the warehouse is displayed below in Figure 2-1. Area 1 shows the steel pallets and self-supporting frames zone. Area 2 includes the shelving (RB) and europallet storage. Area 3 covers the AA, AB and B shelves, which store anonymous products. A magnified image can be found in Appendix A.

Figure 2-1: Floor map of warehouse excl. Lean-Lifts

As mentioned before, the Lean-Lifts are not located in the warehouse, but in the Expedition department, therefore the Lean-Lifts are not displayed in the floor map. A material flow diagram of the warehouse incl. Lean-Lifts is displayed in Figure 2-2. A magnified image can be found in Appendix B.

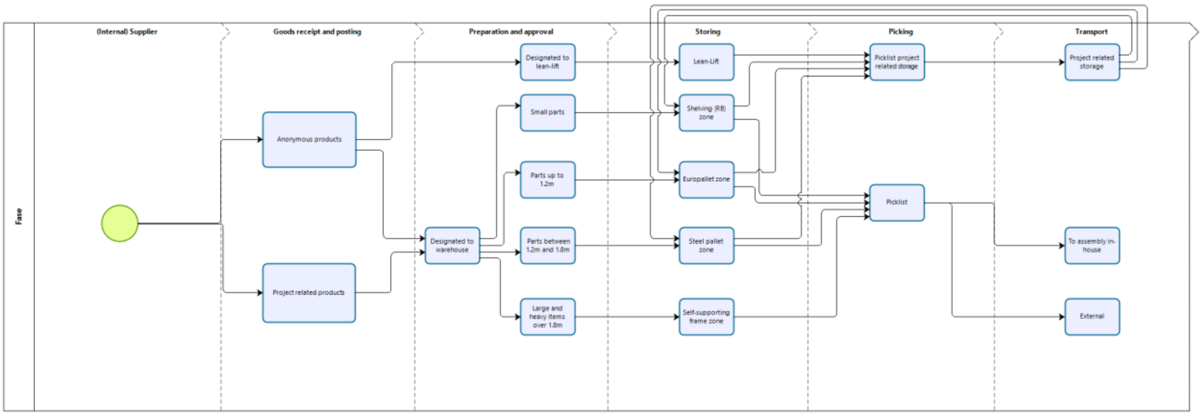

Figure 2-2: Material flow diagram of warehouse incl. Lean-Lifts

When all parts for a particular project are present in the warehouse, including the parts that have to be picked from the Lean-Lifts, the human order-picker can start the order picking process. The pickers pick the items 7 days before the mechanic starts production. When the picker has collected all of the items for a project, they are shipped off to production.

2.2 Current Lean-Lifts

The current Lean-Lifts are located in the expedition department, which is the building next to the main warehouse with a small road for traffic in between. The road used to be for internal traffic only, but currently trucks that are delivering items to VMI also drive on this road. This has led to the road becoming relatively busy, which in turn makes it less easy for items to cross from the warehouse to the expedition department at all times. There are four Lean-Lifts, all from the Lean-Lift supplier Hänel. The VLMs are 15 years old and are all single tray VLMs. Therefore up to 4 people can pick from the Lean-Lifts simultaneously, but normally 1 to 2 pickers work at the Lean-Lifts each day. This way the waiting time of the pickers is minimized. The layout of the Lean-Lifts and the project related bins is shown in Figure 2-3, with the Lean-Lifts at the left and project bins at the right.

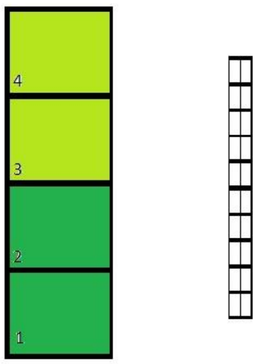

Figure 2-3: Layout of Lean-Lifts and project related bins

The pickers pick according to a pick-to-light system: a light shines in the compartment in the tray the picker should pick items from. This system increases the accuracy of picking and decreases the picking time. The pickers pick in batches of 20 orders, which is the maximum number of orders the Lean-Lift can run a cycle for. For these 20 orders, the Lean-Lift determines the most efficient sequence in which the trays should be extracted by the lift. An example illustrates this optimization: Order 1 consists of items A, B and C, Order 2 consists of items C, D, and E, and Order 3 consists of items B, C and D. In that case, the tray that contains item B will remain in the work window so that the items can be picked for both Order 1 and Order 3. The same holds for items C and D. The sequence in which the trays are extracted depends on their location in the Lean-Lift. The Lift optimizes such that the distance travelled is minimal. After an item has been picked from the Lift, it is placed in its destined bin on the shelving. The shelving consists of 20 bins, 1 bin for each order, also displayed in Figure 2-3, and works according to a Put-to-Light system: a light turns on at the specific bin and the small screen shows the Lift number the item was picked from, to decrease the chances of error as two pickers sometimes work at once.

During the inbound process, in which items are placed inside the Lean-Lifts, the Lift assigns a location to these items. Currently there is no specific priority rule that determines the location of the items, which means that the items are assigned to their location at random. A process flow diagram, which describes all the steps that are taken when placing an item in the Lean-Lift or picking from it, is displayed in Figure 2-4. A magnified image can be found in Appendix C.

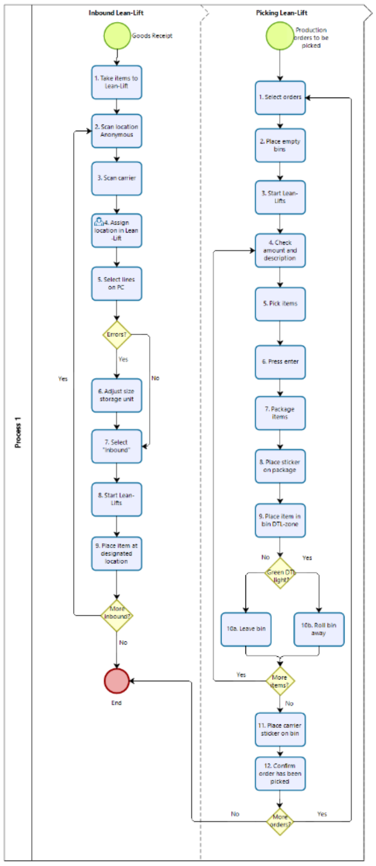

Figure 2-4: Process flow diagram of Lean-Lift

Like mentioned previously, the age and location of the current Lean-Lifts are causing the use of the VLMs to not be fully optimized. In addition, the software company and the Lean-Lift supplier do no longer work together, which caused the software supplier to not be available for updates to the software. As a result, the Lean-Lifts have flaws that VMI is not able to repair. An example of such a flaw is the fact that the Lean-Lift does not recognize 153 storage locations, which causes all of this space to be wasted (Luigjes, 2020). In addition, the Lean-Lift is not able to determine the optimal order picking strategy for an entire day, but only for 20 orders at the same time. An update in the software could allow for this to improve, since the technology has improved a lot over the past years. As a result, the order picking time will likely decrease since the Lean-Lift would have to extract trays less frequently or over shorter distances. Furthermore, when placing items in the Lean-Lift, sometimes the software does not recognize that the items already have a designated spot in the Lean-Lift and therefore assign a new and thus extra location to the items. This results in space being used unnecessarily.

2.3 Performance on Key Performance Indicators

To measure the performance of the current situation at VMI Holland, five Key Performance Indicators (KPIs) are established. These KPIs focus on the performance of the current Lean-Lifts and their role in the warehouse. Below the KPIs are introduced and their performance is discussed. Their performance is also shown in Table 2-1.

2.3.1 Transport time from warehouse to the Lean-Lift

The current Lean-Lifts are located outside of the main warehouse, which causes extra travel time for items to be moved from the warehouse to the Lean-Lifts. Possible improvements, which are discussed in Chapter 3, could reduce this travel time. Currently, transport time from the warehouse to the Lean-Lift amounts to 8 seconds per inbound order line (Luigjes, 2020). An important note is the fact that this does not mean the item is always moved from the warehouse to the Expedition department, where the Lean-Lifts are located, in these 8 seconds. After items are unpackaged in the warehouse at the inbound process, their location is determined. Lean-Lift items are set aside and stored on a pallet until a sufficient number of items has gathered, after which these items are moved all at once. The 8 seconds of transport time from the Lean-Lift to the warehouse thus only shows an average of the actual time in transport divided by the number of inbound order lines on the transport.

2.3.2 Transport time from Lean-Lift to warehouse

As mentioned, the Lean-Lifts are located outside of the main warehouse, which causes extra travel time for the items to be removed from the Lean-Lifts and moved to the warehouse. The current transport time from the Lean-Lifts to the warehouse amounts to 5 seconds per outbound order line (Luigjes, 2020). The same note that holds for the transport time from the warehouse to the Lean-Lift, also holds for the transport time from the Lean-Lift to the warehouse.

2.3.3 Inbound time Lean-Lift

The software, ease of use and speed of the Lean-Lifts determine the time pickers spend to place items in the Lean-Lifts and contribute to their performance. The software will determine the way in which trays are collected and how many items can be placed in the Lean-Lift during one run. The ease of use will influence the time the Lean-Lift worker will have to spend on the process. The speed of the Lean-Lift will determine at which speed the trays are collected and stored, and thus influence the time spend placing items in the Lean-Lift. Right now the Lean-Lift worker spends 70 seconds per inbound order line on the inbound process at the Lean-Lift (Luigjes, 2020).

2.3.4 Picking time Lean-Lift

The picking time, or outbound time, provides insight into the performance of the VLMs since it shows the Lean-Lifts' speed, ease of use and the performance of its software. The software will influence the sequence in which trays are extracted and thus influence the outbound time. In addition, it will influence the number of orders that can be picked during one picking cycle. Moreover, the ease of use will influence the time the picker is busy collecting the needed parts from the tray. In addition, the speed at which the trays are collected and stored will influence the picking time. Currently, the picker spends on average 40 seconds picking an outbound order line from the Lean-Lift (Luigjes, 2020).

2.3.5 Picking error

When a picking error is made at the Lean-Lift, this leads to a lot of extra work and delays, and as a result extra costs. Therefore it is essential to keep the picking errors as low as possible. The picking error is, next to the Lean-Lift workers, influenced by the software that is used to pick items, and thus the ease of use. New technology likely has improved picking systems in such a way that errors are less likely to occur. Currently, the VLMs have a picking error of 2%.

Table 2-1: Performance of KPIs

Key Performance Indicators	Transport time from warehouse to Lean-Lift	Transport time from Lean-Lift to warehouse	Inbound time Lean-Lift	Picking time Lean-Lift	Picking error
Current performance	8s	5s	70s	40s	2%

2.4 Conclusion

The purpose of this chapter was to answer sub-question 1: What does the Lean-Lift process currently look like at VMI Holland? As described in Section 2.1, the warehouse consists of 4 different storage unit sizes on which items that arrive in the warehouse can be stored: Shelving, Europallets, Steel Pallets and Self-Supporting Frames. Items that arrive in the warehouse can also be destined for the 4 Lean-Lifts, located outside of the warehouse. When the picking process starts, 7 days in advance of assembly, the picker will only start picking items from the warehouse after the items from the Lean-Lift have been picked and placed in the shelving zone. To pick items from the VLMs, VMI uses a Pick-to-Light system. The Lean-Lifts are usually occupied by 1 to 2 pickers at once, to minimize waiting times. The current Lean-Lifts have several limitations, including a couple of software flaws that VMI has not been able to resolve. Their performance and the performance of their role in the warehouse can be measured using 5 Key Performance Indicators: “Transport time from warehouse to Lean-Lift”, “Transport time from Lean-Lift to warehouse”, “Inbound time Lean-Lift”, “Picking time Lean-Lift” and “Picking error”.

3 POSSIBLE IMPROVEMENT METHODS

This chapter discusses possible ways to improve the use of the Lean-Lifts at VMI Holland. Section 3.1 explores new improvement methods, including ones that have not yet been considered by VMI. However as VMI has expressed their preference for the use of Lean-Lifts, the focus is on the two preferred approaches: either moving the current Lean-Lifts, discussed in Section 3.2, or purchasing new ones, discussed in Section 3.3.

3.1 NEW IMPROVEMENT METHODS

When looking at possible improvement methods that have not yet been considered by VMI, the focus should be on small parts handling and storage, since the current Lean-Lifts store only such parts. There are various different ways in which small parts can be handled and stored.

The first option is traditional static shelving, which is also currently being used at VMI for some small anonymous parts that are not placed in the Lean-Lift. In this situation, the items that are currently in the Lean-Lift would be moved to the warehouse and placed in shelving units. This would solve the location problem and thus decrease travel time of products and the number of steps in the storage and picking process. Combined with an Automated Storage and Retrieval (AS/R) system, this could improve the general output of the system, since an AS/R system works faster at retrieving and storing items than a human order-picker and allows the shelving to be higher and thus allows for more items to be stored on a smaller floor surface. However, recently during another graduation assignment Luigjes (2020) found that VMI should consider moving the anonymous items currently in shelving units in the warehouse, to the Lean-Lifts since this would save them €14.000 on a yearly basis and free up 41m^2. Therefore, moving the items from the Lean-Lift to traditional shelving is not an advised storage solution.

Figure 3-1: Vertical Carousel

Another possibility could be purchasing a carousel. In contrast to a VLM, a carousel does not retrieve a tray, but rotates the trays to the picker. Carousels come in various different sizes and types and can be horizontal or vertical. In addition, carousels can be both unidirectional (one-way rotating) or bidirectional (two-way rotating). Bidirectional carousels are the most common type, as well as the most efficient (Hassini & Vickson, 2003). As mentioned, the carousel rotates the items to a picker. While the carousel is travelling, the picker has time to perform other tasks, like pack or label the retrieved items or pick from another carousel (Litvak & Vlasiou, 2010). In case of VMI, the horizontal carousel is ruled out, because it does not fit VMI's requirements nor the space they have available for an alternative, as it should roughly take up as much space as Lean-Lifts in order for it to be viable. However, a vertical carousel could be an option. Figure 3-1 (*Innovative Automated Vertical Storage and Retrieval Systems [Image]*) shows a Vertical Carousel. A vertical carousel allows you to use the maximum height available in the building, providing the best use of space by taking up minimal square footage. However, a trade-off has to be made, since using the maximum height available will affect its efficiency, because the height will affect the speed at which the shelves will rotate (Richards, 2011). A strong benefit of carousels is their long service life and low maintenance. This would allow VMI to use the carousels over an extended period of time, with limited costs.

3.2 Relocation of Lean-Lifts

As one of the main limitations of the current Lean-Lifts is their location, one naturally wonders whether this problem could be solved by moving the VLMs into the warehouse. By relocating the Lean-Lifts, the excess transport time and process steps would be reduced or even eliminated, which would result in a shorter and less expensive storing and picking process. The VLMs could even be placed in the warehouse in such a way that intermediate storage in the shelving zone would not be necessary any longer. However, relocating the Lean-Lift from the Expedition department into the warehouse comes at an expense. Therefore it is essential to determine the worth of the current Lean-Lifts compared to the costs of relocation to establish whether or not it is still worthwhile to move them. Even though relocation would solve the location issue, it would not address any of the other problems displayed in the Problem Cluster. This should also be taken into account when considering this approach, as it might solve some issues but leave bigger problems along the road that cannot easily be solved in the future without making large adjustments or investments. The relocation of the Lean-Lifts is explored further in Chapter 4.

3.3 Purchase of new Lean-Lifts

Another way to improve on the current situation is by purchasing new Lean-Lifts and thus updating the current Lean-Lifts. Since the new Lean-Lifts would be placed in the warehouse, the location issue that VMI is currently facing would be resolved. Furthermore, the new Lean-Lifts would make use of all relevant new technology. In addition, they would come with (the possibility of) a software supplier that could install regular software updates and help optimize the software according to VMI's preferences. The purchase of new Lean-Lifts would thus solve all of the problems displayed in the Problem Cluster and should therefore be considered as a viable solution.

VLMs have a lot to offer: they not only save space up to 80%, but also increase the picker's productivity and reduce picking error and inventory by control in real-time (Dukic et al., 2015). This shows that the VLMs are beneficial to the storage and outbound process at VMI Holland, next to the fact that VMI already prefers Lean-Lifts to other storage solutions, because they have been used for the past 15 years.

Moreover, there are some new varieties on the Lean-Lifts, that have followed from the technological innovation over the past years, that are interesting to consider for VMI. Recently some VLM suppliers offer VLMs with two tray extractors, naming them dual-tray VLMs, dual delivery configuration VLMs or VLM with 'double access handling' option (Dukic et al., 2015). These dual-tray VLMs would make it unnecessary to keep on using multiple units for one single picker to reduce waiting times, since the dual-tray VLM would ensure that the picker would not have to wait for a new tray to be extracted. Furthermore, Dukic (2015) mentions that modern VLMs provide increased operational speed, greater weight capacities combined with automated control systems and an easy-to-use interface.

A lot of research has been done over the past years, not only at VMI but also by other researchers that have published their findings in several papers. Findings regarding batching to optimize the use of Lean-Lifts (Nicolas et al., 2018), could be applied to the new Lean-Lifts since alterations to both the Lifts and the software would be possible. All of these developments make purchasing new Lean-Lifts an attractive solution, which is explored more deeply in Chapter 5.

3.4 CONCLUSION

This Chapter served to answer sub-question 2: “What are possible ways to improve the use of Lean-Lifts at VMI Holland?”. It did so by discussing 4 different possible solutions of which 2 are explored further in the coming chapters.

First of all, instead of the Lean-Lifts, VMI could make use of static storage in shelving. However, recently a graduation assignment performed at VMI showed that this is not a viable solution for them, so this improvement method was dismissed.

VMI could also replace the VLMs by Vertical Carousels. They fit the same spatial requirements as Lean-Lifts but their main advantage is that they have a long service life and require little maintenance.

As VMI’s preference lies with Lean-Lifts, Vertical carousels are dismissed, and the improvement methods that include these Lifts are explored further.

One of these improvement methods could be moving the current Lean-Lifts to the warehouse. This way the location problem would be resolved, which would result in several savings. However, it is essential to determine the worth of the Lean-Lifts and the costs of this relocation to establish whether it is worthwhile to execute. The relocation is discussed further in Chapter 4.

Finally, the purchase of new Lean-Lifts should also be considered as a possible improvement method. This would solve all problems displayed in the Problem Cluster: the location, the Lean-Lifts’ age and their software issues. Furthermore, the purchase of new Lean-Lifts would allow for further adjustments that are currently not possible, that would improve the Lean-Lifts’ efficiency. The purchase of new Lean-Lifts is explored in more detail in Chapter 5.

4 Relocation of current Lean-Lifts

This chapter elaborates on the relocation of the current Lean-Lifts. It discusses the expected savings of a new location in Section 4.1. Section 4.2 goes into the costs of the relocation and its different aspects. The current value of the Lean-Lifts is elaborated in Section 4.3. Section 4.4 discusses the logistics of the relocation. Section 4.5 examines the applicability and feasibility of a relocation of the current Lean-Lifts for VMI.

4.1 Expected savings

The expected savings for the relocation of the current Lean-Lifts and necessary data to calculate these savings are displayed below in Table 4-1.

Table 4-1: Expected savings relocation of current Lean-Lifts

Required data for calculations		Expected savings	
Expected number inbound order lines	24,244	Total transport time	€6,932.36
Expected number outbound order lines	175,408	Elimination of storage	€40,646.00
Labour costs per hour	€25	Total	**€47,578.36**
Current transport time warehouse-Lean-Lifts (s)	8		
New transport time warehouse-Lean-Lifts (s)	3		
Current transport time Lean-Lifts-warehouse (s)	5		
New transport time Lean-Lifts-warehouse (s)	0		
Current inbound time shelving (s)	100		
Current outbound time shelving (s)	55		

One of the main limitations to the current Lean-Lifts is their location. In case of a relocation of the Lifts from the Expedition department to the warehouse, this issue would be resolved. As a result of the relocation, items do not have to be moved to and from the Expedition department and do not have to be stored intermediately in the warehouse after being picked and before being shipped off to production.

Currently, the transport time from the warehouse to the Lean-Lifts is on average 8 seconds per inbound order line. An explanation of this KPI can be found in Section 2.3.1. If the Lean-Lifts are to be placed in the warehouse, this travel time would reduce significantly. We expect the travel time in the new situation, where items are moved directly from the inbound area to the Lean-Lifts on the other side of the warehouse, to be on average 3 seconds per inbound order line. This expectation is based on the travelled distance, which will decrease with at least 60%, and the floor map of the warehouse. In his graduation assignment, Luigjes showed in 2018 27,095 inbound order lines were carried out and 2019 amounted to 21,393 inbound order lines (2020). For the purpose of this assignment, we take the average number of inbound order lines over these 2 years as a prediction for the number of lines in the near future. As such, we expect 24,244 inbound order lines per year. Since the move of the Lean-Lift would reduce the transport time from the warehouse to the Lean-Lifts with 5 seconds, the overall time saved per year is roughly 4 working days of 8.5 hours for 1 employee.

Moreover, relocating the Lean-Lifts to the warehouse would allow for items from the Lean-Lifts to be picked as the last step in the order picking process, thus not requiring intermediate storage. The orders picked from the Lifts could be placed straight onto the transport after all other items have already been gathered from the warehouse, and shipped off to production. The material flow diagram displayed below shows the new situation, a magnified image can be found in Appendix B, Figure B-0-2. More explanation regarding the warehouse process and this material flow diagram can be found 2.1. A magnified image of the material flow diagram of the current situation is displayed in Figure B-0-1.

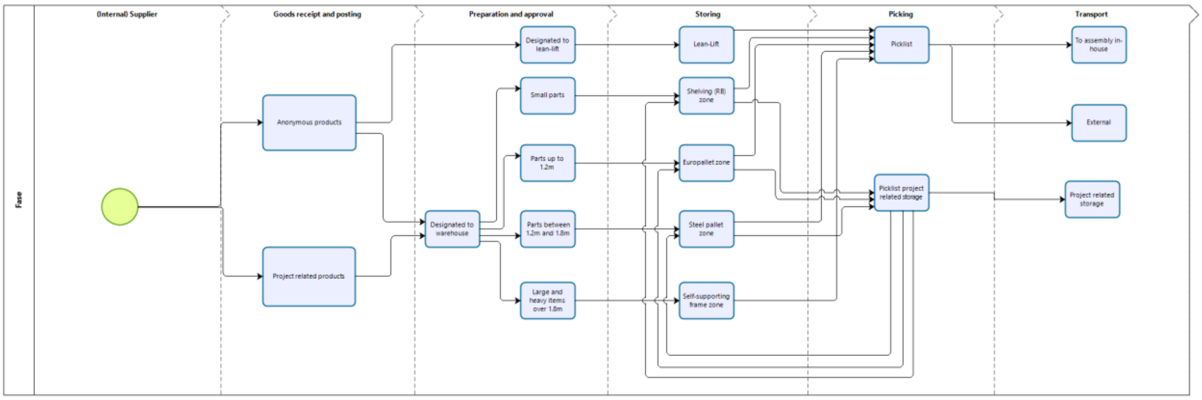

Figure 4-1: Material flow diagram new situation

Since this intermediate storage is not needed, and items are picked from the Lean-Lift directly before being moved to production, the throughput time of items from the Lean-Lift is significantly decreased. We assume that the dwell time of these items is at least 1 day. In addition, time is saved as the pickers do not have to place the items in the shelving as well as pick them from the shelving when all items for a particular project are gathered. A picker spends on average 169 seconds per warehouse inbound order line on the inbound process at the anonymous shelving, and 126 seconds per outbound order line on picking from the shelving. We expect the inbound and outbound process for the project related bins at the shelving area to be slightly shorter, since these actions require considerably less process steps. Therefore we set the time spend on the inbound process at the shelving to be 100 seconds and on the outbound process 55 seconds per respective order lines. Because of COVID-19 it was not possible to conduct measurements, therefore these numbers are based on the number of actions and their evaluated difficulty. In case VMI chooses to investigate the expected savings further, the actual process times should be measured. The number of outbound order lines from the Lean-Lifts were 199,930 in 2018 and 150,886 in 2019 (Luigjes, 2020), resulting in an expected number of future Lean-Lift outbound order lines of 175,408. Based on the measurements conducted in a recent graduation assignment, the average number of Lean-Lift outbound order lines per order, and thus per bin is roughly 5. The resulting savings from these actions no longer being conducted amount to €40,646 at labour costs of €25 per hour.

The travel time from the Expedition department to the warehouse currently amounts to 5 seconds. This time would be eliminated fully should the Lean-Lifts be moved, since the items do not have to be moved from the Lean-Lift into the warehouse before they can be shipped off to production, but instead can be placed straight onto transport. As mentioned previously, we expect 175,408 outbound order lines per year in the near future. Therefore the time savings amount to roughly 29 working days of 8,5 hours for 1 employee.

As a result of the relocation of the Lean-Lifts, the total savings as a result of the decrease in transport time amounts to €6932.36, if we assume labour costs of €25 per hour.

The total savings from relocation the Lean-Lifts from the expedition department to the warehouse amounts to €47,578.36.

In Luigjes' graduation report he advised that 75% of the anonymous items that are currently stored in the shelving area should be moved to the Lean-Lifts, since this would save €15,230 on a yearly basis. As items already have to be placed in the Lean-Lift, this would be a convenient time to also place the items from the anonymous shelving in the Lean-Lifts. In case VMI decides to do so, the yearly savings can be expanded further with €15,230.

4.2 Costs

The costs of relocation of the current Lean-Lifts consist of two different aspects: the actual move of the Lean-Lifts and the transfer of all items currently in the Lean-Lifts. All costs are indicated in the table below, after which the different aspects are discussed in Sections 4.2.1 and 4.2.2.

Table 4-2: Costs relocation of current Lean-Lifts

Required data for calculations		Expected costs	
Labour costs per hour	€25.00	Move (option 1)	€30,138.49
Number of items in Lean-Lifts	5816	Move (option 2)	€22,642.33
Number of items without obsolete	5144	Rental of platform	€1,190.00
Picking time (s)	40	Transfer of items	€4,294.72
Inbound time (s)	70	Total (option 1)	**€35,623.21**
Travel time Lean-Lifts-warehouse (s)	5	Total (option 2)	**€28,127.05**

4.2.1 Moving costs

In 2017, VMI looked into the costs of moving the Lean-Lifts. They received two different offers from Hänel, one for the move to be conducted by 3 Hänel mechanics, one for 2 Hänel mechanics and one VMI employee to assist. To determine the costs to move the Lean-Lifts nowadays, inflation has to be taken into account. The costs of both offers are displayed below. The current total is based on the inflation rate published by the CBS (CBS, 2019).

Carried out by 3 Hänel mechanics:

Disassembly 4 Lean-Lifts, 4 days	€9,624.00
Assembly 4 Lean-Lifts, 8 days	€19,248.00
2017 total	€28,872.00
Current total	€30,138.49

Carried out by 2 Hänel mechanics and 1 VMI employee:

Disassembly 4 Lean-Lifts, 4 days	€6,416.00
Assembly 4 Lean-Lifts, 8 days	€12,832.00
2017 total	€19,248.00
Current total	€20,092.33

These costs are excluding the rent of a platform and forklift truck. VMI has forklifts available, so these forklifts could be used, saving rental costs. However, the platform would still have to be rented. This will cost roughly €1,190.00 for 12 days.

In addition, for the second offer VMI would have to clear the schedule of a VMI employee to assist in the move. Therefore the labour costs of this worker also have to be taken into account, to get a full picture of the costs of this option. The employee would have to assist for 12 working days. If one assumes a working day of 8.5 hours and labour costs per hour to be €25.00, these labour costs would amount to €2,550. Therefore the total costs for the relocation to be carried out by 2 Hänel mechanics and one of VMI's employees are €22,642.33.

4.2.2 Transfer costs items

The costs of removing all items from the Lean-Lift and placing them back, will be considered as one cost. To determine these costs, inbound time, picking time and transport time from the Expedition department to the warehouse should be taken into account. Furthermore, the floor space that is required to store the items should be available, in order for the move to be viable.

Currently, 5816 locations in the Lean-Lift are occupied. For the purpose of this calculation, we assume that these locations are occupied by separate items, i.e. 1 location is occupied by 1 item. All items have to be removed from the Lean-Lifts prior to their relocation. As stated in Table 2-1, the picking time per outbound order line is 40 seconds (Luigjes, 2020). The total picking time to remove all items from the Lean-Lift amounts to roughly 8 days for 1 employee.

We assume that after the items are removed from the Lean-Lift, they are stored at the Expedition department, and will be moved after the Lean-Lifts have been relocated and build. The total period over which items have to be stored amounts to 12 days, as the disassembly and assembly of the Lean-Lifts take 4 and 8 days respectively.

Of the 5816 items, 11.6% has not moved for the past 4 years and is thus considered to be obsolete (Luigjes, 2020). Therefore these items do not have to be placed in the Lean-Lifts after the relocation. As such, 5144 items have to be moved to the warehouse and placed inside the Lean-Lifts. Luigjes found a transport time of 5 seconds and an inbound time of 70 seconds per outbound order line. The total transportation and inbound time amounts to roughly 13 days for 1 employee.

As the transfer of items is rather time consuming, the transfer will be conducted by multiple employees at the same time. Overall, the total transfer time amounts to roughly 7 days, assuming working days of 8.5 hours for 3 Lean-Lift workers. As labour costs are set at €25,- per hour, the total costs, according to the calculation, amount to €4,294.72.

4.3 VALUE OF CURRENT LEAN-LIFTS

To determine whether or not it is worthwhile for VMI to invest in relocating the current Lean-Lifts to the warehouse, it is not only important to look at the costs of such a move, but also at the current value of the Lean-Lifts. The book value shows the value of the Lean-Lifts after taking accumulated depreciation into account.

The Lean-Lifts were purchased in 2006 and had a purchase value of €183,503.00. The book value of this investment is now €0, since it had a depreciation period of 8 years.

In 2012, VMI made an upgrade to the Lean-Lifts, which had a purchase value of €52,911.00. This investment also had a depreciation period of 8 years, as such the book value in April 2020 was €4,409.24. Looking at the future months, the Lean-Lifts will have a book value of €0 overall by the end of 2020.

Naturally, the fact that the book value of the Lean-Lift equals zero, does not mean that the Lean-Lifts have lost all of their worth. They still remain to be functioning Lean-Lifts and therefore they are still of value. However, for the purpose of this assignment, the book value of the Lean-Lifts is used as their value. Nonetheless, should VMI decide not to move the current Lean-Lifts but purchase new Lifts, the recommendation will offer various ways in which the Lean-Lifts can be preserved and/or used for different purposes.

4.4 Logistics

To determine whether or not moving the Lean-Lifts is a viable approach, it is important to determine how long the Lean-Lifts would be down for. As determined in Section 4.2.2, the total transfer time amounts to roughly 7 working days, when 3 Lean-Lift workers would spend their full working days of 8.5 hours on transferring all items. In addition, the actual relocation of the Lean-Lifts takes 12 working days. Together this amounts to a total of 19 working days, which would mean that the Lean-Lifts would be down for almost 4 weeks. Since production must continue during these weeks, the items cannot be unavailable for such an extensive period of time.

One way to make sure the items would still be available, is to ensure storage such that the items can still be picked. However, such storage would require a certain investment, that would come on top of the investments that already have to be made to relocate the Lean-Lifts.

Another approach could be to minimize the number of working days spent on the transfer, by working outside office hours on clearing all items from the Lean-Lifts, and after relocation, placing the items back. This approach would require a slightly higher investment, but could decrease the number of working days significantly, for example by working overtime, and expanding overall working hours with 4 hours and 45 minutes, with an extra shift from 16:15h to 21:00h. This would mean that someone that did not have to work during a particular day, could take on this evening shift. The labour costs during these hours are estimated to be slightly higher. They are assumed to be €35,- per hour. As such, the total costs would increase to €4,910.57. However, due to the overtime, the number of working days needed for the transfer is decreased to a little over 4 days. Naturally, expanding these working hours could decrease the number of necessary days further. Nevertheless, there will be a period during which the items from the Lean-Lifts cannot be picked unless a proper storage solution is found.

As a result, the logistics of relocating the Lean-Lifts would be a challenge for VMI, since production has to continue. Without the appropriate interim storage solution and a minimal number of transfer days, relocating the Lean-Lifts is not a viable solution to improve the use of Lean-Lifts.

4.5 Examination of Applicability and Feasibility

From the expected savings and costs of a relocation, the current Lean-Lifts value and the logistics of their move, we can determine whether such a relocation would be applicable and feasible in case of VMI.

First of all, the total yearly savings that are established in Section 4.1, amount to roughly €47,600. Naturally, these savings are significant, however one has to take into account that the relocation of the Lean-Lifts does not solve all of the problems stated in the Problem Cluster. It resolves the location issue VMI is currently facing, because the Lean-Lifts would be moved from the Expedition department to the warehouse. On the other hand it does not account for any updates to the current software, nor does it offer any developments that improve the speed or use of the current Lean-Lifts.

The costs are dependent on various factors, but for the purpose of this examination we choose these factors such that the costs are as low as possible. The resulting cost that are expected for the relocation of the 4 current Lean-Lifts amounts to a little over €28,000.

As explained in Section 4.3, the book value of the current Lean-Lifts is currently €4,409.24, but will be €0 by the end of 2020.

Moreover, the logistics of the relocation of the Lean-Lifts pose a large challenge to VMI. Because of the fact that all items would have to be removed from the Lean-Lift before the Lifts can be disassembled, moved and re-assembled, the picking process will have to be interrupted. As the expected total duration of the transfer of all items and Lean-Lifts is roughly 4 weeks, VMI would be challenged with stopping their picking process from the Lean-Lifts for these Lifts, unless an adequate intermediate storage solution is found. After careful consideration, VMI expressed that it is not possible to shut down their Lean-Lift picking process for such an extensive period of time as production has to continue.

Because of the Lean-Lifts' value and the relatively large investment when compared, and in addition, the fact that the Lean-Lift picking process cannot be down for almost 4 weeks, the relocation of the current Lean-Lifts is not applicable nor feasible for VMI Holland.

4.6 Conclusion

This chapter serves to explore the relocation of the current Lean-Lifts in more depth.

First of all, sub-question 3, "What savings result from changing the location of the current Lean-Lifts to the warehouse?", is answered in Section 4.1. The relocation of the current Lean-Lifts allows for several savings on a yearly basis. An overview of the costs and savings of the relocation of the current Lean-Lifts can be found in Table 4-3. The transport time is significantly reduced, resulting in savings of up to almost €7,000 per year. Moreover, items do not have to be stored intermediately, which saves a considerable amount of labour costs. This is a result of the Lean-Lifts being located in the outbound area, so that orders can be placed straight onto transport, together with the other items that have been gathered from the warehouse, after they have been picked from the Lift. The resulting savings amount to €40,646 on a yearly basis. As such, the total yearly savings amount to roughly €48,000. The yearly savings can be expanded further with €15,230 by following Luigjes' advice to move 75% of the items from the anonymous shelving to the Lean-Lifts.

The chapter discusses all relevant aspects of the relocation in order to answer sub-question 4: "Is it worthwhile for VMI Holland to change the location of the 4 current Lean-Lifts?". Next to the savings, the costs of a relocation are discussed in Section 4.2. In 2017, this option was explored and thus the offer Hänel made at the time is used to establish the costs of the actual move. The costs amount to €23,832.33 for the move to be executed by 2 Hänel mechanics and 1 VMI assistant and €31,328.49 for 3 Hänel mechanics. Next to these costs, the transfer costs of the items of €4,294.72 have to be taken into consideration.

Table 4-3: Overview costs and savings relocation current Lean-Lifts

Expected costs		Expected savings	
Move total (option 1)	€31,328.49	Total transport time	€6,932.36
Move total (option 2)	€23,832.33	Elimination of storage	€40,646.00
Transfer of items	€4,294.72		

The book value of the Lean-Lifts, explained in Section 4.3, in April 2020 amounted to €4,409.24. Based on the depreciation period however, they will have a book value of €0 by the end of 2020. When one looks at the logistics, discussed in Section 4.4, it becomes clear that the operation is not executable for VMI, nor worthwhile. Because of the fact that the Lean-Lifts have to be empty at the time of the relocation, and the fact that disassembly and reassembly takes at least 12 days, the Lean-Lift picking process would be down for at least almost 4 weeks. Because production has to continue, and finding a storage solution for the Lean-Lift items that would allow for the picking process is nearly impossible and very costly, it can be concluded that the relocation of the Lean-Lifts should not be considered an option for VMI Holland.

5 PURCHASE OF NEW LEAN-LIFTS

This chapter elaborates on the purchase of new Lean-Lifts. Section 5.1 mentions which Lean-Lift suppliers are selected for analysis. Section 5.2 shows the developments over the past 15 years and the new features that are available at the 4 Lean-Lift suppliers. In Section 5.3 the technical specifications of the Lean-Lifts are discussed based on the data of the VLMs of the different suppliers. In Section 5.4 the advised number of Lean-Lifts to be purchases is calculated. Section 5.5 offers an evaluation of the payback time. Section 5.6 describes the new location of the Lean-Lifts in the outbound area of the warehouse. The new Lean-Lifts' sustainability is discussed in Section 5.7.

5.1 SELECTION OF LEAN-LIFT SUPPLIERS

In order to analyse the possible purchase of new Lean-Lifts, a selection of Lean-Lift suppliers has to be made. This Bachelor Thesis focusses on 4 market leading suppliers. A market research report showed that Kardex, Hänel, Ferretto, and ICAM S.r.l. are market leading suppliers (MarketsandMarkets, 2018). Therefore these suppliers are analysed.

5.2 NEW FEATURES AVAILABLE

Over the past 15 years the VLMs have developed on several aspects. This section serves to illustrate these new features.

5.2.1 Structural features

The 4 current Lean-Lifts are all separate modules, and therefore there is no horizontal or diagonal exchange between these modules. However, it is now possible to extract trays from multiple modules through one extraction device. Both Hänel (Hänel, 2018) and ICAM use a multidimensional system that operates along 3 axes, horizontal (X), vertical (Y) and tray storage and retrieval (Z) (ICAM, 2019). Kardex uses a diagonal extractor to retrieve and store trays in multiple modules (Kardex, 2014).

Moreover, dual tray VLMs are now available, which are offered by Kardex (Kardex, 2014). These dual tray VLMs, also known as VLMs with double-access handling option, offer the possibility to use two work levels in the picking window, one at the bottom of the window and one at middle height. First a tray is moved into the first work level and the shutter door closes. While the picker is storing or removing articles from this tray, another tray is being retrieved and kept waiting behind the picking window. When the picker is done with the first tray, this tray is removed from the picking window and the waiting tray is placed on the second work level. As a result of this new development, the picker does not spend any time waiting for a tray to be retrieved. Before, this waiting time would be minimized by one picker picking from at least two picking windows, but this would no longer be needed.

Hänel uses a similar system, without having two work levels (Hänel, 2015a). Their Dual-Drive system allows the Lift to retrieve a tray, whilst a picker is busy picking from another tray. Once this tray is retrieved, it is stored at the bottom of the shaft. Once the picker is done picking, the tray he or she was working on is stored and the tray from the bottom of the shaft is moved into the picking window. This way, the picker doesn't have to wait for a tray to be extracted and can work at one picking window continuously.

Resulting from both achievements, the multimodular exchange and double access handling or a dual drive system, a picker no longer has to handle multiple picking windows, like 2 picking windows for 2 Lean-Lifts, at once. This improves overall ease of use and reduces the picker's physical labour.

Hänel also uses optimization movement, to eliminate minor gaps created by a high number of tray movements. This technology ensures an optimal compression of the storage volume, so no space gets lost (Hänel, 2015a).

Furthermore, Kardex produces VLMs that can easily be modified to fit future needs. Extra picking windows can be added to the structure later on and the Lifts can also be moved easily (Kardex, 2014). Hänel also offers options to modify their VLMs later on, like heightening them, adding a unit, or changing their location (Hänel, 2015a). This would be beneficial for VMI specifically, since there are plans to expand the location in Epe over the next few years. A new warehouse will be built across the road and this would mean that, would VMI decide to purchase new Lean-Lifts before, they would have to be moved. In addition, Kardex's VLMs offer the possibility to adjust the working height according to the pickers preferences. This ensures the most ergonomic and thus efficient working height for the picker.

During the contact with Hänel, they expressed that they also offer various new solutions to put items away after they have been picked. Currently, an item is placed in its assigned bin on the shelving that works according to a Put-to-Light system. The layout of the Lean-Lifts and project related bins is shown in Figure 2-3. Hänel is still able to offer the same system, but they can make slight alterations to it. In addition, they offer the possibility of a roller conveyer. This roller conveyer would eliminate the fact that pickers currently sometimes have to cross each other as a picker from Lift 4 has to move to the other side of the bin shelving behind lift 1 and vice versa. The conveyer belt would allow VMI to pick in zones, such that picker 1 could pick from zone 1, which would include lifts 1 and 2, and picker 2 could pick from zone 2, with lifts 3 and 4. Another possibility could be movable shelving racks, that could be moved between the zones and would effectively work in the same manner as the conveyer belt, without taking up as much space. For the purpose of this assignment, these different possibilities will not be explored further, but VMI should look into these options in case they decide on the purchase of new Lean-Lifts.

Table 5-1: Overview structural features

Suppliers	Multidimensional movement	Dual tray	Easy modifications	New order bins system
Kardex	X	X	X	X
Hänel	X	X	X	X
Ferretto	-	-	-	-
ICAM	X	-	-	-

5.2.2 Software

In addition, a lot of headway has been made regarding the software behind the Lean-Lifts and ERP (Enterprise Resource Planning) systems. In this area, the biggest improvements have taken place. Next to improvements regarding the layout of the Lean-Lifts, which also depends on the user's preferences, the control system and pick instructions have evolved.

For example, ICAM now offers a head-up digital dashboard that the picker sees when he has to pick an item (ICAM, 2019). On this dashboard, next to the name and quantity of the item that has to be picked, an image of this item is displayed. This way, the picking errors are reduced further, because it is clear which item has to be picked even if the picker is not familiar with its description/name.

Most suppliers still use a Pick-to-Light system, which is also currently in use at VMI. Hänel for example, still offers their Pick-o-Light system with the option to show a reticle, so even small articles can be identified easily (Hänel, 2015a). Even though the system has remained the same, the technology has been optimized further over the past years, allowing it to become even more precise.

The control system has evolved to a user friendly touch-screen, which eliminates the keys getting stuck when the picker confirms the item has been picked for example, and increases the overall ease of use.

Hänel now also offers PictureControl, where a camera takes a picture of a tray each time it moves. This image is then shown on the control monitor or in their software program's graphical stock overview, to visually show the current stock. A set number of images is archived, so it can later be used to monitor stock changes (Hänel, 2015a).

As a result, the control of the Lean-Lifts has become a more efficient and pleasant process.

Furthermore, the software issues will be resolved and adjustments can be made to further optimize the use of the Lean-Lifts. One way to do so is to implement a new strategy to assign items to a location in the Lean-Lifts. Currently, the items are assigned to their location at random. However, by using Order Oriented Slotting (OOS) for example, by which items that appear together in an order, are located close to each other, the tray movements can be reduced severely (Mantel et al., 2007). This way time can be saved, in case of a single tray VLM, but more importantly the number of tray movements is decreased, which results in the VLMs needing less maintenance and having a longer service life.

These software and ERP developments offer a solution to the current Lean-Lifts' software issues. They do not only take away the issues regarding the software updates, but also provide improvements on the software and ERP system.

Table 5-2: Overview software features

Suppliers	Head-up digital dashboard	Pick-to-Light	Touch screen	Picture Control
Kardex	-	X	X	-
Hänel	-	X	X	X
Ferretto	-	X	X	-
ICAM	X	X	X	-

5.2.3 Environment

Another new aspect of the VLMs is that the environment is taken into account, now more than ever before. Therefore suppliers have started to adjust to this need, resulting in several solutions making new Lean-Lifts more sustainable. Hänel for example offers the Hänel Ecodrive, a system that uses a frequency converter to convert the energy from a lowering extractor into electrical energy that is returned to the electricity network (Hänel, 2015a). This sustainability aspect is discussed in more depth in Section 5.7.

Table 5-3: Overview sustainable features

Suppliers	Sustainable features
Kardex	-
Hänel	X
Ferretto	-
ICAM	-

5.3 Technical specifications Lean-Lifts

To gain insight into the capacity of the new Lean-Lifts, they have to be compared to the current Lean-Lifts. As a basis for the new Lean-Lifts the current Lean-Lifts' dimensions are used. Therefore, the technical specifications of the current Lean-Lifts are described first in Table 5-4. These specifications are then compared to relevant Vertical Lift Modules of the four selected suppliers: Kardex, Hänel, Ferretto and ICAM S.r.l..

Table 5-4: Current Lean-Lift specifications

Current Lean-Lift specifications (per 1)	Value
Dimensions h*l*d (mm)	7,202*2,385*2,810
Number of trays	80
Tray dimensions l*d (mm)	2,060 (2,300)*825
Average tray storage height (mm)	126
Tray payload (kg)	250
Number of depots	156
Minimum tray spacing (mm)	75
Vertical speed (m/s)	1.0 (empty)
Tray storage or retrieval (m/s)	0.5

5.3.1 Kardex

The Kardex Remstar Shuttle XP is available in the same dimensions as the current Lean-Lift. The trays are also available in the same dimensions. The payload for the trays however is significantly higher compared to the current Lean-Lifts, which would allow for heavier items to be placed on the trays as well. Moreover, the speed at which the tray is able to move has increased significantly, which would mean that overall the picking and storage process would become shorter.

Table 5-5: Kardex Remstar Shuttle XP 250/500 specifications (Kardex, 2014)

Kardex Vertical Lift Specifications	Value
Dimensions	Same dimensions available
Tray dimensions	Same dimensions available
Tray payload (kg)	560
Storage space pitch (mm)	25
Minimum tray spacing (mm)	75
Vertical speed (m/s)	2.0
Tray storage or retrieval (m/s)	0.7

5.3.2 Hänel

The 4 current Lean-Lifts at VMI are Hänel Lean-Lifts. As such, the technical specifications of the Lean-Lift nowadays should provide some insight into the developments that have taken place at Hänel, and in general, next to the new developments mentioned in Section 5.2. Two types of Vertical Lift Modules are relevant to review: the original Lean-Lift and Hänel's new storage solution, the Multi-Space. Their technical specifications are shown in Table 5-6 and Table 5-7 respectively.

Hänel's Lean-Lift has not undergone any major changes over the past 15 years. The same dimensions, for both the Lean-Lift and its trays are still available. The payload has remained the same or has slightly increased depending on the specific version. The minimum tray spacing has also remained the same, using grid profile walls designed by Hänel. The vertical speed of trays has improved significantly.

Table 5-6: Hänel Lean-Lift 2060-825 specifications (Hänel, 2015a)

Hänel Lean-Lift specifications	Value
Dimensions l*d (mm)	Same dimensions available
Tray dimensions	Same dimensions available
Tray payload (kg)	250/500/650/900 (dependant on version)
Minimum tray spacing (mm)	75
Vertical Speed (m/s)	2.3 (empty)/1.0 (loaded) at 500kg
Tray storage or retrieval (m/s)	0.5

As mentioned in Section 5.2, Hänel has also developed a Vertical Lift that moves along 3 axes, the Multi-Space. The specifications of the Multi-Space version, that is of similar dimensions to the current Lean-Lifts, are shown in the table below. Up to four units can be added to this specific edition. The Multi-Space is easily customizable, also at a later date. It is able to move trays vertically at a higher speed of 1.7 m/s when empty, and horizontally at 1.0 m/s. The tray storage and retrieval has remained at the same speed.

Table 5-7: Hanël Multi-Space 2060 specifications (Hänel, 2018)

Hänel Multi-Space specifications total	Value
Number of units	2-4
Dimensions l*d (mm)	4,875-9,410*2,330/2,900/3,565/4,240
Container dimensions	Same dimensions available
Tray payload (kg)	250-500
Minimum tray spacing (mm)	75
Vertical speed (m/s)	1.7 (empty)/1.3 (max. payload)
Horizontal speed (m/s)	1.0
Tray storage or retrieval (m/s)	0.5

5.3.3 Ferretto

The Ferretto Vertimag is not available in exactly the same dimensions as the current Lean-Lifts, however Ferretto offers a close match. By decreasing the height of the lift slightly compared to the current Lean-Lifts, the volume of the Vertimag could remain equal. This adjustment in height is offered in the Vertimag in the range noted in Table 5-8, with adjustments in steps of 200 millimetres. The tray payload depends on the configurations of the Vertimag, but is higher than the current payload.

Table 5-8: Ferretto Vertical Lift Module Vertimag specifications (Ferretto, 2020)

Ferretto Vertical Lift Module specifications	Value
Dimensions l*d (mm)	2,455*3,406
Dimensions h (mm)	3,200-12,000
Tray dimensions l*d (mm)	3,050*650
Tray payload (kg)	300-550
Maximum storage height (mm)	120

5.3.4 ICAM

ICAM's Vertical Lift, named Silo^{Plus} is available in the same dimensions as the current Lean-Lifts. The trays are also available in the same dimensions, should VMI choose to use dividers and separators. If VMI wants to use Euro Standard Boxes, they have to decide on 4 different tray dimensions. The one closest to the current tray is mentioned in Table 5-9. Notable is the difference in tray payload of the $\text{Silo}^{\text{Plus}}$ compared to the current Lean-Lifts. This would mean that possibly some items would have to be spread more over the VLMs to ensure that the tray would not be overloaded. Another remarkable fact is that ICAM's Vertical Lift not only has a vertical and tray storage and retrieval speed, but also an horizontal speed. As mentioned in Section 5.2, this is a result of their multimodular extraction and storage feature, allowing a tray to be extracted from a module next to the picking window's module. Overall, the Vertical speed (and Horizontal speed) are higher compared to the current Lean-Lifts, but the tray storage and retrieval remain at the same speed.

Table 5-9: ICAM S.r.l. $\text{Silo}^{\text{Plus}}$ specifications (ICAM, 2019)

ICAM Vertical Lift specifications	Value
Dimensions	Same dimensions available
Tray dimensions l*d (mm)	1,253*802 (Euro Standard boxes)/Same dimensions available (dividers)
Tray payload (kg)	100
Maximum storage height (mm)	450/675 (Euro standard boxes/dividers)
Minimum tray spacing (mm)	75
Vertical speed (m/s)	1.4
Horizontal speed (m/s)	1.7
Tray storage or retrieval (m/s)	0.5

Overall, all VLM suppliers offer VLMs of roughly the same dimensions as the current Lean-Lifts. If the dimensions are not exactly the same, the Lifts can be customized such that the volume will remain roughly the same to the current Lean-Lifts. As a whole, the technical specifications will not be the main determinant in the choice for any of the suppliers, since all suppliers offer VLMs with similar specifications. However, the payload could be a factor that could weigh more heavily in the decision, should VMI decide to move heavier items to the Lifts. This aspect is discussed further in Section 5.4. Moreover, the speed at which the tray moves should be taken into consideration, since this could possibly offer significant time savings.

5.4 Number of new Lean-Lifts to be purchased

According to VMI's standards, items are obsolete after they have not moved for four years. Luigjes found that 11.6% of the total number of items in the Lean-Lift are obsolete (2020). These obsolete items now occupy 672 items in the Lean-Lift. We assume that one item occupies one location in the Lean-Lift. In case of the purchase of new Lean-Lifts and thus the move of all items, the obsolete items should be removed. The current utilization is 61% (October 2019), but removing the obsolete items would result in 5,144 locations of 9,480 locations being occupied.

We assume that if the new Lean-Lifts would be of the same dimensions they would offer roughly the same number of storage locations. This means that one module/Lean-Lift, consists of roughly 2,370 locations. Below the calculations of the utilizations for 3 and 4 Lean-Lifts are displayed.

$$Utilization\ 3\ Lean - Lifts = \frac{5{,}144}{7{,}110} * 100\% = 72.3\%$$

$$Utilization\ 4\ Lean - Lifts = \frac{5{,}144}{9{,}480} * 100\% = 54.3\%$$

Based on VMI Holland's current storage demand, VMI could do with 3 Lean-Lifts, as the utilization rate is 72.3%. However, during a recent graduation assignment, VMI received an advice to move 75% of items that are currently placed on shelving since this would save €15,230 (Luigjes, 2020). This would amount to approximately 888 items. This change would result in the following utilization rates for 3 and 4 Lean-Lifts:

$$Utilization\ 3\ Lean - Lifts = \frac{6{,}032}{7{,}110} * 100\% = 84.8\%$$

$$Utilization\ 4\ Lean - Lifts = \frac{6{,}032}{9{,}480} * 100\% = 63.6\%$$

Since some of the technical specifications in Section 5.3 show that the tray payload is significantly higher, VMI could look into moving the full 100% of the items currently placed on shelving to the Lean-Lifts. Luigjes advised against moving all items, since items over 1 kilo would be too heavy to be placed in the Lean-Lift, however this higher payload will likely allow for this extra weight. If all items would be moved, it would mean that 1,183 articles would be moved to the Lean-Lift. This adjustment would result in the following utilization rates for 3 and 4 Lean-Lifts:

$$Utilization\ 3\ Lean - Lifts = \frac{6{,}327}{7{,}110} * 100\% = 89.0\%$$

$$Utilization\ 4\ Lean - Lifts = \frac{6{,}327}{9{,}480} * 100\% = 66.7\%$$

Frazelle mentions that as the utilization of storage locations exceeds 85 percent in non-real-time warehouses and 90 percent in real-time warehouses, the productivity and safety of the operations decline dramatically (2016). Tompkins mentions that the utilization should always be between 80% and 90%, but ideally should be 90% (1998).

However, one should take into account VMI's expected growth when deciding on the recommended number of Lean-Lifts. Therefore it is better to have some extra capacity available to allow for future growth, even if that means the current utilization would fall below 80% for example. As such, it would be wise to choose 4 modules/Lean-Lifts even though the current occupancy rate is lower than the preferred value in literature.

5.5 Payback Time

The Payback Time of the purchase of new Lean-Lifts helps determine whether or not this is an advised approach to improve the use of Lean-Lifts at VMI Holland.

To determine this payback time, the offers of Hänel are used. The decision to only focus on Hänel for this aspect was made, since Hänel not only has a long standing relation with VMI, but also was the most proactive in providing help and all relevant information. During the contact with Hänel, they have expressed that they offer a wide range of possibilities and are always able to customize the Lean-Lifts and their features to fit VMI's needs.

The initial investment consists of all costs that have to be made should VMI decide to purchase new Lean-Lifts. All of these aspects are elaborated in Section 5.5.1. Section 5.5.2 discusses the expected savings. Both Sections are combined in Section 5.5.3, in which the payback period of the investment is calculated.

5.5.1 Initial investment

The initial investment consists of various costs, displayed in Table 5-10, that are elaborated below.

Table 5-10: Costs purchase of new Lean-Lifts

Required data for calculations		Expected costs	
Labour costs per hour	€25.00	Purchase	€165,000.00
Number of items in Lean-Lifts	5816	Rental of platform	€500.00
Number of items without obsolete	5144	Controller machines	€1,062.50
Picking time (s)	40	Transfer of items	€4,366.17
Inbound time (s)	72	Total	**€170,928.67**
Travel time Lean-Lifts-warehouse (s)	5		

The main part of the initial investments is the cost of the purchase of the new Lean-Lifts. As mentioned previously, Hänel's offers are used to provide insight into the initial investment.

When purchasing new Lean-Lifts at Hänel, VMI could decide on one of two different approaches: they could purchase completely new Lean-Lifts or purchase new Lean-Lifts but reuse the trays from the current Lean-Lifts in case their dimensions (depth and width) remain equal. For the purpose of this assignment, only Lean-Lifts of equal dimensions are considered. Should VMI decide to heighten the new Lean-Lifts, a combination of new trays and the current trays could be made. Reusing the current trays would save costs, and allow VMI to move the items quickly and effectively, since they can remain in the tray during the move. However, they would not allow for any major changes to their layout.

For the purpose of this assignment, the following offer will be considered: the purchase of 4 completely new Lean-Lifts, not considering the reuse of trays or possible sale of the current Lean-Lifts. Some of the specifics of this particular offer are that the 4 Lean-Lifts use a Pick-to-Light system, similar to the one that's currently in use. Moreover, the Lean-Lifts use Hänel's new and improved software, VMI themselves can decide on the specific type of software they would like to use. The Lean-Lifts also use Hänel's high-speed and EcoMode technology. The total costs of the purchase of 4 Lean-Lifts according to this offer amount to €165,000.

Similar to the situation discussed in Section 4.2.1, a platform has to be rented for the period of time during which the new Lean-Lifts would be build. The build of these Lean-Lifts will take roughly one working week, as such the rental of a platform will amount to around €500.

Moreover, a VMI employee has to be available to control the forklift and the platform. Based on an expected duration of 1 working week, these costs are set at €1,062.50 with labour costs of €25 per hour.

In addition, all items have to be taken out of the current Lean-Lifts and placed into the new Lean-Lifts. The items can be taken out of the Lean-Lift one tray at a time. The items from the tray can then directly be moved to the new Lean-Lifts. Therefore, no intermediate storage is required and the normal picking process can continue at all times, picking from both the old and new Lean-Lifts as long as the transfer takes. This is a clear advantage of the purchase of new Lean-Lifts compared to the relocation of the current Lean-Lifts, as for the relocation picking from the Lean-Lifts would have to be stopped for roughly 4 weeks. Currently, 5816 locations in the Lean-Lift are occupied. For the purpose of this calculation, we assume that these locations are occupied by separate items, i.e. 1 location is occupied by 1 item. As stated in Table 2-1, the picking time per outbound order line is 40 seconds (Luigjes, 2020). The total picking time to remove all items from the Lean-Lift amounts to roughly 8 working days of 8.5 hours for 1 employee, if items would be taken from the Lean-Lifts continuously.

As mentioned previously, of the total number of 5816 items from the Lean-Lifts, 11.6% hasn't moved for the past 4 years and is thus considered to be obsolete (Luigjes, 2020). Therefore these items do not have to be placed in the new Lean-Lifts. As such, 5144 items have to be moved to the warehouse and placed inside the Lean-Lifts. Luigjes found a transport time of 5 seconds per outbound order line and an inbound time equal to 70s per inbound order line, but we assume that the inbound time increases to 72 seconds per inbound order line, because the Lean-Lift workers have to get used to the new system even though the Lean-Lifts themselves will perform faster. The total transportation and inbound time amounts to roughly 13 days, if the work would be done continuously by 1 employee.

The transfer of items from the old to the new Lean-Lifts can be done in sections of several hours a day, to allow the Lean-Lift workers to conduct their picking activities during the other working hours. If the transfer would be done in shifts of 4 hours per day, the transfer would be complete in roughly 44 days if the work would be conducted by 1 employee. However, because of the high work load, we assume that the transfer will be done by 3 employees, resulting in the transfer taking roughly 15 working days. This might seem like an extensive period of time, but one has to take into account that this would allow for the normal picking process to continue. The total costs of the transfer would amount to €4,366.17, assuming labour costs to be €25,- per hour.

As mentioned previously, VMI could also decide to reuse the trays and sell the remainder of the current Lean-Lifts. This would lower the investment to €128,000. Reusing the trays would ensure easier transport of the items, however, the picking process would not be able to continue during such a move. Moreover, the current Lean-Lifts could not be used for different purposes such as storage of equipment or work clothes. Nevertheless, it would be a sustainable and cost-saving solution.

In case VMI Holland chooses to purchase completely new Lean-Lifts, and not reuse the trays of the current Lean-Lifts or sell these Lifts, the total expected costs amount to €170,928.67. These costs consist of the purchase cost of the 4 Lean-Lifts, rental cost of a platform, labour costs of a VMI employee, and transfer costs.

5.5.2 Expected savings

Next to the needed investment to purchase new Lean-Lifts, there are savings that can be made from these Lifts. The expected saving consist of several aspects, displayed in Table 5-11, that are elaborated below.

Table 5-11: Expected savings purchase new Lean-Lifts

Required data for calculations		Expected savings	
Expected number inbound order lines	24,244	Total transport time	€6932.36
Expected number outbound order lines	175,408	Elimination of storage	€40,646.00
Labour costs per hour	€25	Picking time	€5,296.14
Current transport time warehouse-Lean-Lifts (s)	8	Total	**€52,874.50**
New transport time warehouse-Lean-Lifts (s)	3		
Current transport time Lean-Lifts-warehouse (s)	5		
New transport time Lean-Lifts-warehouse (s)	0		
Current inbound time shelving (s)	100		

Current outbound time shelving (s)	55		
Current time spend waiting whilst picking (s)	10		
New time spend waiting whilst picking (s)	4.3		

First of all, the savings that result from the new location of the Lean-Lift. These savings are comparable to the savings discussed in Section 4.1. Therefore the similar aspects of the savings resulting from the Lean-Lifts' new location will only be briefly discussed, as a more elaborate discussion can be found in Section 4.1.

The travel time from the Warehouse to the Lean-Lifts decreases from 8 seconds per inbound order line to 3 seconds per inbound order line. The expected yearly number of inbound order lines for the near future is set at 24,244. Since the move of the Lean-Lifts reduces the travel time from the warehouse to the Lean-Lifts with 5 seconds per inbound order line, the overall time savings per year amount to roughly for 4 working days of 8.5 hours for 1 employee.

In addition, the travel time from the Lean-Lifts to the warehouse is eliminated. Currently this travel time amount to 5 seconds per outbound order line, but because of the fact that items picked from the Lean-Lifts can be placed on transport to production directly, this time if completely eliminated. With an expected number of future outbound order lines of 175,408 per year, the total time saved per year amounts to roughly 29 working days of 8.5 hours for 1 employee.

The savings resulting from both decreases in the travel time are € 6,932.36 per year.

Since the items no longer have to be stored intermediately in case new Lean-Lifts are purchased this also decreases labour costs severely. As stated in Section 4.1, the inbound process of bins at the shelving is set at 100 seconds per bin, and the outbound process amounts to 55 seconds per bin. One bin contains roughly 5 outbound Lean-Lift order lines. The expected number of Lean-Lift outbound order lines per year for the near future is 175,408. As a result of this process step being eliminated €40,646 will be saved on a yearly basis.

In addition, the new Lean-Lifts offer several benefits compared to the current Lean-Lifts, that offer further savings, for example with respect to picking time. The new Lean-Lifts would have increased in vertical speed from 1.0 m/s to 2.3 m/s for empty trays. This severe improvement allows the Lean-Lifts to perform at a faster picking time, and thus picking rate. This picking time has an effect on the savings that result from the purchase of new Lean-Lifts. Currently the picking time amounts to 40 seconds per outbound order line. In consultation with VMI, we set the percentage of this time during which the picker is waiting for a tray to be extracted at 25%, considering that the measurement of picking time was conducted when two Lean-Lift workers were picking from the Lifts (and thus the fraction of the total picking time during which they are waiting is minimized). Therefore, we assume that on average 10 seconds per order line are spend waiting for the tray to be extracted. Because the vertical speed at which trays are moved has increased with a factor 2.3, the time that pickers will spend waiting decreases to 4.3 seconds. The total time saved per outbound order line thus amounts to 5.7 seconds. The yearly expected number of outbound order lines for the near future amounts to 175,408. Based on labour costs of €25 per hour, the savings amount to €5,296.14 per year.

Therefore, the total amount of yearly savings is €52,874.50, consisting of savings as a result of the reduction in transport time, savings coming from the elimination of intermediate storage, space savings, and savings from the reduced picking time.

Furthermore, additional savings can be made by implementing Luigjes' advice that 75% of the anonymous items that are currently stored in the shelving area should be moved to the Lean-Lifts, since this would save €15,230 on a yearly basis.

In case of new Lean-Lifts however, it could be that, like mentioned before in Section 5.3, the payload of the trays is significantly higher, such that the items that normally would have been too heavy, can then be placed inside the Lean-Lifts. In case all of the items from the anonymous shelving area would be moved to the Lean-Lifts, the total shelving area of 51.2m^2 would be cleared. The space savings would amount to €1536, based on a cost of €30 per m^2. As such, the total yearly savings would amount to €15,536. In case of the Hänel Lean-Lift that are currently being considered however, this does not hold, since these Lifts offer the same payload as currently available.

Further savings can be made through the various options that Hänel offers. A few examples are now briefly discussed.

VMI could choose to install Hänel's EcoDrive system, explained further in Sections 5.2.3 and 5.7. This system can regain up to 40% of energy, and implement this back into the energy network. Hence using this system would result in considerable yearly energy savings.

Furthermore, VMI could use Hänel's Dual-Drive system, explained in Section 5.2.1, allowing for a faster picking rate. The waiting times of the system would be reduced to 0, allowing further savings, however the system would work the most efficiently if up to 4 Lean-Lift workers would be picking from the Lifts. Naturally, VMI could decide to keep working with 1 to 2 workers on a daily basis, and increase this number when the extra capacity is needed.

Lastly, VMI could improve the current order bin system, by opting for one of the possibilities currently offered by Hänel. The likely most suitable option is the use of 2 shelving racks, discussed in Section 5.2.1. This would decrease the picking time, since Lean-Lift workers no longer have to move as much, nor cross each other, and therefore would result in further savings.

5.5.3 Payback time

The total investment amounts to €170,928.67, as described in Section 5.5.1. The yearly savings amount to €52,874.50. As a result, we find that the Lean-Lifts pay-off after 3 years and 3 months.

The average lifetime of Lean-Lifts is 15-20 years, so these large savings can continue to be made for many years after the Lean-Lifts' payback period.

Important to note is the fact that these savings can be expanded further, through implementing Luigjes' advice or the use of several systems offered by Hänel, which would result in a shorter payback time. To get insight into the exact number of savings, further measurements have to be conducted that were not able to be executed in the current climate, also considering the period during which this thesis has to be conducted.

Another way to decrease the payback period would be to consider reusing the trays and selling the remainder of the Lean-Lifts, an option discussed previously in Section 5.5.1. If we do not integrate any systems that could further increase savings, this would already shorten the payback period to a little over 2 years, as according to Hänel's offer the Lean-Lifts would cost €128,000.

5.6 LOCATION

The new Lean-Lifts should be located in the warehouse, as mentioned previously, and should be placed in a convenient and suitable location. As discussed before, in case the Lean-Lifts would be located in the warehouse, it would allow for items from the Lean-Lift to be picked as the last step in the order picking process, thus not requiring intermediate storage. The orders picked from the Lift could be placed straight onto the transport after all other items have already been gathered, and shipped off to production. As such they should be located as close to the outbound area and the 'transportation trains' as possible. Their recommended location based on discussions with VMI is displayed in the floor map with the blue ellipse.

Figure 5-1: Floor map incl. location new Lean-Lifts

5.7 SUSTAINABILITY

Climate change has become a more serious issue over the past years. Companies are considered to have a certain social responsibility to take these issues into account and move into a more sustainable way of doing business. Customers are also starting to consider companies' sustainability as this has become a growing issue of concern. As a company in the current business environment, VMI Holland also has a social responsibility to uphold.

VMI is already looking into ways to make their Lean-Lifts more sustainable. Several students are currently working on their graduation project, researching ways to reduce the use of plastic at the Lean-Lifts. Now items are placed in single use plastic bags when they are picked from the Lean-Lift, but the students are looking into ways different systems can be used so this would no longer be needed. It could be beneficial to also discuss these plans with the Lean-Lift supplier and see whether or not they are able to help in any way with this new method, should VMI decide to purchase new Lean-Lifts.

Because of the transition into a more sustainable and environmentally friendly world, suppliers have also been looking at ways to make the VLMs more sustainable. These developments could be beneficial to VMI should they decide to purchase new Lean-Lifts.

Hänel for example is using an EcoDrive system, that generates energy from the downwards extractor movements using a frequency converter, and feeds this energy back into the energy system (Hänel, 2015b). This energy can then be used for another Lean-Lift or for another device at VMI. Up to 40% of energy can be saved, which not only saves money but also reduces the company's CO_2 emissions. In addition, Hänel offers EcoMode, that turns the Lean-Lift into several programmable stand-by-modes before turning it off, after the Lean-Lift hasn't moved for an extended period of time (Hänel, 2015b). During almost all stand-by modes the Lean-Lift is almost immediately ready for use, should the controls be operated again. This EcoMode increases energy efficiency and thus offers a more sustainable use of the Lean-Lifts.

5.8 Conclusion

For the possible purchase of new Lean-Lifts, 4 suppliers were analysed. The purpose of this analysis was to answer sub-question 5 a. "What do new Lean-Lifts offer compared to the current Lean-Lifts?". The features of new Lean-Lifts and their technical specifications show an answer to this question.

Some of the new features are now offered by these suppliers that have been developed over the past 15 years. For example, Kardex, Hänel and ICAM offer VLMs with multimodular tray storage and retrieval possibilities. In addition, dual tray VLMs are now available, that decrease waiting times for the pickers and thus offer the possibility of one picker serving one picking window. Combining these two features would allow one picker to serve two modules at one picking window without excess waiting times. Kardex also offers VLMs that can easily be adjusted to future needs. Moreover, a lot of progress has been made regarding the Lean-Lifts' software and the ERP system. This has increased their ease of use and efficiency, and decreased picking error. Furthermore, the speed at which the tray moves has increased overall. Some of the analysed VLMs also have a higher tray payload, offering the possibility to move some of the heavier items from the shelving area into Lean-Lifts.

The technical specifications, elaborated in Section 5.3, help to answer the next sub-question: 5 b. "How many new Lean-Lifts are needed without changing the current storage demands?". Since all suppliers offer Lean-Lifts of similar dimensions, we assume that the number of storage locations in the VLMs are all roughly equal. To determine the advised number of Lean-Lifts to be purchased, it was important to look at the utilization levels of the Lean-Lifts. To determine the utilization levels, three situations were taken into account: (1) removing the obsolete items from the Lean-Lift, (2) removing obsolete items and adding 75% of the items from shelving storage, and (3) removing obsolete items and adding roughly all items from the shelving storage. Based on the calculations in Section 5.4, I would advise VMI to invest in 4 Lean-Lifts rather than 3, based on the expectation of future growth.

Furthermore, this chapter answers sub-question 6: "What is the payback time of new Lean-Lifts at VMI?". As mentioned previously, the advised number of Lean-Lifts is 4, which was also the number that was discussed for the offer from Hänel. Based on VMI's preferences, Hänel provided an offer on 4 completely new Lean-Lifts of similar dimensions as the current Lean-Lifts. The new Lean-Lifts would require an investment of €170.928.67, including the purchase price of the 4 Lean-Lifts, transfer costs of all items and rental of a platform. The exact calculation of these costs can be found in Section 5.5.1. To calculate the payback time, the savings are explored. The total yearly number of savings amount to €52,874.50, elaborated in Section 5.5.2. These consist of the savings that result from the reduction in transport time and picking time, and the elimination of intermediate storage. From these costs and savings, we find in Section 5.5.3 that the payback time is a little over 3 years. Further ways to decrease the payback time are mentioned in this section, such as opting for the Hänel EcoDrive, which would save VMI energy costs.

Table 5-12: Overview costs and savings purchase of new Lean-Lifts

Expected costs		Expected savings	
Purchase	€165,000.00	Total transport time	€6932.36
Rental of platform	€500.00	Elimination of storage	€40,646.00
Controller machines	€1,062.50	Picking time	€5,296.14
Transfer of items	€4,366.17		

This chapter also discusses the location of the new Lean-Lifts. The Lifts would have to be located in the outbound area, so that the items that are picked from the Lean-Lift can be placed straight onto the transport to production.

Furthermore, the chapter mentions ways in which the new Lean-Lifts have improved on and could contribute to VMI's sustainability. For example, energy can now be won from the Lean-Lifts that can then be led back into the system. This method saves energy use and CO_2 emissions and thus increases sustainability.

6 CONCLUSION

The purpose of this research is to answer the main research question: “What is a smart way to improve the use of Lean-Lifts at VMI Holland?”. Throughout the thesis, 7 sub-questions are used to answer this question. The answers to these questions can be found in the conclusions of the chapters, specifically in Sections 2.4, 3.4, 4.6, and 5.8. This chapter, the conclusion, shows the answer to the main research question.

The various different solution options showed that the relocation of Lean-Lifts and purchase of new Lean-Lifts are the most relevant to consider for VMI. The relocation of Lean-Lifts seems like an attractive solution, however it only resolves the location issue, mentioned in the Problem Cluster, and the value of the current Lean-Lifts is nearly €0. Moreover, the relocation results in a down-time of the Lean-Lift picking process of at least 3 weeks and 4 working days. Since production has to continue, and the items from the Lean-Lifts are needed to allow for that, the relocation of the Lean-Lifts is considered impossible. Next to the fact that the logistics of the relocation are a downfall, the value and age of the Lean-Lifts does not justify the investment that has to be made, despite the savings.

However, the purchase of new Lean-Lifts offers an adequate solution to all of the problems stated in the Problem Cluster. It addresses the location issue, since new Lean-Lifts would be located inside the warehouse. It also accounts for the software and technology issues, since new Lean-Lifts will come with the latest technology and software, as well as a software contract so any issues that might arise can easily be resolved and software updates can be installed regularly. As a result of technological developments over the past 15 years, new Lean-Lifts also offer multiple new features that benefit the Lean-Lift process. For example, Lean-Lifts with two trays are now offered, to ensure minimum waiting times when picking from a single Lift. This significantly increases the picking rate and capacity, certainly when combined with the generally increased vertical speed at which trays are able to be moved.

Naturally, new Lean-Lifts come at a price, which Hänel has expressed to be €165,000. VMI could also choose to reuse the trays from the current Lean-Lifts and sell the remainder of the Lifts. This would leave the costs of new Lean-Lifts at €128,000. The rental of a platform and labour costs of an employee to be available to control the machines are also added to the costs. In addition, there are transfer costs for the move of all items to the Lean-Lift, but in case of new Lean-Lifts the picking process will be able to continue, which is one of its clear benefits. However next to the costs, there are also significant yearly savings that result from the investment, coming in at a total of €52,874.50. The savings result from several aspects. Firstly the picking time is decreased, as the new Lean-Lifts operate at a greater speed. Furthermore, because the items no longer have to be moved to and from the warehouse, the time they spend in transport is decreased. Because intermediate storage is no longer needed, since items can be placed straight onto transport to production after they have been picked, a lot of process steps and thus labour costs are saved. The savings could be expanded even further by integrating more features that further decrease picking times or save energy costs, or by implementing Luigjes’ advice to move 75% of all items from the anonymous shelving to the Lean-Lifts. As such, the payback period of new Lean-Lifts amounts to a little over 3 years at most, in case completely new Lean-Lifts are bought and no further savings are made. As mentioned, VMI would be able to decrease this payback time even further if they wish to do so. The average lifetime of Lean-Lifts is 15 to 20 years, so VMI would be able to benefit from the investment for an extensive period of time.

Therefore, we can conclude that the purchase of new Lean-Lifts would be a smart way to improve the use of Lean-Lifts at VMI Holland.

7 RECOMMENDATION

The main aim of this research is to properly formulate a recommendation to VMI about how to improve the use of Lean-Lifts within their warehouse. It shows various ways in which improvement is possible, but focusses on the relocation of the current Lean-Lifts and the purchase of new Lean-Lifts.

Based on the finding reported in Chapter 5, the purchase of new Lean-Lifts will provide the biggest improvement to the use of Lean-Lifts at VMI Holland. New Lean-Lifts will solve the issues of the location of the current Lean-Lifts, as the new Lean-Lifts will be located in the warehouse. As a result, the transport time of products significantly decreases and items do not have to be stored intermediately, eliminating several process steps and thus costs. Moreover, it allows for regular software updates and fixes the limitations that the current software has. New Lean-Lifts will also be provided with the latest technology, to ensure an optimal performance compared to the current Lean-Lifts, such as a decrease in picking time. The new Lean-Lifts should be located in the outbound area of the warehouse so that items can be placed straight onto transport to production after they have been picked from the Lean-Lifts. VMI should purchase 4 Lifts, since this will allow for the expected future growth.

7.1 RECOMMENDATIONS FOR FURTHER RESEARCH

As this thesis was conducted during the period of COVID-19, it was not possible to perform any experiments. Therefore, some of the data used in the thesis is based on assumptions and/or expectations. Even though, naturally, these expectations and assumptions were thoroughly discussed and their validity has strong arguments, should VMI decide they want to further substantiate the arguments and calculations, more experiments would have to be conducted.

In addition, the specific costs of the Lean-Lifts that are stated in the offer made by Hänel should be discussed more thoroughly. More specifically, the different features that are available should be evaluated to find whether or not these would be beneficial addition.

Because of the limited time during which this research was performed, some aspects that are relevant for the purchase of new Lean-Lifts could not be looked at extensively, such as the various different new systems to put items into order bins after they have been picked from the Lean-Lifts. The solution that seemed the most suitable were two movable shelving units, that can be exchanged between two different zones (zone 1 including Lifts 1 and 2, zone 2 including Lifts 3 and 4). VMI should discuss these shelving units, and the other possibilities, with Hänel during the negotiations as they could significantly benefit the Lean-Lift picking process, and thus result in further savings.

Furthermore, it is important to take the possible costs for the connection between the Lean-Lifts' software and VMI's ERP system Infor into account. The two software programmes are compatible and Hänel offers to make this connection between the two different software programmes. However, it could be that the IT department has to make adjustments to specific files for example, to ensure everything functions properly.

Another important note is the time frame for implementation. VMI Holland is currently planning on moving some of its activities across the road at their current location in Epe. There are plans to build a new warehouse there, as well as a new headquarters office and other buildings. Should VMI continue with this plan of creating a new warehouse across the road, it is important to consider whether or not it would be wise to purchase new Lean-Lifts now. Naturally, VMI could decide to purchase the Lean-Lifts now, and move them at a later date in cooperation with Hänel when this becomes necessary. However, as the current Lean-Lifts are still functioning, they should also consider keeping the Lean-

Lifts and warehouse process as it is currently, and investing in new Lean-Lifts once the move to the new warehouse will be made. In order to establish which approach is the most appropriate, the savings of the new Lean-Lifts should be compared to the cost of relocation to across the road in the near future.

As discussed previously, sustainability is becoming an increasingly important topic. VMI should consider implementing several of the different features Hänel offers, for example, as this will not only be beneficial to the company and the environment now, but also in the future. Furthermore, the findings of the recent graduation assignment researching ways to reduce the use of single use plastic at the Lean-Lifts should be taken into consideration when purchasing new Lean-Lifts. Consulting with Hänel in order to find whether they would be willing to help realise any changes, could be beneficial to both them and VMI.

As mentioned previously, another sustainable option that should be explored by VMI, is the reuse of trays and sale of the remainder of the Lean-Lifts. This way no new trays have to be produced and the remainder of the Lean-Lifts gets reused by another party. In case VMI decides against the reuse of the trays the current Lean-Lifts could still be used for different purposes, so they do not go to waste. The Lean-Lifts could be used for the storage of equipment or work clothes, or be sold as a whole.

Moreover, the new Lean-Lifts would allow for changes to the software, such as implementing an allocation strategy. VMI should look into which allocation would best suit their needs, possibly through another graduation assignment. Implementing the OOS strategy, mentioned in Section 5.2.2, for example, could increase the picking speed and life time of the Lean-Lifts. Further research is needed to calculate the exact benefits of implementing such an allocation strategy.

Lastly, more research into purchasing more items anonymously and in bulk could be of great worth to VMI. The Lean-Lifts would allow for these items, and purchasing more items in bulk could save costs. To gain insight into the exact approach, further research is needed.

With these recommendations, I would like to conclude my Bachelor Thesis.

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APPENDIX A

Figure A-0-1: Magnified image of floor map of warehouse

APPENDIX B

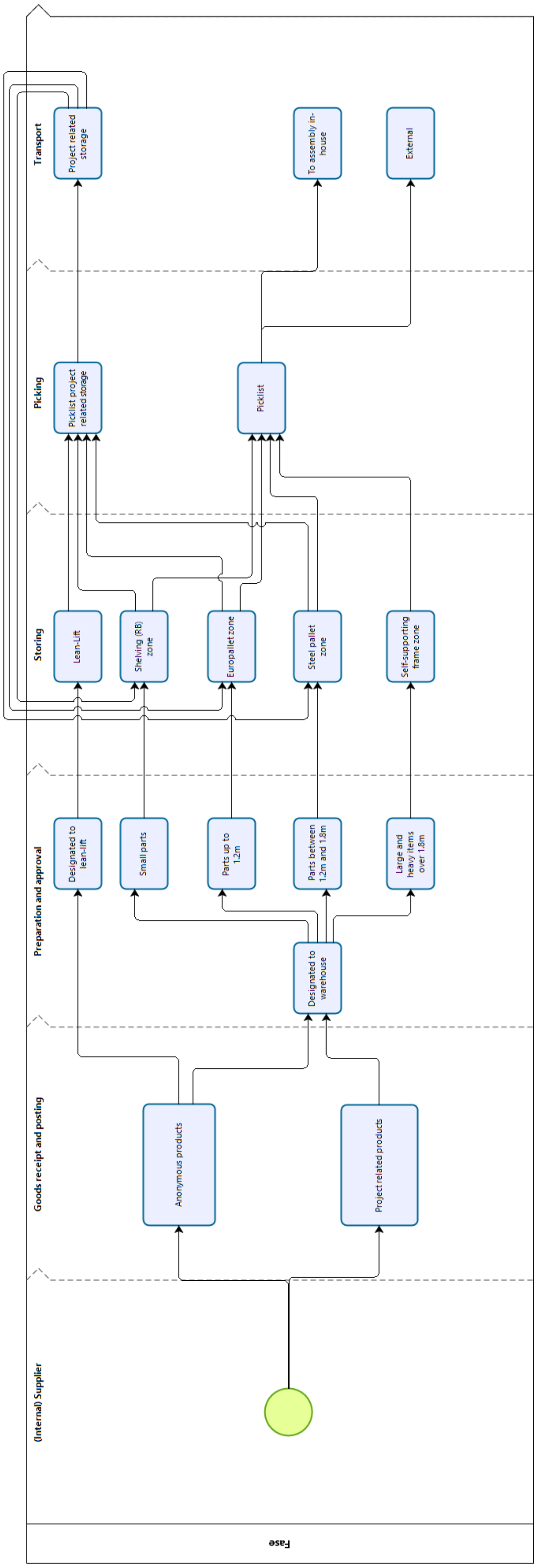

Figure B-0-1: Magnified image of material flow diagram of warehouse incl. Lean-Lift

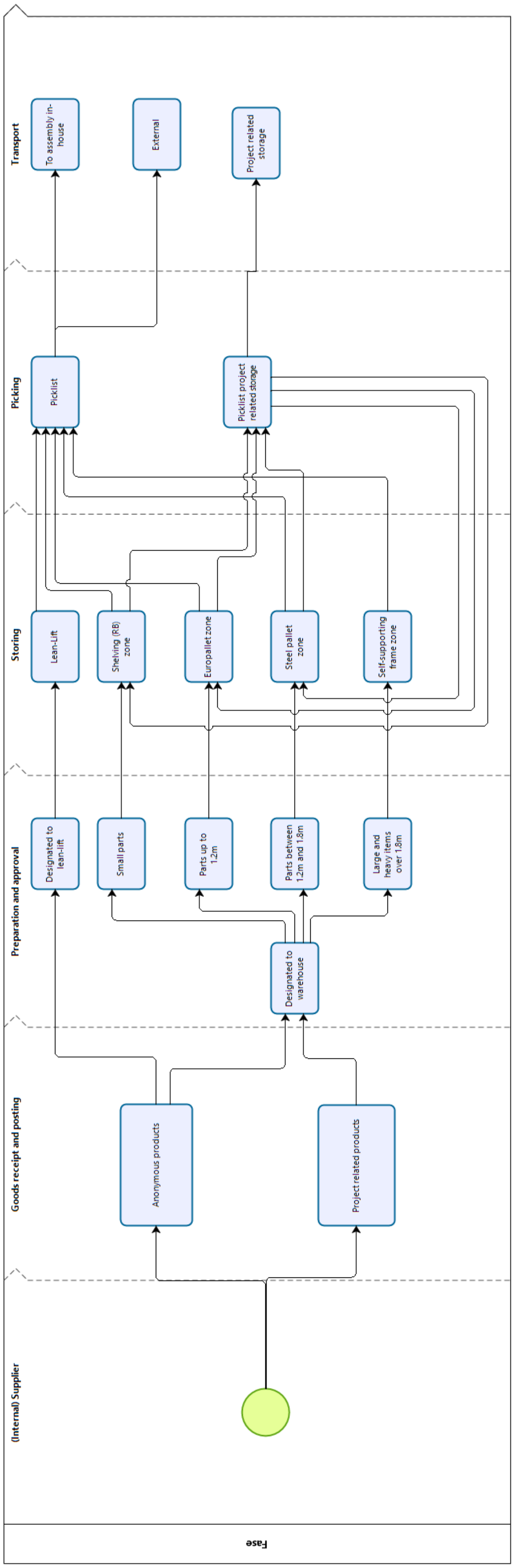

Figure B-0-2: Magnified image of material flow diagram of warehouse new situation

Appendix C

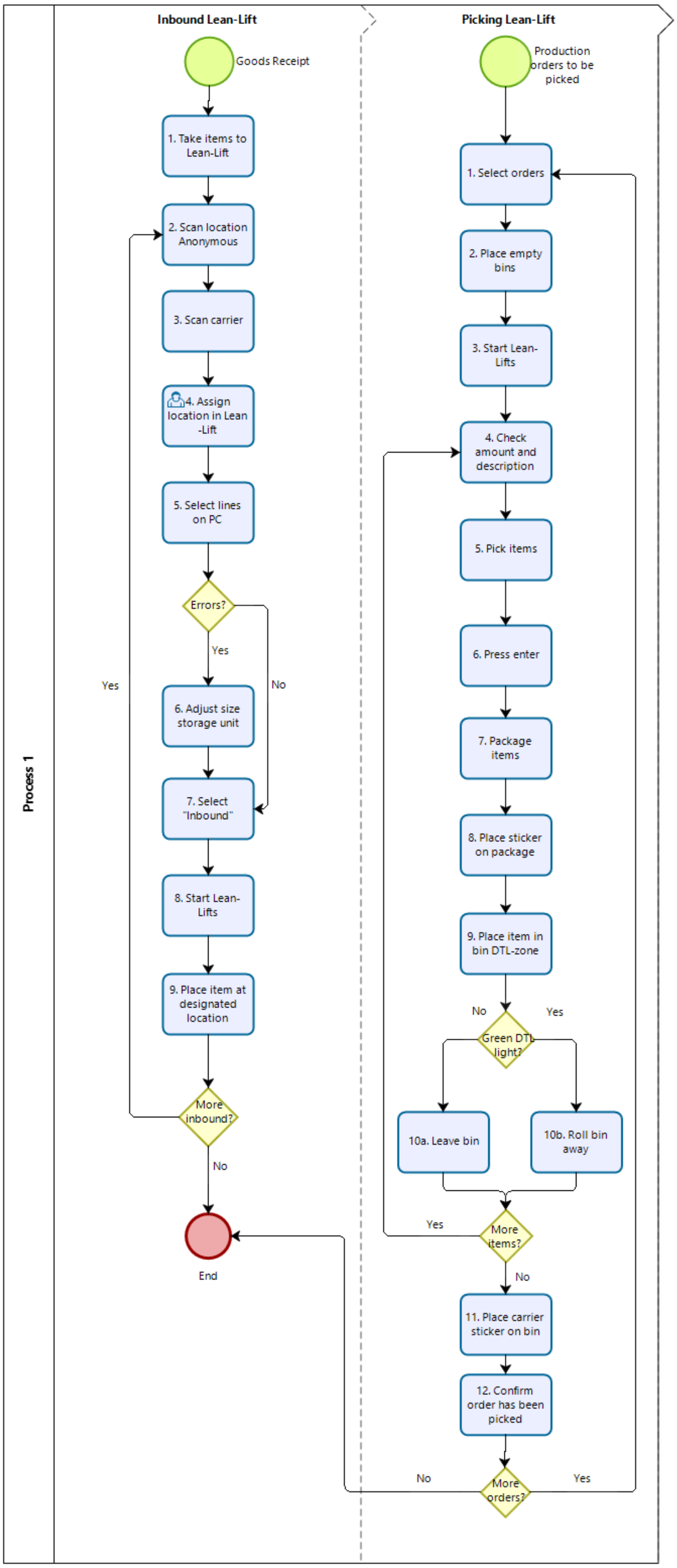

Figure C-0-1: Magnified image of process flow diagram of Lean-Lift