Master Thesis

Performance improvement in Europlant's component warehouse

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"The goodwill of the people is the only enduring thing in any business. It is the sole substance... the rest is shadow."

H.F. Johnson, Sr.

Disclaimer

This thesis was written in collaboration with SC Johnson Europlant B.V. in Mijdrecht, in order to obtain the Master of Science degree in International Business administration of the University of Twente. The author is responsible for the content of this thesis.

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Ferdi Baveld
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Summary

SC Johnson Europlant B.V. (hereinafter referred to as Europlant) is a specialist in the manufacturing of household cleaning supplies and other cleaning chemicals. The production plant is located in Mijdrecht and is one of the largest operating plants located in the SC Johnson's EMEA region. The plant had some rough changes to go through during the past decade. This led to significant improvements within the processing and production departments. Nevertheless, no attention was paid to mapping and improving the performance of the warehouse. Recently, questions were raised by Europlant's management with respect to the current performance of the inbound logistical processes and how the performance and efficiency of the warehouse can be improved.

The focus in this study lies exclusively on the liquids component warehouse whereby the inbound logistical processes are designated as: receiving, put-away, storing, picking and line supply. The processes receiving and put-away and also the processes picking and line supply are combined because one truck driver is responsible for both activities at the same time.

The objective of this study is to gain insight in possible problems in the inbound logistical processes, how to solve these problems and subsequently how it will improve the performance of Europlant in order to improve the performance of the inbound logistical processes. The main problem is defined as: "*What improvement is required at SC Johnson Europlant B.V. with respect to the inbound logistical processes, in terms of warehouse utilization and balanced component flow, in order to improve performance".*

From the research it appears that the major adjustments that will have biggest effect on improving the performance of the inbound logistical processes are: the abolishing of 031 storage locations, expansion of the storage availability and implementation of a storage strategy and tracking of utilization data. These results follow from the identification of bottlenecks within the current processes, expressed as Key Performance Indicators (KPIs), leading to a plan of approach per bottleneck based on scientific literature. Calculations are made in order to indicate the effect regarding the improvements as expressed in the KPIs.

One bottleneck is identified in the receiving and put-away process. Waste in the process that must be eliminated is identified as waiting and unnecessary motion causing long throughput time. If storage availability is guaranteed the throughput time improves with 2.45 minutes per truck. Implementation of EDI will result in an improvement of 6.54 minutes per truck. Throughput of component will improve significant.

Three bottlenecks are identified within the storage process and can be described as: wrong use of ERP system, insufficient knowledge about performance and an inefficient storage strategy. The alternatives for this process are that SAP settings are adjusted to the current situation and 031 storage types should be abolished. Furthermore, class based storage strategy with distribution 58-32-10 should be introduced that improves the bottleneck with 37.24 percent. The A components should be stored nearby the production lines in a pallet shuttle system and additional storage locations should be created of created of 727 pallet locations. The effect of the alternatives will lead to improvement in costs, quality, OEE, component flow and also the efficiency of the truck driver increase. The investment costs of the new situation are approximately € 184.720,00.

One bottlenecks is identified in the picking and line supply process. This process can be improved if the non-value adding activity identified as waiting is converted to efficient work time. The alternatives that are found to improve the throughput in the picking and line supply process are: kanban pull cards, stack lights or kanban pull automatic. All alternatives for this bottleneck will improve the throughput in the process but have differences in investment costs, hardness of implementation and technological development. The results of

the alternatives are difficult to estimate at this stage, further research is desirable to improve the picking and line supply process.

This study starts with information about SC Johnson, SC Johnson Europlant and thereafter the research structure is described. In Chapter 4, the current situation is described. Based on this research, bottlenecks have been identified and elaborated on in Chapter 5. In Chapter 6, these bottlenecks are expressed as KPIs. A plan of approach in order to improve the KPIs is described in Chapter 6. In Chapter 7, insights are given in the extent to which these alternatives will improve performance as expressed in the KPIs. In Chapter 8 a structured implementation plan is presented in order to execute the major and best suitable alternatives.

Glossary

5-S	Lean tool that create a work environment that is clean and well-organized
Aerosol	Department producing air-spray cleaning products and refreshers
APT	Autonomous production team: TPM tool to support a production line to produce at a constant high level
Beechnut	Toilet cleaning product
Bottleneck	The limiting element in a process, whose capacity slow or vague the pace in the chain of elements; it sets the pace in the entire process.
Clocon	Wet tissue
COI	Cube per Order Index
EDI	Electronic data interchange: electronic communication method that provides standards for exchanging data via any electronic means
Efficiency	Doing the thing right, usually measured as the output per unit input
EMEA	Europe, Middle-East & Asia: Operational region
ERP system	Enterprise resource planning: Business management software used to support processes
FMCG	Fast moving consumer goods: Competing sector
Gel	Toilet cleaning products
Kaizen	Lean tool that practice of continuous improvement
KPI	Key performance indicator: a quantitative measurement focusing on the organizational performances that are the most critical for the current and future success of the organization
Lean	A long-term approach that systematically seeks to achieve small, incremental changes in processes in order to improve efficiency and quality
Liquids	Department producing liquid cleaning products
OEE	Overall equipment effectiveness: performance management tool to evaluate how effectively a manufacturing operation is utilized
Reach truck	Vehicle that is used for picking and transporting pallets
RF scanner	Radio Frequency scanner: storage application technology
S&OP	Sales and operations planning: business management process that determines the optimum level of manufacturing output.
SAP	Systems, Applications & Products in Data Processing: ERP system
SHE	Safety, Health and Environment: department at SC Johnson
SKU	Stock keeping unit: Identifier for a finished product that can be purchased
Sun label	Sun labels and system Inc. is the company that provides the technique for the stickers that are attached to the pallets in the warehouse
Terminal	Data communication device fixed to a reach truck
TPM	Total production manufacturing: approach to equipment maintenance that strives to achieve perfect production
VSM	Value Stream Mapping: Method that can be used for exposing and elimination of non-value adding activities

Contents

1. Introduction

In the framework of completing the Master International Business Administration at the University of Twente, I performed research at S.C. Johnson Europlant B.V. at possible performance improvements within the liquids warehouse in terms of warehouse utilization and component flow.

In academic manufacturing literature is widely described that in a manufacturing environment the warehouse plays a major role within the supply chain. From beginning of the 21st century it has been argued that warehouses play an ever more important role in the success or failure of business and that it continues to do so for the foreseeable future (Richards, 2014; Frazelle, 2002; Yu & de Koster, 2009).

A warehouse can be defined as material handling station dedicated to receiving, storage, order-picking, accumulation, sorting and shipping of goods (Van den Berg & Zijm, 1999). This definition covers a wide variety of systems, and may be broadly categorized by three types of warehouses: distribution warehouses, production warehouses or contract warehouses (Van den Berg, 1999). The liquids warehouse of SC Johnson Europlant B.V. investigated in this study can described as a production warehouse.

The warehouse at SC Johnson Europlant is divided into two departments: aerosols and liquids. This research focusses purely on the liquids warehouse. Unavailability of data and a limit in research time resulted that a choice must be made between the two warehouses. In the first phase of this research the liquids warehouse exposed more issues regarding work processes, storage space availability and warehouse utilization compared to the aerosols warehouse.

The goal of this research is to give management of Europlant advice about possible improvements according to efficiency and performance in the liquids component warehouse.

This study has a qualitative approximation. Information is gathered by interviewing warehouse staff and employees from the production and planning departments. Further, external company are visited and professionals were interviewed from the field of lean management and operations logistics. Also a comprehensive research is done regarding the ERP-system that is used in the warehouse. In this research the following performance indicators in the liquids warehouse are examined: work processes and training, warehouse utilization, storage space utilization, component handling, picking popularity and the functionality of the ERP-system.

In this study the following research question is going to be answered:

What improvement is required at SC Johnson Europlant B.V. with respect to the inbound logistical processes, in terms of warehouse utilization and balanced component flow, in order to improve performance?

The research question is divided into seven sub-questions:

1. How are the processes established in the liquids warehouse?

1a. What KPIs are currently in place?

2. What bottlenecks are faced in the current processes?
3. What KPIs can be used to measure the effect of the bottlenecks on performance?
4. What does literature say about improving the performance measured by these KPIs and in what way can the performance of the bottlenecks be improved?
5. What alternatives are available for the bottlenecks?
6. How to implement the solutions at SC Johnsen Europlant B.V. in order to improve performance?

2. SC Johnson & Son

> The following chapter gives information about S.C. Johnson & Son and S.C. Johnson Europlant B.V. located in the Netherlands. Section 2.1 describes the general company information and history. Section 2.2 provides information about the organizational structure. In section 2.3 different products are described and section 2.4 give further information about the operational part of the plant based in the Netherlands.

2.1 "A family company"

SC Johnson & Son is a global manufacturer of household cleaning supplies and other consumer chemicals. Headquarters is based in Racine in the state Wisconsin, America. In 1886 the founder, Samuel Curtis Johnson, started the firm as a prepared paste wax company that was formerly known as S.C. Johnson Wax Inc. In 1906 Johnson changed the company's name to SC Johnson & Son Inc. Management has, since the start, passed down through five generations of the Johnson family. The family believes that it is important to brand SC Johnson & Son as a "Family Company" that provides a safe and healthy workplace and protects the environment in the communities they are operating in.

Picture 2.1- Production plants in EMEA region

SC Johnson is competing worldwide in the fast moving consumer goods (FMCG), producing products that are exclusively chosen to meet the high market demand. Characteristics of FMCG are that products sold quickly at relatively low cost and have a short shelf-live. In December 2015 the company had a global market share of 43 percent. With approximately 13,000 employees' globally working, the company was able to generate $10 billion in sales in the fiscal year 2014-2015.

Headquarter is still based in Racine, the company expanded and nowadays operates in 72 countries and sells products in over 110 countries. Operations are separated in four regions: North-America, South and Central America, Asia and EMEA (Europe, the Middle-East and Africa). The EMEA region contains of nine operating plants (given in picture 2.1) and 20 distribution centres spread over the region. Headquarter of the EMEA region is located in Zurich, Switzerland.

2.2 SC Johnson Europlant B.V.

SC Johnson Europlant B.V. (hereinafter referred to as SC Johnson or Europlant) is one of the largest operating plants located in the EMEA region. The Dutch plant is located in Mijdrecht, Zuid-Holland. Centrally located close to Amsterdam and the port of Rotterdam is within a one hour drive. The management team of Europlant directly report to the management in Racine, America. The team consists of a Plant Manager who gives lead to 10 managers, all responsible for their own department. An organigram of Europlant's management team is added in Appendix I.

Picture 2.2 - Pillar structure

In 2010 SC Johnson & Son introduced lean into their global manufacturing strategy. On the foundation of the 5-S, to create a work environment that is clean and well-organized, the Total Productive manufacturing (TPM) approach has been introduced in 2014. A TPM approach (as showed in picture 2.2) is a structured improvement process that strives to optimize production effectiveness. The approach identifies and eliminates equipment and production efficiency losses throughout the production system. Losses are attacked through active team-based participation of employees across all levels of the operational hierarchy. The structure is divided into seven pillars, each responsible for their own targets, with the goal to achieve zero losses. An example of TPM is Autonomous production team (APT). APT is a TPM tool to support a production line to produce at a constant high level. The members of the APT team are independent, experienced operators and support staff who are responsible for the maintenance and the output of a machine and/or production line.

Picture 2.3 – Europlant's License to fill

Europlant's production is being conducted with 14 production lines and the expectation is that an additional toilet duck line starts to operate from the end of 2016. Europlant distribute household cleaning products and consumer chemicals through the entire EMEA region. The product portfolio consists of home cleaning products, maintenance products, air fresheners and products for insect control.

During the last decade the organization has shrunk considerably due to automation, digitization and outsourcing. Today the organization in Mijdrecht consists of 230 fulltime employees and 30 casuals. The employees are active in the departments of the management team.

The plant's vision is to earn a "License to fill" (showed in picture 2.3), by creating top quality consumer goods for competitive prices. Europlant management wants to offer the highest possible service level and react quick and professional on partner's demands in the product supply chain. In addition, the target is to become the safest and most environmental friendly manufacturer, which is also friendly for their employees.

2.3 Products

Europlant produces a wide range of products for the European market. All products are classified in four different product types. The first type is *home cleaning* products, which include deep cleaning, disinfecting, degreasers and dust removing products for kitchens, bathrooms, furniture and floors. The second type is air care products (*aerosols*), such as home fragrance products. The third group are the maintenance products (*shoe care*), such as waxes, cleaners, protectors for cleaning inside or outside house and waterproofing products for shoes and laces. The last group consist of pest control products, like mosquitoes repellents and bug killers.

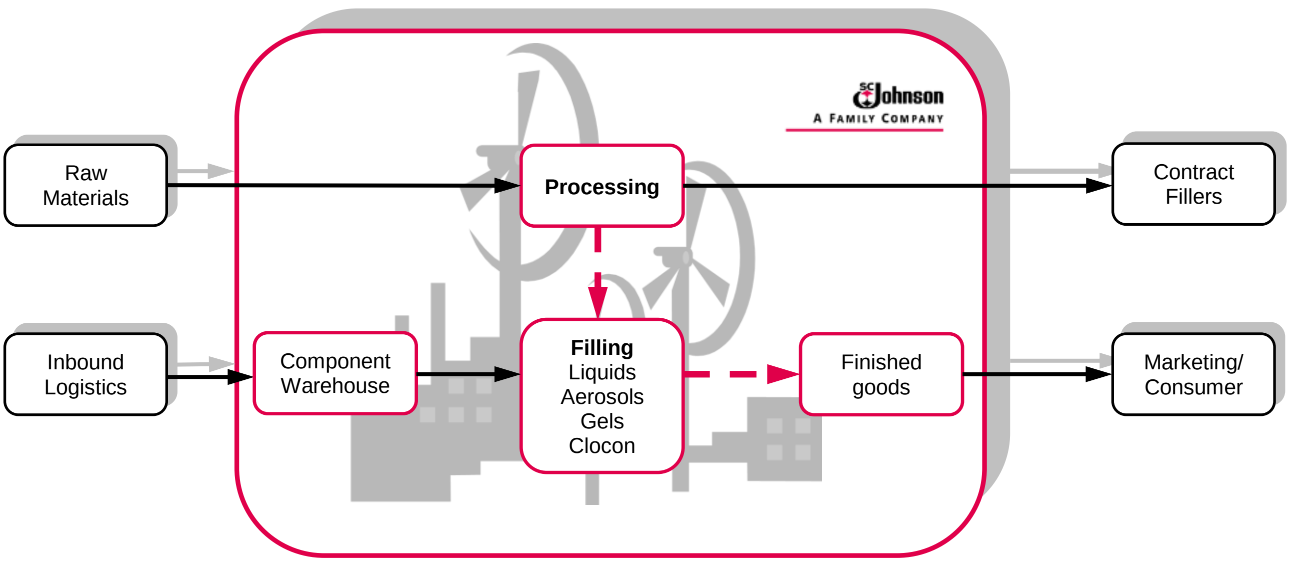
SC Johnson always wants to improve their products to meet the demand of customers and also tries to develop innovative new products to gain market share in an ever changing market. Popular brands which Europlant produces are Pronto®, Shout®, Mr. Muscle®, Brise® and Glade®. An overview of the products offered is added in appendix II.

Since 2001, all the products SC Johnson produces have to be filled following the SC Johnson Greenlist™ process. The goal of the Greenlist process was to go beyond taking out “bad” ingredients and instead focus on choosing “better” options and continuously improving formulas based on information about ingredients’ impact on the environment and human health. The year-on-year percentage of our ingredients that has a lower impact on the environment and human health has increased with 47 percent.

Picture 2.4 - Composition of Europlant brands

2.4 Operations

In a production environment like Europlant the most important department is Operations. At Europlant operations consists of the following departments: processing, filling (aerosols, liquids, gels and clocon) and logistics. The sequel of this section provides more specific information about the departments. Picture 2.5 shows the overview how operations are executed at SC Johnson. Europlant operational department produce products with 14 production lines. 12 production produce five days per week from Monday to Friday. This production continues 24 hours per day separated into three shifts. The other two production lines are designated as priority line because of high demand from the customer market. Production lines 29 and 41 produce seven days a week 24 hours a day. Every year production output shows an increasing trend. The production forecast for fiscal year 2016-2017 is 426 million units.

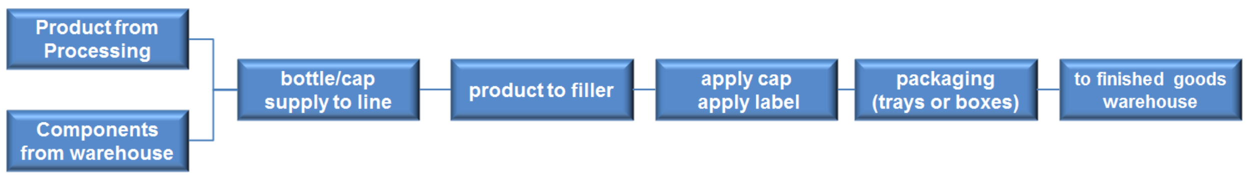


Picture 2.5 - Operations

Processing
The processing department processes raw materials into a product. Raw materials are the unprocessed materials or substances used in the primary production or manufacturing of a good. At SC Johnson raw materials are delivered in bags, containers or tankers. All raw materials are stored in the raw material warehouse or storage tanks stored at safe locations outside the factory. According to the formula of processing the raw materials are combined in reactors and mixed to a bulk product. When the mixing process is finished, the bulk product is transported via a closed system of pipelines to the filling section of aerosols and liquids. Additionally, about 20 percent of the bulk is processed at Europlant and transported to contract fillers.

Aerosols

Aerosols (*in Dutch: spuitbus*) is the department responsible for filling all the aerosols cans within Europlant. Production lines 15, 16, 18 and 99 fill large aerosol cans and line 22 fills mini aerosols. Filling of the products is a fully automated process were cans are filled with the processed raw materials and gas. The gas is added in order to get the product out of the can. Next steps are placement of a valve and a cap, labels are attached and finally the product is packaged in boxes or trays. In the past the aerosol department was considered as the most important department within Europlant, because about two-thirds of sales came from this department. Picture 2.6 shows the aerosol production process.

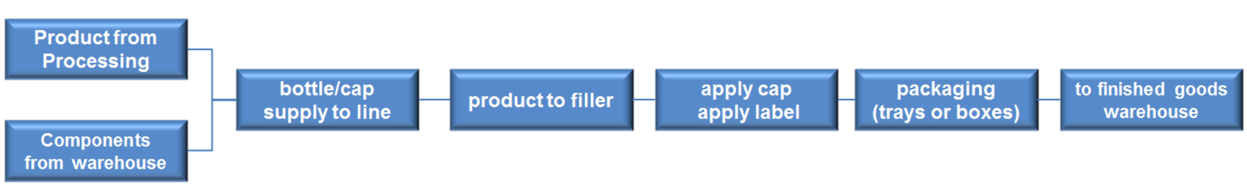


Picture 2.6 - Aerosol production process

Picture 2.7 - Samples of Aerosols and Liquids products.
Adapted from SC Johnson & Son, Retrieved April 1, 2016, from http://www.scjohnson.com/en/products/overview.aspx. Copyright 2013.

Liquids

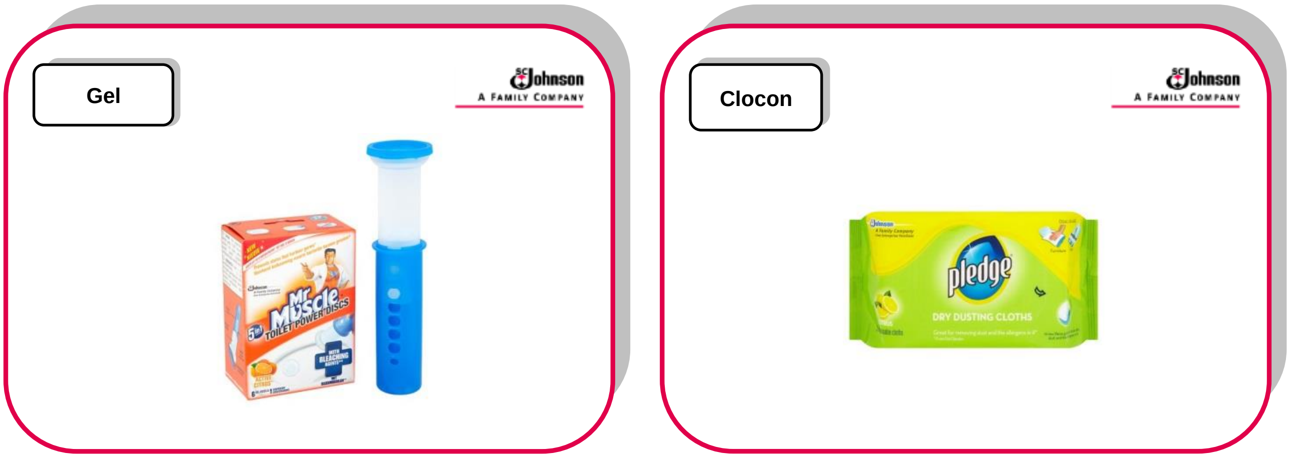
The liquids department (*in Dutch: spuitfles met vloeistof*) is responsible for filling bottles or tubes. In this department, the production process (showed in picture 2.8) is fully automated showed in picture 2.8. Based on the order, the production line fills the bottle and the next machine in line place a push-pull cap or trigger and a cap on the bottle. Subsequently, the product is labelled and packed in a box for transportation. The liquid department is responsible for the production lines 4, 8, 27, 29, 33, 94. The liquid department has currently the highest volume output at Europlant.



Picture 2.8 - Liquids production process

Gels

Toilet gel and fresh sticks are subdivisions of the liquids department and the newest products of SC Johnson. Production line 41 gets the required raw materials from processing. The fully automatic production line fills the tubes, apply a handle and a cap, attach a label and pack the product the finished product into boxes. Line 42 produces fresh sticks and is also full automatic. Strips are drenched with the same gel as line 41, then cut into short strips and packed into boxes.



Picture 2.9 - Samples of Gels and Clocon products

Adapted from SC Johnson & Son, Retrieved April 1, 2015, from http://www.scjohnson.com/en/products/overview.aspx. Copyright 2013.

Clocon

The production process of the wet cloth conversion division (*in Dutch: vochtige doekjes*) is based on the impregnation of cloth material. The material is supplied in rolls of 2000 meters. After the impregnation the material is folded, cut and packaged. Line 35 is an automatic production line that has a small output of product. This production line is left out of this research because production and storing of components is in a different building of the plant and the liquids warehouse have nothing to do with clocon.

Logistics

Logistics at Europlant is separated into two phases. These phases can be described as the process before the production line (inbound) and the process after the production line when the finished product is ready for shipment (outbound).

Logistics in the first stage of the operational process is responsible for receiving and handling of incoming goods. Storing of pallets in a proper way and picking the goods for supply of the production line. This study focusses exclusively on this stage of the logistics because management wants more insight in this process.

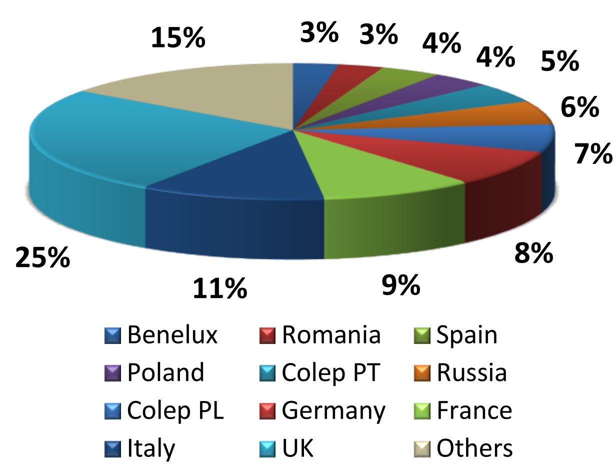
The second phase of logistical process is the responsibility of the finished goods. After the product is filled, checked and packed the boxes or trays are transported from the production lines to another building via automatic conveyor belts. In the central hall the boxes and trays are placed on pallets, stored and distributed often the same day.

2.5 Customers

The customer base of Europlant is widely distributed throughout the EMEA region. When Europlant finished the products the goods are immediately shipped to one of the twenty SC Johnson warehouses in the EMEA region. From there the centralized marketing & sales department sell and distribute the product to distributors, wholesalers, grocery stores and supermarkets.

Graph 2.1 gives an overview of the countries where Europlant has consumers. The latest country that is added to Europlant's customer base is Russia. SC Johnson's plant in Kiev was always responsible for manufacturing products for the Russian market. But since the Ukrainian conflict, Russian president Putin established an import boycott for all Ukraine products. Europlant was able to take over production of around ten MM Russian products.

SC Johnson competes in a competitive market with low profit margins. The organization must continuously invest in Research & Development and innovation to outperform the competition. Focus lies on continuing to monitor the developments in this market, reduce cost, be innovative and response before competition does.



Graph 2.1 - Production volume distributed to per country

3. Research structure

> This chapter gives insight in the structure of this research. In section 3.1 the problem definition is described and subsequently in 3.2 the scope is further explained. Section 3.3 contains the project approach of this study. Finally, in section 3.4 the deliverables are described.

3.1 Problem definition

The operational organization of SC Johnson has faced many changes in the warehouse during the last decade that led to several problems. The changed came at a leisurely pace but comparing the current situation with the situation 10 years ago gives total different performance figures.

The first change is also the change with the highest impact; production volume has increased in the last 10 years almost with twenty percent. The second change is that the number of stock keeping units (SKU; finished inventory item) has been increased from 293 SKUs in 2006 to 860 SKUs in 2016, due to changes in labelling legislation and new product development. The third change that occurred is the number of components on a single pallet. An example is the toilet duck bottle where the number on a pallet has decreased from 1200 bottles per pallet to 960 bottles per pallet. This change resulted in a warehouse availability decrease of 20 percent.

The next change that influenced the warehouse was that purchasing changed from decentralized to a centralized purchasing environment. From that moment, the liquid warehouse had to work with larger batches. Decisions by headquarters regarding minimum order quantities and longer lead times led to higher stocks.

Solution for these changes lies in implementing a good warehouse management system. In 2005 SC Johnson worldwide changed to SAP enterprise. All warehouse personnel were trained for two days in SAP. Afterwards management expected that employees could work with the new system. Research made clear that personnel still do not know exactly how to operate with SAP and where the system can be used for.

Production has increased, the number of SKUs also increased and the warehouse had to store higher stocks and employees work with a system they didn't really understand. The warehouse availability also decreased. All these changes cause pressure on the storage availability and also on the work processes of both truck drivers and warehouse administrators. The work processes in the warehouse have been the same since a long time and the management mind-set was: "it all works fine, so we do it the way we always did". Yet the question is whether these processes are still productive and the most efficient way to work? The objective in this research is to gain insight if there are problems in the inbound logistical process, how to solve these problems and subsequently how it improves the performance of Europlant.

In this research the topic of mixed components at Europlant is also investigated. Mixed components are a quality failure in the production process whereby incorrect components are placed in a SC Johnson product. If these failures are not identified in the production processes these products enter the market. The entire production order has to be reclaimed, and outside to the costs, it cause loss in brand reputation. Failures in the inbound logistical process could be a reason that these problem occur in the finished products.

The first four weeks of the period at SC Johnson is used as an observation period. Mapping the processes and interviewing truck drivers, warehouse administrators, production and planning personnel. These observations made clear that the work processes and use of SAP enterprise in the liquids warehouse not have been reviewed or improved for a long time and face factors of inefficiency.

The observation period result in the following problem definition of this research:

What improvement is required at SC Johnson Europlant B.V. with respect to the inbound logistical processes, in terms of warehouse utilization and balanced component flow, in order to improve performance?

In 1985 M.E. Porter invented a value chain consisting of five primary activities that directly create value. The primary activities that are involved create and bring value to the customer, whereas the support activities improve the primary activities performance. Porter described these activities together as inbound logistics, operations, outbound logistics, marketing & sales and service. These activities combined are the track that eventually leads to a finished product into the market (Porter & Millar, 1985).

This study focuses exclusively on the inbound logistics of the component warehouse of the liquids department. The reason of specifying only on the liquids warehouse is that this warehouse faces more capacity problems compared to the other warehouse. The second reason in focusing only on the liquids department is due restrictions of the research period.

Further investigation and comparing literature on warehouse operations show similar results as the theory from Porter. There are many authors who describe the processes in a warehouse on the foundation of Porter's definition. While in contrast to the very simple view on warehouse processes, other writers describe it broader as receiving, storage, order picking and the shipping process (Rouwenhorst et al., 2000). In this research a more elaborate description of the process of inbound logistical processes is followed. Karácek (2013) describes the processes in a warehouse as receiving, put-away, storing, picking, retrieving and shipping of components/goods (Karácek, 2013). In this study the shipping process is not being investigated because this process has relation with outbound activities.

The term component flow in the problem statement refers to the philosophy of lean manufacturing. Lean means that production emphasizes a minimum amount of recourses used in the various activities of the enterprise. It involves identifying and eliminating non-value-adding activities in design, production, supply chain management and dealing with customers (Blackstone, 2008).

Non-value-adding activities include the word value. Womack and Jones (1996) define the term value in their book as: "*capability provided to customer at the right time at an appropriate price, as defined in each case by the customer*" (Womack & Jones, 1996). The authors identify seven different types of waste: 1. Over-production; 2. Defects; 3. Unnecessary inventory; 4. Inappropriate processing; 5. Excessive transportation; 6. Waiting and 7. Unnecessary motion. The goal of this research is to eliminate or reduce the seven types of waste, so performance in the in the inbound logistics processes are going to be improved. Performance, however, is still a vague and broad word and can be interpreted in different ways. To give answer to the objective of this research it is important to define the word performance.

In 2005, Combs, Crook, and Shook analysed all articles identifying performance published in the *Strategic Management Journal* between 1980 and 2004. The authors found out that 238 empirical studies were analysed, using 56 different indicators. The authors reported that in 82 percent of the cases financial outcomes are the most important indicator in describing performance. Profitability was with 52 percent the most common choice as accounting measurement (Combs, Crook, & Shook, 2005). In addition, a more recent study, analysing different journals in other time periods, reported a similar picture (Richard, Devinney, Yip, & Johnson, 2009). So, theory shows that the most important indicator of performance is financial outcome.

Nevertheless, Europlant's management wants to look to performance at a broader perspective. That is why it is interesting to read that Yamin, Gunasekruan and Mavondo (1999) define organizational performance as how well an organization achieves its market-oriented goals as well as its financial goals (Yamin, Gunasekruan, & Mavondo, 1999). Combining the definition from Yamin et al. (1999) with the perspective of Europlant's management, this research measures performance according to the following indicators: performance in euros, overall equipment effectiveness (OEE) and quality. Important in this research is also the term efficiency. Efficiency can be described as: getting the most output of a given input (Okun, 2015). Meredith and Schafer (2006) argues that doing the thing right to get a maximum output from the minimum input (Meredith & Schafer, 2006). In this study efficiency is also an indicator of performance.

3.2 Scope

Focus in this research is on improving performance of the activities between the receiving process and the line supply process. Included are the main activities described by Karácek (2013): Receiving, put-away, storing, picking and line supply. In this research the processes of receiving and put-away and also the processes of picking and line supply are combined because one truck driver is responsible for both processes at the same time.

The physical layout of the warehouse is implemented long time ago. A thoroughly review of this layout has never been carried out. Management focus was on other processes and departments in the plant. Now management wants to gain insight in alternatives given the current situation. The procurement of products, supplier agreements and stock level management are processes executed or influenced by EMEA headquarters in Zurich and therefore not included in this research.

The current ERP system has been implemented in 2005. Management of Europlant is curious about the current performance of SAP and the use of the system in the warehouse. Despite the curiosity there has not be any analysis regarding the system. So no data is collected and no KPIs are measured. All information about processes and performance of SAP in the warehouse has to be gathered during this research.

3.3 Project approach

The research question is divided into six smaller sub-questions. These sub-questions are explained in the following subsections and also the approach for answering is explained briefly. The answers of the sub-questions are the foundation of the answer to the research question, further described in Chapter 9 '*Conclusions and recommendations*'.

3.3.1 Current situation

The first subsection of this research gives information of the current situation at Europlant. In the first place it is important to know how the processes at Europlant are established in the warehouse. Secondly, it is important to find out which decisions and underlying decisions were made by management in the past. The first sub question:

1. How are the processes established in the liquids warehouse?

Additional to this question, it is important to know how data is measured in the current processes and to what extend the data is evaluated and tracked with KPIs. The additional sub question regarding the current situation is as follows:

1a. What KPIs are currently in place?

3.3.2 Current performance and bottlenecks

After describing the current inbound logistical situation at Europlant the next step in this research is to go further in depth about the current performance in the liquids warehouse. In order to give answer to the question, performance problems in the current process has to be found. These problems in the process are called bottlenecks end expressed in key performance indicators (KPIs).

In literature a common definition of a bottleneck does not exist. Reviewing literature on bottleneck in logistics management and related fields show a wide variety of disciplines like: traffic planning, computer network bandwidth allocation, population bottlenecks and reduction in gene pool variation and production planning and control. In this research the last discipline fits best. Goldratt, Cox and Whitford (2004), authors of the book *the goal*, describe a bottleneck as "any resource whose capacity is equal to or less than the demand placed upon it." (Goldratt, Cox, & Whitford, 2004). Another definition describes a bottleneck as the element that limits the system in attaining higher throughput beyond a certain threshold, determined by the bottleneck's physical throughput capacity, organizational rules or operational practices (Beer, 2015). In this study a combination of these definitions is used: *A bottleneck is the limiting element in a process, whose capacity slow or vague the pace in the chain of elements; it sets the pace in the entire process.*

The term KPI is described in theory as a set of measurement focusing on those aspects of organizational performance that are the most critical for the current and future success of the organization (Parmenter, 2015). KPIs represent business goals that a company wants to achieve on a rather strategic. In this research performance of a bottleneck is expressed in KPIs. These indicators are based on the output and input and therefore related to the performance indicators described section 3.1. Possible new alternatives can be judged on the improvement of the KPI. Sub question 2 and 3 are:

2. What bottlenecks are faced in the current process?

3. What KPIs can be used to measure the effect of the bottlenecks on performance?

Per bottleneck the performance of the process must be measured. All bottlenecks are analysed with use of cause and effect diagrams. Data for defining KPIs are gathered from the ERP system and previous research done by employees and interns of Europlant. Data that is unknown must be gathered by own measurements in order to define the indicators. Finally data have to be gathered from the pick lists and measurements in travel time and distance. For each bottleneck a KPI is defined regarding the collected data.

3.3.3 Literature study

The third step of the research is to develop a plan of approach to solve the bottlenecks. What information is needed and how to gather information to solve the bottlenecks. The next step is to find literature which can be used to improve the KPIs. Therefore sub question 4 is:

4 .What does literature say about improving the performance measured by these KPIs and in what way can the performance of the bottlenecks be improved?

Per bottleneck a plan of approach is developed for improving the KPI. Literature is searched for providing alternatives for each bottleneck. Information is searched by use of the databases Google Scholar, Scopus and Web of Science. Focus in this research lies on journals from operational management and logistics management.

3.3.4 Alternative assessment

The next step of the research is to give insight to what extent the alternatives are improving the current KPIs. Methods and theories from the literature study are adapted to SC Johnsons situation to give answer to sub question 5:

5. What alternatives are available for the bottlenecks?

To answer this question calculations are made regarding the improvement of the KPIs. The constraints of the layout and type of products are taken into account for the adaption of the literature to SC Johnson specific case. The selected alternatives from sub question 4 are adapted to the case and calculations are made regarding the improvement of the indicators. The alternatives are finally judged regarding significant improvement of the performance indicators. The performance indicators improve if waste is eliminated and when the KPIs improve significantly. The research question can be answered when other alternatives improve the performance. In this research performance indicators are expressed in KPIs, if the indicator improves the performance improves also. The possible improvement of the performance is presented to the management of Europlant who can make the choice for implementing or not implementing one or more solutions.

3.3.5 Implementation

Step 5 of the research is to draw up an implementation plan for implementing the new solutions for solving the bottlenecks.

6. How to implement the solutions at SC Johnsen Europlant B.V. in order to improve performance?

This question is answered by making a structured implementation plan. The basic concept that results in profitability is worked out in detail. This plan must be evaluated and established with the process owners and employees and the management of the production plant.

3.4 Deliverables

The deliverables of this research exist of a report that offers new storage methods and an adjusted ground plan of the liquids warehouse. The main deliverable is this report. The report contains relevance (Chapter 1) and structure (Chapter 3) of this study. Furthermore a description of the global company and of the plant in Mijdrecht is given (Chapter 2). Also the analysis of the current situation and performance indicated with bottleneck is given (Chapter 4 & 5). The results of the literature study (Chapter 6) and important the alternatives for the bottlenecks (Chapter 7) are also added in this report. The implementation of the alternatives is added in Chapter 8. Conclusions and recommendations for further research can be found in chapter 9. Finally the list of literature that is used in this study is added regarding the references.

3.5 Summary

The research structure is described in this section. The incentives, objective and scope of this research are described in the first section. The approach of the research is divided into several sub questions that are answered in the report. The sub questions give answer to the problem definition:

- *1. How are the processes established in the liquids warehouse?*
- *1a. What KPIs are currently in place?*
- *2. What bottlenecks are faced in the current processes?*
- *3. What KPIs can be used to measure the effect of the bottlenecks on performance?*
- *4. What does literature say about improving the performance measured by these KPIs and in what way can the performance of the bottlenecks be improved?*
- *5. What alternatives are available for the bottlenecks?*
- *6. How to implement the solutions at SC Johnsen Europlant B.V. in order to improve performance?*

4. Current situation

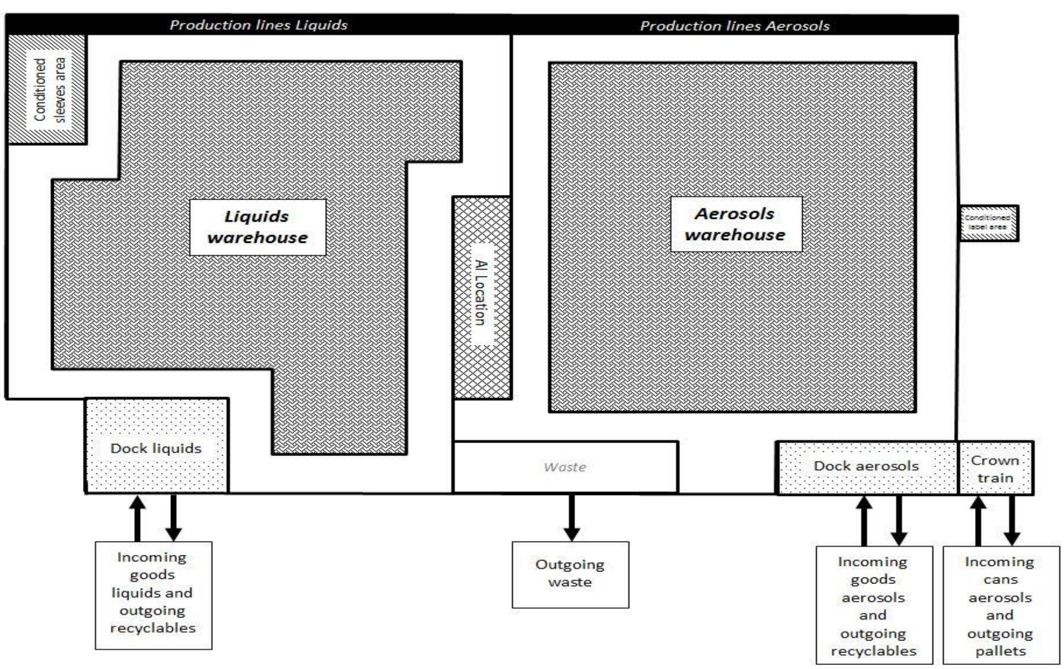
Chapter 4 gives an overview of the current situation at the inbound logistical processes in the liquids warehouse. Section 4.1 presents the layout of the warehouses at Europlant. Sections 4.2 to 4.4 give a clear explanation about the processes from the receiving and put away of the component, the storing of components until the picking and supplying of the components towards the production line. The following section of this chapter describes the data collection and KPIs in the current situation. Section 4.6 summarizes the current situation in the liquids warehouse. This chapter gives answer to the first sub questions: "*How are the current processes established in the component warehouse?"* and *"What KPIs are currently in place?"*

4.1 Layout

4.1.1 Component warehouse

Warehousing has an important role in attaining the overall objectives of an organizational supply chain system. A Warehouse is a place where inventory is stored; it plays a major role in providing a desired level of service to the customer, at the lowest possible cost (Lambert, Stock & Ellram, 1998). The overview of the warehouses at Europlant is showed in picture 4.1. In this study the focus lies on investigation of the liquids warehouse. Nevertheless, this subsection also describes the aerosols warehouse because this warehouse is directly linked to the liquids warehouse and areas are shared between the two warehouses. Europlant third warehouse, the raw material warehouse, located on the other side of the plant is left out of this research.

The component warehouse is divided in two different areas, a warehouse for the aerosols department warehouse and a warehouse for the liquids department. The aerosols component warehouse borders five production lines and houses all the components that are needed for the production of aerosol products. The second component warehouse is named liquids warehouse and is located next to aerosols warehouse and houses components for eight production lines.



Picture 4.1 - Overview Europlant's warehouses

In the liquids component warehouse (further described as liquids warehouse) components are stored used for manufacturing liquids and gel products. In between the two warehouses is the AI area. This area is used as a shared storage area used for both aerosols and liquids. The distribution between the goods in the AI area depends on the amount of goods in stock and the demand. In this research AI is left out because storage fluctuates on regularly.

Furthermore, two conditioned storage units are located in the warehouse area. The first unit is a climate storage area for Toilet Duck sleeves located in the liquids area and consists of 150 square meters. The other climate storage area has a size of 72.95 square meters used for aerosols department as a storage area for pack code stickers.

Picture 4.1 also reveals three receiving locations: dock liquids, dock aerosols and Crown train. Incoming goods are supplied in different processes. The first process is via the supplier called Crown Aerosols Nederland B.V. This supplier is located on the same property to SC Johnson and supplies directly to the plant via an interlinked transport train.

The other delivery process is used for all other external liquid and aerosol suppliers. Concerning goods are delivered at the docks. The docks are used besides delivery also used as temporary storage location for outgoing recyclables. Instead of the fully automatic crown train, that takes pallets automatically back after delivery, liquid and aerosol recyclable material to external suppliers has to be collected and stored first. Sometimes suppliers forget to take back these materials resulting that almost all the dock capacity is used for the recyclable materials.

The receiving of the pallets from the supplier in the liquids warehouse occurs on the liquids dock. The supplier is responsible for placement of the goods on the dock. The suppliers use an electric pallet truck from Europlant. Further movement of pallets is done by truck drivers using electronic reach trucks. Europlant's ERP-system SAP enterprise designates automatically a storage location (further described in the chapter 4.3.2). SAP is wireless connected to the reach truck and the driver can use the system via a terminal. A Radio Frequency scanner (RF scanner) scans the data from the pallets into SAP. An overview the materials used in the process of incoming goods is showed in appendix 2.

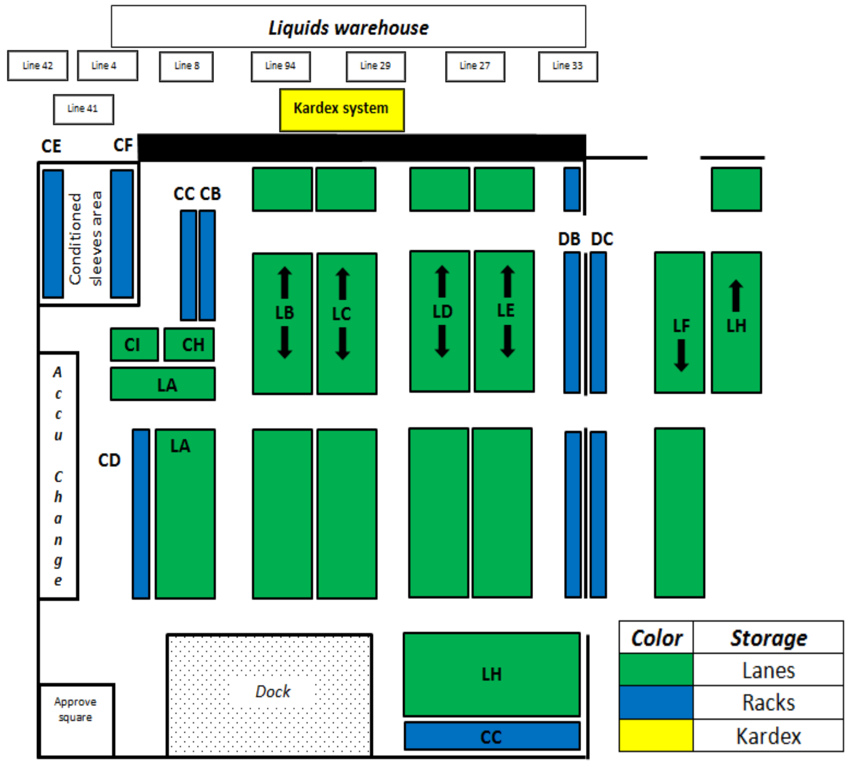
The supervisor in the warehouse is the warehouse coordinator, who report directly to the team coach logistics. The coordinator is head of a team that consist on average of four or five employees in the morning and afternoon shift. One truck driver is responsible for the receiving and put-away process while two truck drivers are responsible for picking and supplying the production line. Another warehouse employee is full-time responsible for all administrational tasks. At the night shift the team of truck drivers consists out of two truck drivers who only have to supply the production lines. Receiving during night hours does not take place so non dock or administrative related tasks have to be executed.

In this subsection the warehouses at Europlant are described general. The aerosols warehouse is left out in this research because time restrictions and lower priority. Hence, improvements in the liquids warehouse can be easily copied to the aerosol warehouse. In the following subsection a deeper elaboration of the liquids warehouse is given.

4.1.2 Liquids warehouse

As said before this research focusses exclusively on the liquids warehouse. More capacity issues and pressure of size and utilization made it of higher priority to focus on this warehouse. The following subsection gives an overview of the layout in the liquids warehouse.

Picture 4.2 shows the liquids warehouse in the current situation. The warehouse is divided in ten block stacking lane areas displayed in green (i.e. LA & CI) and nine selective pallet racking construction areas displayed in blue (i.e. CC & DC). Indicated with the yellow colour is a kardex shuttle for storing small rolls with pack code stickers. A more detailed map of the liquids warehouse including all storage locations is showed in appendix 5.



Picture 4.2 - Overview of the liquids warehouse and section names

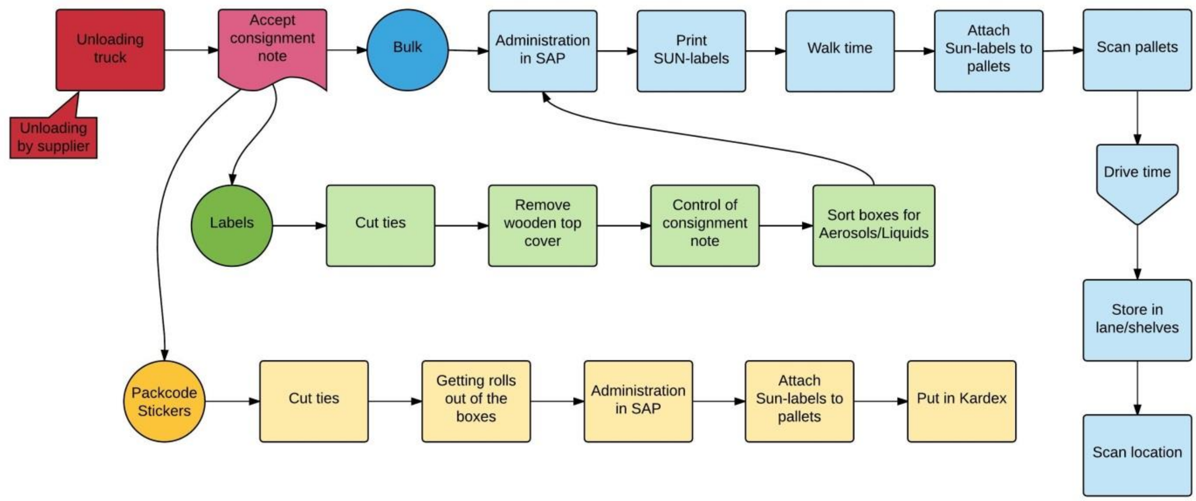
In the storage lanes area, pallets are stored according to block stacking strategy. Block stacking is a form of palletised storage that does not require any type of storage equipment. The pallets are placed on the floor and built up in stacks to a maximum stable and safe storage height. The height depends on the stability and height of the component. Lane areas are further separated in single storage locations called storage bins. Every storage bin has its own characteristics in terms of depth, maximum height and maximum number of pallet locations. The total number of block stacking location in the liquids warehouse 353 bins. In these bin locations the maximum storing capacity is 6630 pallets.

The second storing method is storing in selective pallet racking. In picture 4.2 pallet racking systems are displayed in blue. This storage method is a common used and is designed to provide easy access to a pallet. Pallet racking is ideal with multiple components that have low stock because every pallet rack bin location has a maximum pallet quantity of one. The liquids warehouse of Europlant has in the current situation storage availability of 1355 pallets racking locations.

The third storage method in the liquids warehouse is the kardex shuttle. A kardex shuttle is a highly flexible solution for storing and retrieving small-volume goods. The shuttle is not suitable for storing pallets. At Europlant the shuttle is used to store pack codes stickers with 3500 stickers per roll.

4.2 Receive and put-away process

The first inbound logistical processes in the liquids warehouse can be described as the receiving and put-away process. These processes are combined in one process because one truck driver is responsible for both processes the same time. The products groups that are involved at the liquids dock are the following: bulk, labels and pack code stickers. The process overview of receiving a put away is exhibited in picture 4.3.



Picture 4.3 - Receiving and put-away process

Components delivered by a supplier are received at a dock. The docks are only suitable for receive cargo that is delivered by trucks. Every weekday 22 deliveries are recorded on average at the dock in the liquids warehouse. Supplier must subscribe in a time slot management system between 7 o'clock in the morning until 11 o'clock in the evening. When the truck is approved according to time slot by the warehouse administrator also a dock location is assigned. The truck driver from the supplier is responsible for unloading the goods out of the truck into the receiving area with an electric pallet truck.

When bulk is delivered at the dock the first task of the truck driver is to inspect the delivered goods regarding to the consignment note on quantity and quality. If the delivered goods match the purchase order and meet the quality standards the administrational task starts. The administrational action has to be done in the office so the truck driver has to walk towards the office. The first action is to enter the delivery codes and into SAP enterprise, so the truck has to walk to the liquids office. The second step in the administration is to insert all the article numbers into the system and print Sun labels. After printing of the labels the employee has to walk back to the pallets. The next step is to check if the article codes on the sticker of the supplier match with the printed labels, only if the codes math the truck driver is allowed to attach the sticker to the boxes on the pallets. The pallets are now ready for the put-away process.

The process of labels delivery is quite similar with the delivery of bulk components. The difference is that before administration in SAP the truck driver first has to cut the ties, remove wooden top cover and check and sort per box on quantity and quality.

The third product group is the pack code sticker. The sticker rolls are always stored in the kardex shuttle. After truck drivers accept the load according to the consignment note, the next steps are cutting ties, getting the rolls out of the boxes, administration in sap, attach Sun labels and put in kardex shuttle.

Alpla Nederland B.V. (hereinafter referred to as Alpla) is Europlant's most important supplier regarding liquids and gel components. Alpla is one of world's leading suppliers of packaging solutions, and supplies several plants of SC Johnson & Son worldwide. Alpla is also located in Mijdrecht approximately 500 meters from Europlant and supplies every 45 minutes a full truck of 33 pallets. From Monday to Friday Alpla delivers between 7.00 and 23.00 o'clock. Because of the high number of deliveries the vendor scheduler responsible for ordering liquids components spreads the deliveries from the other suppliers over the week to unburden the liquids dock. The average number of truck deliveries per day is 22.

When the components are checked and all administrational tasks are done the received pallets are ready for put-away. First, the truck driver scans the Sun label that is attached to the components on the pallet. SAP controls the component on the quantity and automatically designates a bin location. After SAP determines the location, the truck driver drives the pallets to the right bin location and scans both the Sun label on the pallet and the bin. However, the truck driver can decide himself or after consulting the warehouse administrator to place the pallet at a different bin location. SAP is now overruled.

At the end of the week the utilization pressure in the warehouse is high because production two production line is continuously through the week but the delivery of components stop during the weekend. That is why just before the weekend the warehouse is almost fully occupied. For the truck driver it is despite hard to find storage space for the pallets and to maintain FIFO. Problems with availability to store bulk pallets occur regularly also the conditioned warehouse for toilet duck sleeves has too little storage availability.

4.3 Storage process

After receiving and put-away of the pallets the next process in the warehouse is the storage process.
In this section researching the storage process in the liquids warehouse gives acknowledgement about the current situation in the storage process. The storage process is an important part of chapter four. Therefore, the sections are comprehensive described and structured in the following subsections. Subsection 4.3.1 consists of technical information about the size and used capacity of the warehouse. Followed by an explanation of the ERP-system that is used in the warehouse in subsection 4.3.2. The enterprise resource planning system that is used at Europlant is extensive so in subsection 4.3.3 this is further explained and linked with the current storage strategy. In subsection 4.3.4 the SAP storage types are further described. The last subsections (4.3.5 & 4.3.6.) contain of an explanation of the capacity and mapping of storage on bin level and pallet level. In the current situation collecting data in this process is difficult due to a lack of training and knowledge about SAP and processes of SAP. The wrong use of the ERP-system and wrong documentation on realistic numbers of pallets per bin makes it also hard to analyse the current performance in the storage process. Finally, due to the size of the storage process subsection 4.3.7 gives a summary.

4.3.1 Size

Picture 3 in subsection 4.1.2 shows the layout of the liquids warehouse. The original liquids warehouse is 68.50 meters width and the length is 100 meter. That capacity consists out of 5963 square meters store availability for storing bulk and rack storing. 150 square meters is used as a conditioned warehouse for toilet duck sleeves. After the warehouse had a lack of storage space; 884.25 square meters extra space has been obtained from the aerosol warehouse. Combining these areas the total floor capacity of the liquids warehouse is 6997.25 square meters. In all areas the height of the warehouse is 7 meters so the volume of the liquids warehouse is 48980.75 cubic meters.

4.3.2 SAP Enterprise

The Enterprise Resource Planning (ERP) systems that we know these days have their roots in Materials Requirement Planning (MRP) systems, which were introduced in the 1960s. The first MRP I system is a computer-based system for inventory control and managing production schedules. As data from the factory floor, warehouse, or distribution centre began to affect more areas in manufacturing companies. The need to distribute these data across the entire enterprise contributed that other business area databases had to be updated and linked with the MRP I system. After was found out that the MRP I system had limitations on its functionality it was followed up by the MRP II system. MRP II now has given its function through to the more developed ERP systems (Chung, Skibniewski, Lucas & Kwak, 2008).

O'Leary (2000) defined an ERP systems as *"computer-based systems designed to process organizational transactions and facilitate integrated and real-time planning, production, and customer response*" (O'Leary, 2000). The process of ERP systems includes data registration, evaluation, and reporting. Data registration is entering data into a database, data evaluation is reviewing data quality and consistency, and data reporting is the process of data output sorted by certain criteria (Januschkowetz, 2001).

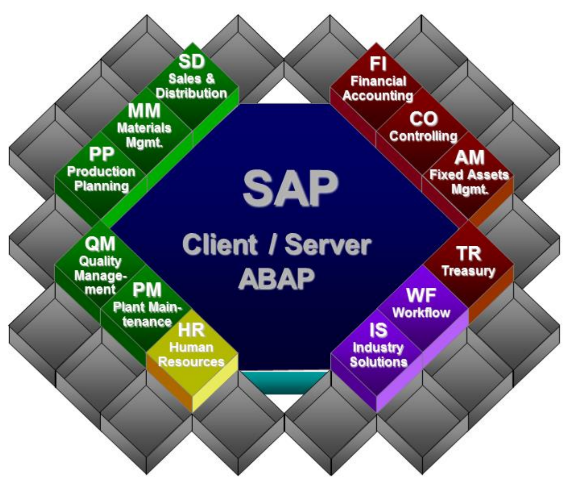
SAP AG, a German software manufacturer, was the first company which introduced a functional enterprise system. Nowadays SAP is the world's largest enterprise software company and the world's third largest independent software supplier (SAP, 2016). SAPs strength is the breadth and extensive capability of its software's functionality, even though it leads to complexity in the system and its implementation. SAP spends much more on R&D than any other competitor and is most likely to introduce new functionality as a result (Davenport, 2000).

The advantages and disadvantages of SAP enterprise according to Davenport (2000) and Chung et al. (2008):

Advantages
- Integrate financial information
- Integrate customer order information
- Standardize and speed up manufacturing processes
- Reduce inventory
- Standardize HR information

Disadvantages
- High investments costs of ERP
- Inflexibility
- Long implementation period
- Overly hierarchical organizations

Warehouse Management System
ERP systems are groups of several application modules. SAP has upgraded their original program to 12 modules, where each module supports a business goal as showed in picture 4.4. The modules can interact automatic with each other either directly or by being updated manual a central database. In the world of warehouse operations the most important modules are the production planning, material management, and production planning. Combining these modules create SAPs Warehouse Management System (WMS).



Picture 4.4 - 12 Modules of SAP Enterprise. Adapted from ERP Certifications, Retrieved March 16, 2016, from http://sap-certification.info/how-does-sap-work/. Copyright 2015.

Definitions of a WMS in literature do often have the same scope, two examples are:

"A WMS collects, stores and reports the necessary information to the functions of the warehouse efficiently manage from the moment it received the goods to the shipping" (Faber & de Koster, 2002).

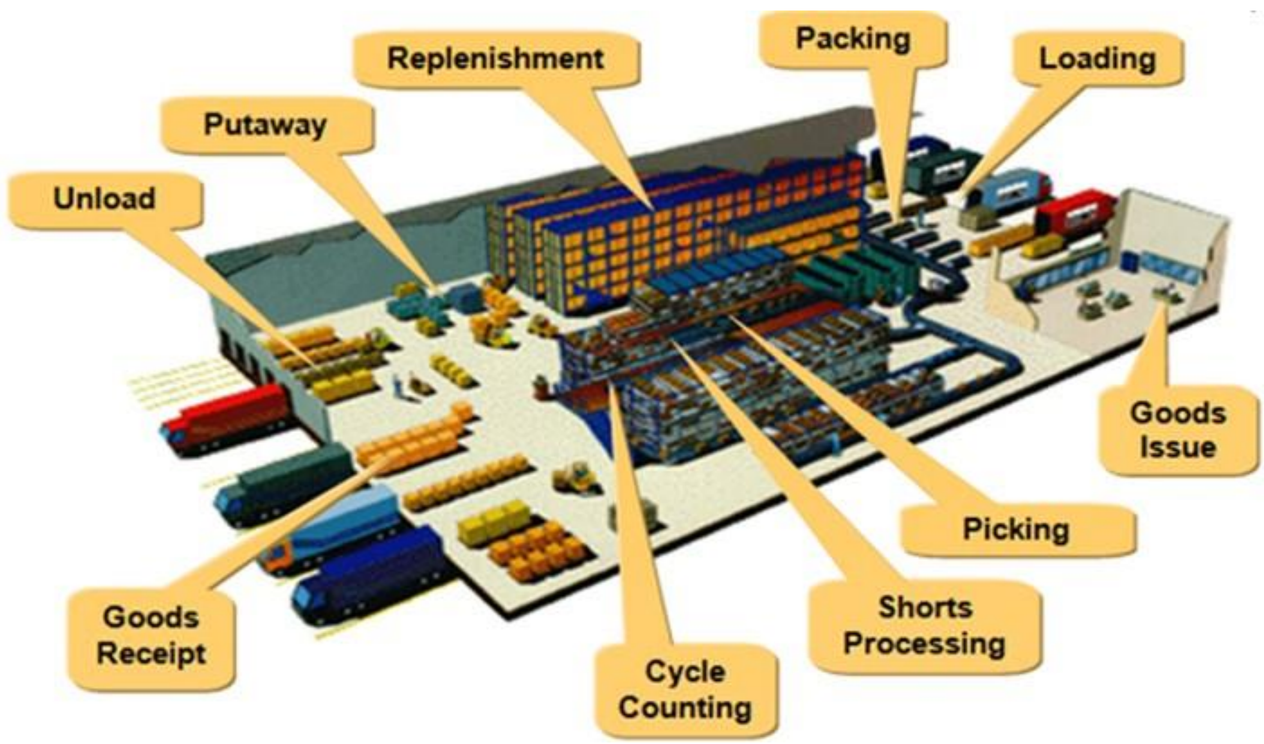
"The WMS essentially controls the flow of material, and keeps statistics such as work requirements, labour productivity and equipment utilization" (Hackman, Frazelle, Griffen, Griffen, & Vlasta, 2001).

The scope of the definitions remains broadly unchanged, but unfortunately, the concept of information and internal warehouse process herein are not evident. In this thesis has therefore opted for a broader definition because the WMS is intended to support the complete flow within the warehouse. The following definition (derived from van den Berg & Zijm, 1999), is close to all of this and is therefore the starting point:

A Warehouse Management Systems facilitate the registration, planning and control of warehouse processes.

SAP at Europlant

When the modules of WMS as mentioned above are combined correct it gives advantages to different processes in a warehouse. Picture 4.5 exhibit the processes in a warehouse. In this study not all the processes are contribute but are despite part of WMS.



Picture 4.5 - WMS processes Adapted from SCM & SAP ERP, Retrieved March 14, 2016, from http://scminerp.com/sap-erp-overview/warehouse-management-system-wms/.

In 2005 SAP has been globally implemented at SC Johnson. Every SC Johnson plant around the world works with same standards because the operational processes, performance indicators and finished products also match. The WMS is also implemented in the SAP package since the first day of usage. The advantages that should be obtained using SAP in a production environment according to Lambert et al. (1998) are:

- Reduction of direct labour
- Increased efficiency of the deployment of equipment
- Improved utilization of storage

So, WMS can support the process in the warehouse and contribute to improve performance in the warehouse. Next step in this study is to investigate the storage strategy and explore the storage structure implemented by the SAP system. Further explanation of the current strategy and storage structure at Europlant is given in the next chapter.

4.3.3 Storage strategy

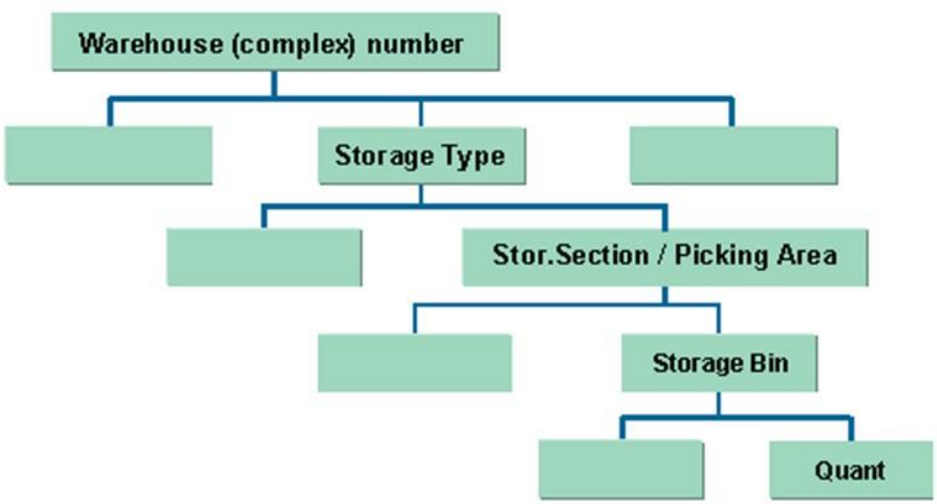
In simple words a storage strategy is a policy that determines where in a warehouse products have to be stored (Yu & de Koster, 2009). The authors describe the importance of a good storage strategy because it impacts the amount of space needed to store component and the time needed to retrieve load from the warehouse towards the production line.

According to Handfield et al. (2013), warehouses are responsible for about 15 percent of the total logistics cost in developed countries in West-Europe. So, with a volume of 420 million units last year can be determined that the logistics costs directly related to the component warehouse at Europlant are high.

However, Management of Europlant has never executed research about a storage strategy that can be applied at the warehouse. Focus was on improving the production lines and the products instead of the storage strategy. Employees of the liquid warehouse showed some initiatives to implement storage improvement through the years. Bulk is stored in the bins next to the production lines and additional bin location was created by adding racks with different heights. However, storing important components next to the production lines is not always possible through high utilization and FIFO strategy is not performed.

4.3.4 Storage structure

Despite no theoretical storage strategy has been implemented in the warehouse. The implementation of SAP is a strategic choice made by the directors in Racine. SAP is build-up according to a storage structure that hierarchical and consists of the following elements:



Picture 4.6 - Build-up of elements in storage structure of SAP. Adapted from ERP Certifications, Retrieved March 20, 2016, from http://sap-certification.info/how-does-sap-work/. Copyright 2015.

Picture 4.6 shows that the steps in storage structure follows a hierarchical structure. In the following part the elements of SAP structure are explained step-by-step that also consist out of a description of the current situation of the elements in the liquids warehouse:

Warehouse number
The first element of the storage structure in SAP is the warehouse (complex) number. An entire physical warehouse complex uses a single warehouse number. When it occurs that a company owns one or more warehouses or hires additional warehouse space all the processes can be customized that all warehouses use the same setting but have different warehouse numbers. In the current situation at Europlant the entire warehouse has the same number. Both the aerosol and liquids warehouse use number 620.

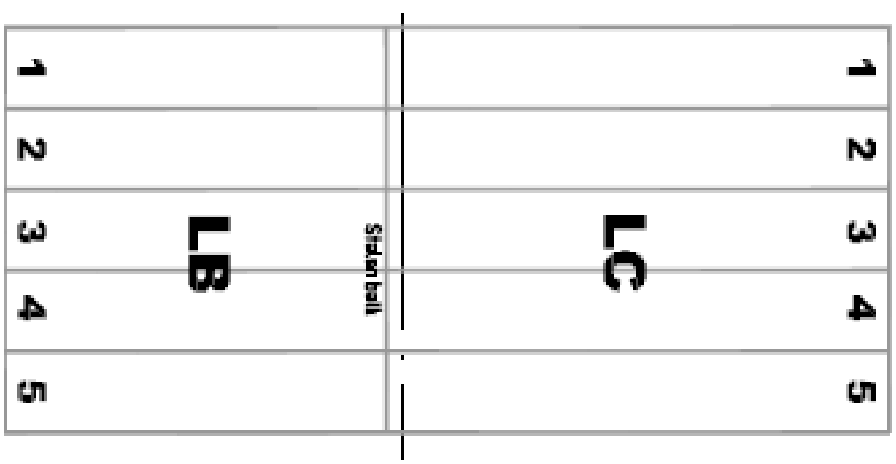
Storage type
The storage type is the second element in the structure. This element is a physical or logical subdivision of a warehouse and the technical, spatial, and organizational characteristics per storage type are further elaborated. A storage types include more complex warehouse settings of one or more warehouse facilities. The physical storage types can be characteristics in the following:

- Bulk storage area
- General storage area
- High rack storage area
- Fixed bin storage area
- Rack storage area

In the following subsection the storage types in the current situation at Europlant are further analysed. In the sequel of this subsection first the next elements of the storage structure are explained.

Storage section
In SAPs third step of the storage structure is that each storage type is divided into storage sections. A storage section is an organizational subdivision of a storage type. The storage section groups together several storage bins with similar attributes with the same purpose of put away. All storage sections have specific attributes. In simple words a storage section is a bundle of bins, combined together as storage section.

The storage sections in the liquids warehouse are already described in subsection 4.1.2. In that section picture 4.2 exhibits an overview of ten block stacking lane areas and the eight selective pallet racking constructions. Picture 4.7 shows an example of the storage sections lanes LB and LC. The numbers 1 to 5 in the picture all represent different storage bins. A comprehensive overview of all the storage sections and bins is showed in Appendix V. The bins are the following element in the storage structure and explained hereafter.



Picture 4.7 - Picture of two storage sections including ten storage bins

Storage bin

As explained previously a storage type consists out several storage sections. Thereafter, a storage section consists of a selection of storage compartments called storage bins. The coordinates of the storage bins tell the exact warehouse position where components must be stored. Picture 4.7 show five storage bins in both LB and LC. The total number of bin locations in the liquids warehouse is 1700.

All the pallet racking locations can handle one pallet, while the bins in the block stacking lane area vary in number of pallets between 2 to 34 pallets. The third storage bin type in the liquids warehouse is the kardex shuttle. This kardex shuttle can only store rolls with pack code stickers. No full pallets or boxes can be stored in the shuttle. Subsection 4.3.6 describes the storage bins at Europlant more elaborate.

Quant

The element quant is used for inventory management of a product in a storage bin. The quantity of component per pallet that is stored in the warehouse differs per article.

4.3.5 Storage types

In the previous subsection the third element in a storage structure, the storage types, is already brief examined. Interviews with truck drivers and warehouse administrators expose that in the past several problems occur due to wrong use of the storage types. This subsection contains of an in-depth analyse of the storage types in the liquids warehouse.

The extensive description that SAP enterprise (2016) gives to a storage type is "a *storage space, storage facility, or storage zone, which you define for a warehouse number in Extended Warehouse Management (EWM). The storage type is a physical or logical subdivision of a warehouse complex, which is characterized by its warehouse technologies, space required, organizational form, or function. A storage type consists of one or more storage bins.*" (SAP, 2016)

As mentioned in section 4.2 the component groups used as Europlant can be described as bulk, labels and pack code stickers. The element storage type is normally used to give a more comprehensive and clearer description of the type of goods that are stored on a specific location. So the storage types should make it easier for a warehouse administrators and truck drivers to recognize which type of group a specific component belongs to.

When SAP was introduced at Europlant in 2005 a list of storage types was designed in order to describe the types at Europlant. The storage types were designed for the right components. All storage type contains their own settings, which include the control indicators that control the material flow in each storage type. The control indicators include the settings for the put away and picking strategy. The list of storage types that original was designed for the liquids warehouse is showed in table 4.1.

Storage type number.	Original invented storage type for Europlant
017	Liq. Bulk components
025	NFG Line Returns
041	Lic. Racks
043	Lic. Label Room
044	Clocon Rack Cloth
045	Clocon Rack Pouches

Table 4.1 - Storage types designed by SAP for Europlant

After introduction all employees in the warehouse had two SAP training days. After the two days employees should have enough knowledge to work with the program on daily basis. Thereafter additional knowledge about SAP has not been provided. Knowledge that employees have is learned by trial and learn or obtained from colleagues. Decisions were made based upon own experience and knowledge of colleagues. Furthermore the decisions that were made a long time ago have never been reviewed. Shortly after introduction of the SAP the first decision was made that influenced the use of the storage types.

Decision 1: Complains were that a truck drivers lost too much time with scanning in the handling fast moving components from the warehouse towards the production line. The warehouse administration asked for an additional storage type from processing. In the new situation the storage type is used to store fast good components and the truck driver can pick the pallets without scanning. Resulting that SAP cannot control the process. *Result: addition of storage type 031.*

After several years after introduction of the storage type 031 the second decision was made. The European Union declared that it wasn't allowed anymore to put product information in several languages on one label. Causing that SKU numbers increased from 293 in 2006 to 657 in 2016. This resulted that extra component had to be stored and the liquids warehouse faced problems with capacity. The problem is further described in decision 2.

Decision 2: Capacity problems cause that goods returning from the production line had to be stored back in the original bin. Warehouse personnel did not know about the existing storage line 025 designed for return components. At a new production order SAP set the components lower than the newer components on the pick list. Resulting that the number of rest pallets increased. Warehouse administration were advised by colleagues and decide that all return pallets had to be stored in 031 storage type. *Solution: Place line returned material back in the bin to 031 storage type.*

So, after eleven years of working with SAP the current list of storage types is described in the following table:

Storage type number.	Current use storage type for Europlant
017	Bulk components
025	Sleeves toilet duck and Label storage
031	Free picking area and line returned material
041	Label storage
043	Pack code stickers
044	Beechnut components
045	L-42 beechnut cases

Table 4.2 - Storage types in the current situation

From the moment that the storage types were changed the situation in the warehouse has never been analysed. Further analysis of the current storage types and their features gives further insight in the characteristics of the types. It also reveal if the current use of the storage types can be improved. Due to the high technological difficulties the use of the storage types are further explained in the sequel of this subsection.

017

This storage type is used to store bulk needed in the production process. Type 017 is only used for components that are stored in large batches. 017 locations are used for the block stacking bins and can always store two or more pallets. Examples of products that are stored with 017 are: bottles, cases, tubes and triggers.

025
Storage type 025 is originally introduced as storage type for line return material that comes back from the production line. In this storage type the line return material that is placed back in the original bin are displayed on top of the pick list when a new production order is released. In the current situation at Europlant storage type 025 is used for toilet duck sleeves stored in the conditioned area and labels.

031
As described in previous storage type 031 was used as solution for two warehouse problems but original introduced as a process production location for Raw Materials. 031 have currently two different purposes. The first purpose is that it is used as a free picking area where component can be picked. Advantage is that it should save time because scanning is unnecessary. The second purpose of storage type 031 is that this type is the solution for line return material. Lack of knowledge and training about SAP were the reason that warehouse administrators used 031 to solve the issues.

041
Storage type 041 is used almost in the correct way it was original introduced. Almost all the labels that are used in the production of liquids products are stored in pallet racking with storage type 041. Due to labelling legislation changes has the number of SKUs increased and also the number of labels increased.

043
Storage type 043 is used at Europlant as a storage location for pack code stickers. Storing is done in the kardex shuttle. Original was storage type 043 invented for storing liquids label room.

044
Original invented for clocon rack cloth. Due to the shifting of the clocon production to another building at the plant this storage type is now used for storage of gel components. The gel components are stored in pallet racking.

045
Original invented for clocon rack pouches. Clocon is removed to another area of the plant. Since the introduction of the gel products the pallet racking construction of 045 are used to store gel cases.

4.3.6 Storage capacities and mapping on bin level

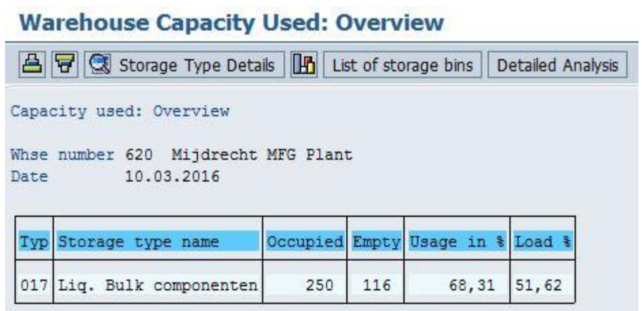
In this subsection the element storage bin is further explained and translated into warehouse utilization on bin level. The storage bin is the fourth element in the storage structure and are the next element after the storage sections. The number of bins depends on the scope of a specific section. As mentioned in subsection 4.1.2 the storage sections are divided block stacking lane areas, pallet racking and a kardex shuttle. These sections can be described as:

Block stacking lane areas
The lane areas in the warehouse are most suitable to store bulk pallets. Each bin is different in depth and can store between 2 and 34 pallets. The bins are divided into long bins and short bins. In the last decade additional short bins where created as reaction on the extra SKUs and the arrival small batches.

Pallet racking
The warehouse contains of eight pallet racking constructions. The constructions do all have the same depth but are different in height. The pallet racking constructions are divided into bins that all have capacity of one pallet.

Kardex shuttle
The kardex shuttle had a fixed number of bin locations used just for storing sticker rolls.

In a normal situation analyse of warehouse utilization is automatically done by SAP. The WMS function capacity load utilization in SAP in transaction code LX04 should measure the utilization rate. After entering the storage types SAP gives automatically the capacity load utilization. The data that is generated by SAP is showed in picture 4.8. In the picture storage type 017 is used as an example. The data generated gives information about occupied bins, empty bins and load in percentage.



Warehouse Capacity Used: Overview

Storage Type Details | List of storage bins | Detailed Analysis

Capacity used: Overview

Whse number 620 Mijdrecht MFG Plant
Date 10.03.2016

Typ	Storage type name	Occupied	Empty	Usage in %	Load %
017	Liq. Bulk componenten	250	116	68,31	51,62

Picture 4.8 - LX 04 warehouse utilization

In-depth analysis of the data show reveals the problem in the data. Picture 4.9 (List of storage bins) reveals that several bins are missing, in this example LA001 and LA008 are not included in the list. This problem could be declared because the bins could be used as 031 storage location. This is tested by entering the bin location into transaction LX04 instead of research per storage type.

Warehouse Capacity Used: List of Bins

Warehouse Capacity Used: List of Bins

Whse number 620 Mijdrecht MFG Plant
Stor.ty. 017 Liq. Bulk componenten

Sec	BT	StorageBin	S	Resreved	Empty ind.	Load in %
021	S8	LA002		X		10,53
021	S8	LA003			X	0,00
021	S8	LA004		X		100,00
021	S8	LA005		X		100,00
021	S8	LA006		X		89,47
021	S8	LA007		X		73,68
021	S8	LA009		X		78,95
021	S8	LA010		X		68,42

Picture 4.9 - LX 04 List of storage bins

Inserting all the storage locations in the warehouse result that there are issues with the bins who are active in one original designed storage types 017, 025 or 041. These storage types also include storage types that are active with a 031 storage type for line return material. The double activity cause that the warehouse capacity overview in LX04 gives incorrect numbers of utilization. This is because the bins are double occupied, double empty or full/empty in two storage types. The outcome of this investigation is that almost all the bin locations are active in both storage types due to the use of 031 for line return material. Conclusion is that warehouse utilization cannot be generated directly from SAP. Thus warehouse performance cannot be measured quickly, KPIs cannot be update and management cannot be informed from SAP.

Another approach to get an overview of the warehouse utilization is to perform a visual inspection in the warehouse. However, due to the size of the warehouse and the number of components this option of no value because it would take a warehouse employee a full time job in checking every day.

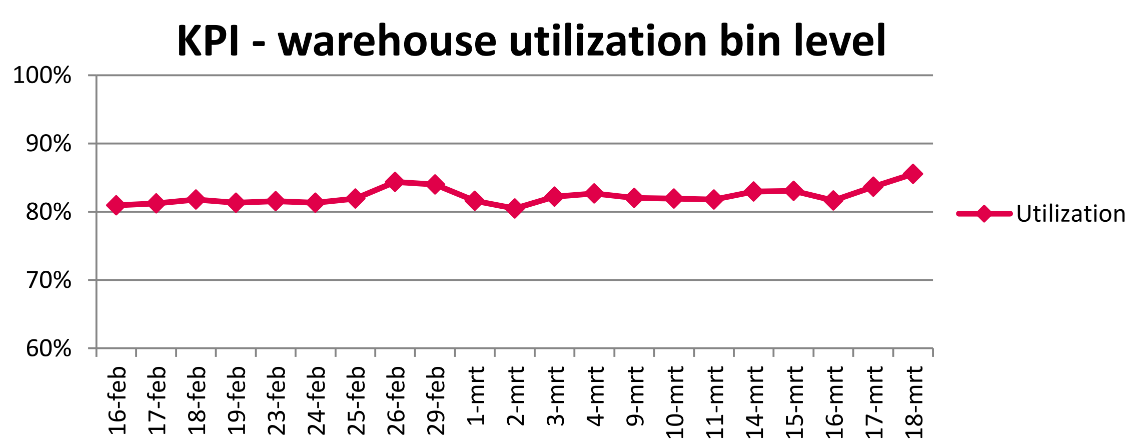
In this research an own approach is used. The first approach gave incorrect results and the second option take too much time. In the third option also LX04 is used, the list of bins selected per storage type is selected an exported from SAP to Microsoft Excel. Every bin location is examined if it is double active with the excel tool duplicate formatting. Active bins that are not occupied are filtered out. The bins that are active in more than one storage types are highlighted. The storage type with less occupation is filtered out.

Exporting, filtering and removing of bins give a good overview of bins utilization in the liquid warehouse. The result of this investigation is summarized in table 4.4 and a comprehensive analysis is showed in appendix VI.

Warehouse storage options	Number of bins
Long block stacking bins	234
Short block stacking bins	124
Pallet racking	1324
Kardex shuttle	377

Table 4.3 - Warehouse storage option

In order to analyse the warehouse utilization the total of bins has to be determined. In the liquid warehouse at Europlant the total of bins is 2095. Warehouse utilization is examined at bin level on daily basis. The graph of current warehouse utilization on bin level is given in graph 4.1.



Graph 4.1 -Warehouse utilization on bin level

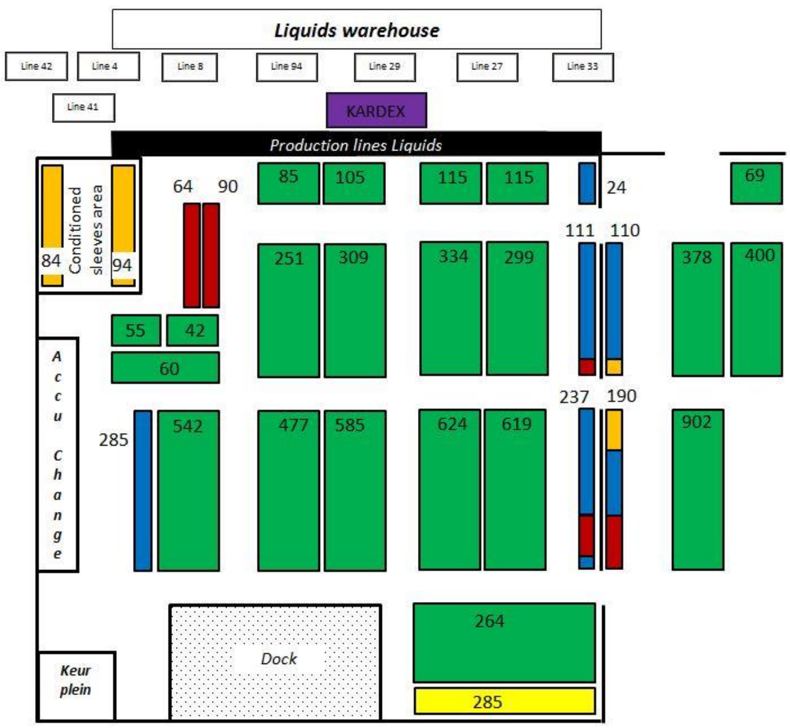
Graph 4.1 shows that the warehouse utilization on bin level during the measurement period is always above 80 percent. Yet this result is not a reliable outcome of warehouse occupancy because the block stacking bins in the warehouse have a storage capacity between 2 and 34 pallets per bin. The following step in this study is to get a clear overview of the number of pallets that the warehouse can handle and the warehouse utilization on pallet level.

4.3.7 Storage capacities and mapping on pallet level

After researching the warehouse on bin level the next step in this research is examining warehouse utilization on pallet level. Examination on pallet level gives insight about the availability in the liquids warehouse on daily basis. Numbers about warehouse utilization on pallet level give further insight in warehouse efficiency and the risks can be analysed.

The first step is to combine the data about the bins in the warehouse with the number of pallets. SAP transaction LS03N, Display storage Bin, is used to determine the number of pallets that can be stored per storage bin. However, after inserting the bin location into SAP the result is that the capacity of pallets per bin in SAP not correspond with the real capacity. Due to this lack of the correct settings WMS is disabled and capacity cannot be obtained.

Visual inspection and interviewing the warehouse administrator revealed the correct numbers. Picture 4.10 gives an overview of the pallet availability in liquids warehouse. Per storage type is determined the correct numbers of pallet per bin location.



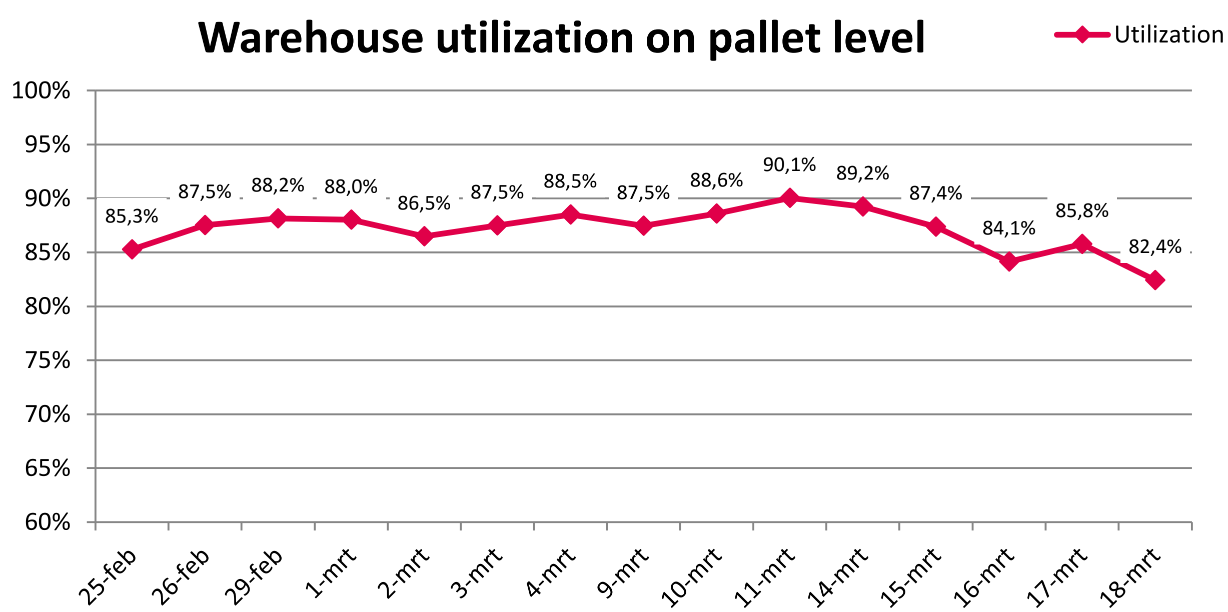
Color	Stor. Type.	Number of bins	Number of pallet locations
Green	017	358	6629
Orange	025	224	224
Yellow	DD-031	36	36
Blue	041	816	816
Purple	043	377	-
Red	044	248	248
X	045 In Aerosols Warehouse	36	36
	Total	**2095**	**7985**

Picture 4.10 - Pallet numbers per storage option

To determine the warehouse utilization, the number has to be established on daily basis. Per bin location research has to be done into the status of availability to store new components and to number of pallets that can be add to a bin. Important is to keep in mind that components cannot be stored with different components due to the risk of mixed components issues. So this study, no account is taken of the capacity load utilization of single bins. A bin location is only available when it is total empty.

The total of pallet capacity in the liquid warehouse is 7985. Included in this research are the storage types 017, 025, 031, 041, 044 and 045. Storage type 043, used for storing pack code stickers in the kardex shuttle, is left out of this study because the kardex shuttle can only be used to store rolls with pack code stickers. The shuttle system cannot handle pallets.

In this research the availability is reviewed on daily basis over a period of 15 days. Results of this research are portrayed in graph 4.2. Comparing both graphs show that the utilization on pallet level is higher than the utilization on bin level. This can be declared by the fact that bins used for block stacking bulk storing can handle multiple pallets in one storage bin.



Graph 4.2 -Warehouse utilization on pallet level

4.3.8 Summary of the storage strategy

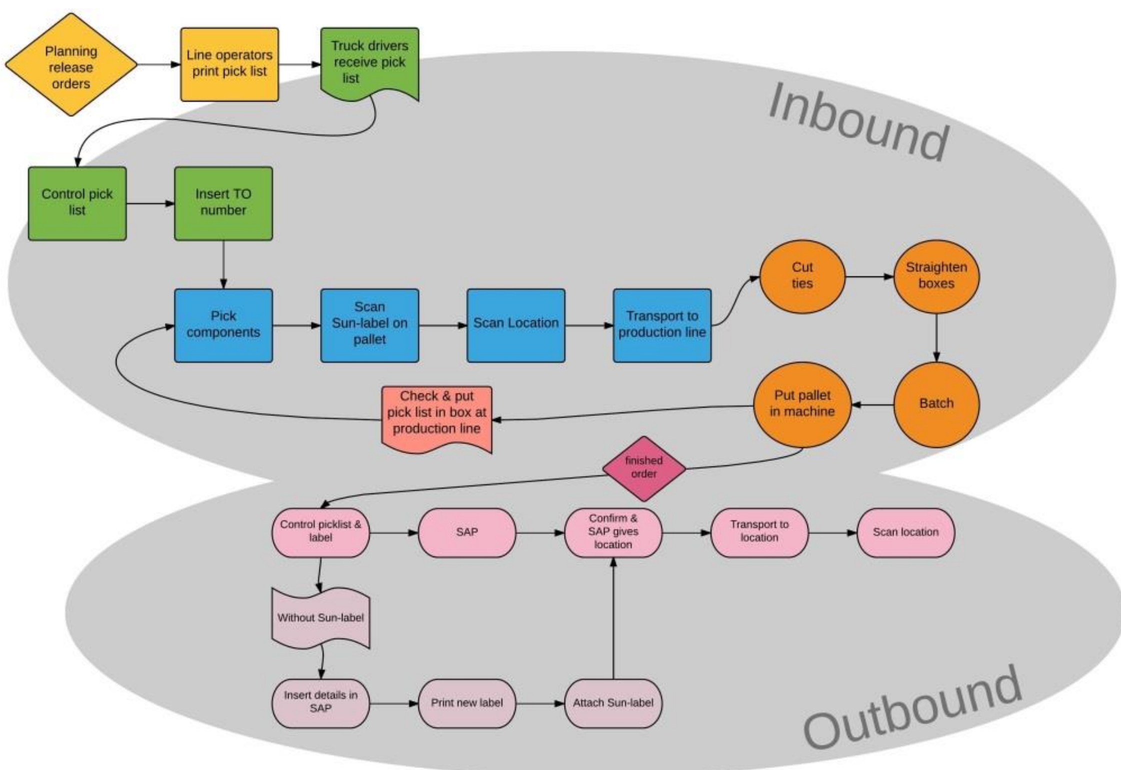
Due to the length and detailed description of the current situation in the storage process this section provides a brief summary. Europlant's liquids warehouse consist of 48980.75 cubic meters. The maximum pallet occupancy is 7985 pallets that can be stored in block stack locations and pallet racking locations. The warehouse also houses a kardex shuttle to store rolls with pack code stickers. The utilization levels in the warehouse are determined during this research on 82.4 percent on bin level and 87.1 percent on pallet level. These numbers have been obtained by a devious and time consuming calculation. The numbers cannot be acquired from SAP by employees in the warehouse and management cannot be informed about utilization levels on daily basis. Also, in the current situation no warehouse storage strategy has been implemented.

4.4 Picking and line supply process

The last process in the liquids warehouse is the picking and supply of components to the production line. This process is important to operations because wrong delivery of components can cause mixed components, scrap, safety issues and machine breakdowns. Late supply of components can cause machine stops that have a detrimental effect on the overall equipment effectiveness (OEE). Picture 4.11 contains a clear overview of the picking and line supply process. The picture is divided into two logistical processes, inbound logistics and outbound logistics. The inbound process is the process that components are supplied towards the production line, while the outbound logistics is the process where components are returned from the production line back into the warehouse.

In the inbound production process starts when the team coach (responsible of managing daily operations & planning) releases a production order. After the production order is received at the production line the pick list is printed and checked by the line operator. The truck driver receive the pick list from the line operator, controls the pick list again and enters the Transaction Order (TO) number into SAP on the reach trucks terminal. The following step is that the truck driver drives to the storage location and scans both pallet and the location, followed by transport of components to the production line.

The components stored with storage type 031 do not have to be scanned by the truck driver. The pick list contains the information of the storing location and the number of components needed for the specific production order. Because scanning is not necessary for the picked component that is stored with 031 storage type, components have to be write-off after the production order is finished. The warehouse manager has a full time job in correcting all the issues occur with this procedure.



Picture 4.11 - Overview of the picking and line supply process

When no problems are faced in the picking process the truck driver can transport the components towards the production line. At the production line are areas indicated where the components should be placed, due to safety regulations. Tasks that are necessary in the process as tie cutting and box straitening have to be done before the pallets can be put on the pallet conveyor system. After finishing the pick list according to the production demand the line operator put a new pick list in a box near the production line.

In order to reduce work pressure during the picking and line supply process the driver is allowed to use space, next to the production line, as buffer zone for pallets. Buffering of material is called batching. Truck drivers need to adhere to rules regarding the maximum number of pallets batched at the production line. In practice it often happen that truck drivers place more pallets in the buffer zone than allowed and batch even in the warehouse. Exceeding of the batching rules occurs in particular with components that have the highest pick frequency.

Differences in pick frequency occur due to different quantities of components placed on a pallet. An example of quantity differences is displayed in table 4.4. The popularity of picking bottles is much higher than picking popularity of trays at production line 27 due to the quantity of components per pallet.

Line 27 Liquids				
Component	Bottle	Caps	Valves	Trays (12 per pack)
Total on pallet	840	8600	8640	2700
Required per shift	79	8	8	3

Table 4.4 - Amount of components needed per shift at production line 27

Picture 4.11 also includes the outbound process of production line. Outbound components are materials that have to be transported from the production line back into the warehouse. First, the truck driver has to check if the component code correspondent with the pick list. The following step is to check whether there is a Sun label attached to the component. If so, the truck driver has to insert the component code and quantity in SAP with the terminal. SAP gives automatically the location the line returned material have to be placed. After transport the truck driver has to scan both Sun label and bin location. If the Sun label is missing the truck driver has to print a new Sun label first and complete the same steps as mentioned when the line returned material do have a Sun label. All line returned materials are stored with storage type 031 as mentioned before in subsection 4.3.5.

4.5 Current data collection and KPIs

Currently no performance measurement is done in the liquids warehouse. Once a month cycle count is done by the warehouse coordinator and the warehouse administrator has a full time job correcting stock levels. Furthermore no data is analysed and no KPIs are measured over time. Subsection 4.3.5 describes that collecting data from SAP is a major problem due to the decisions according to the storage types in the past.

Thus, current data collection and performance measurement in the warehouse is substandard. Nevertheless, in other departments of Europlant the situation is the other way around. Good examples are the SHE department (Safety, Health and Environment) and the planning and operation departments. At these departments the use of KPIs is fully integrated and used on daily basis. These departments use the indicators in the first place to measure their current performance and subsequently as measurement tool to maintain performance. If the results of the indicator show a decrease in performance it is recognized on short terms and actions can be taken against the decreasing performance.

The absence of data collection and poor availability of performance measurement in the warehouse are the first bottlenecks that exposed. In order to give valuable answers to the research question, three months of this research are used to expose the bottlenecks in the liquids warehouse. Data is collected from SAP and measurements are done in the warehouse. According to the obtained data, the true bottlenecks are going to be exposed. In the following chapter the bottleneck are further described. The current performance of a bottleneck is expressed in KPIs. In the sequel of this study possible new alternatives can be judged on the improvement of the KPI.

4.6 Summary current situation

The component warehouse is divided in two different areas, a warehouse of the aerosols department warehouse and a warehouse of the liquids department. The focus in this research is on the liquids warehouse. Storing in this warehouse is possible in three different storage possibilities: block stacking lane areas, pallet racking systems and a kardex shuttle. The lanes and racking areas are suitable to store pallets in bins and the kardex shuttle had ability to store pack code stickers rolls.

In this study the processes are distributed into receiving & put-away, storage and the picking & line supply process.

Receiving & put-away
Per day on average cargo of 22 trucks is received at the dock. Alpla Mijdrecht is the most important supplier with 16 deliveries per day. After receiving of components and check for quantity and quality the truck driver have to do some administrational tasks before the components can be put away in the warehouse. Put-away goes by scanning of the pallets, where after SAP automatically designates a storing location. After transport to the location the truck driver have to scan both the location and the Sun label on the pallet again. In this process it often occurs that the truck driver can’t store the components because there is no warehouse availability.

Storage

Europlant's liquids warehouse consist of 48980.75 cubic meters. The maximum pallet occupancy is 7985 pallets that can be stored in block stack locations and pallet racking locations. The warehouse also houses a kardex shuttle to store rolls with pack code stickers. The utilization levels in the warehouse are determined during this research on 82.4 percent on bin level and 87.1 percent on pallet level. These numbers have been obtained by a devious and time consuming calculation. The numbers cannot be acquired from SAP by employees in the warehouse and management cannot be informed about utilization levels on daily basis. Also, in the current situation no warehouse storage strategy has been implemented.

Picking & line supply

Picking and line supply is an important process in the warehouse. If failures are made wrong component can be picked and quality issues can occur. Picking and line supply consist of inbound and outbound handling in the process. At the inbound process the truck driver is responsible for picking up component from the warehouse according to the pick list. The pallets must be scanned and transported to the production area. When a production order is finished the truck driver has to return the excess material back into the warehouse. If it is the case that components are stored with storage type 031, no scanning has to be done by the truck driver.

The pick frequency of the component differs due to different quantities of components placed on a single pallet. Pallets with low quantity of component per pallet must be picked more often than high pallets with high quantity. So, in order to reduce work pressure during the picking and line supply process the driver is allowed to use space, next to the production line, as buffer zone for pallets. This behaviour is called batching.

5. Current performance and bottlenecks

> This chapter gives answer to sub question 2: *"What bottlenecks are faced in the current processes?"* and sub-question 3: *"What KPIs can be used to measure the effect of the bottlenecks on performance?"* Due to lack of research and data on warehouse processes new data must be gathered. In section 5.1 this data is exposed in bottlenecks and the KPIs are also defined and calculated for each warehouse process. Section 5.2 gives the summary of the bottlenecks and KPIs selected in this study

5.1 Bottlenecks and KPI

Due the non-existence of KPIs the first step is to make the bottlenecks clear. KPIs used in this research must indicate waste which has a direct result on the performance. The first step is to define the bottlenecks in the current situation. The second step is to measure the performance and calculate the KPI related to the bottlenecks.

The bottlenecks in the current situation are exposed by analysing data from the ERP system and by observing the processes in the warehouse. By answering sub question *1. "How are the processes established in the liquids warehouse?"* in chapter 4, insight is gained regarding the current processes.

In this research the warehouse processes are classified into three processes: receiving and put-away, the storage process and the picking and line supply process. Per process one or more bottlenecks are defined and suggestions are made through observations, previous research and information gathered from the management and employees of Europlant. Also the ERP-system SAP enterprise is thoroughly investigated. The processes with the pertaining bottlenecks are listed below and further elaborated in the sequel of this chapter.

Process 1 - Inefficiency in the receiving and put-away process

Bottleneck 1: Inefficiency causes long throughput time in the receiving and put-away process

Process 2 - Inefficiency in the storage process

Bottleneck 2: Inefficient use of ERP-system in warehouse
Bottleneck 3: Insufficient knowledge of the own current performance in the liquids warehouse
Bottleneck 4: Inefficient storage strategy of components in the liquids warehouse

Process 3 - Inefficiency in the picking and line supply process

Bottleneck 5: Inefficiency causes long throughput time in the picking and line supply process

In the sequel of this research an analysis is done regarding the various degrees of inefficiency corresponding to the bottlenecks.

5.1.1 Inefficiency in the receiving and put-away process

Inefficiency in the receiving and put-away process is further analysed in this subsection. The current situation of the receiving and put-away process is described in section 4.2. An overview of the activities in this process is added in table 5.1.

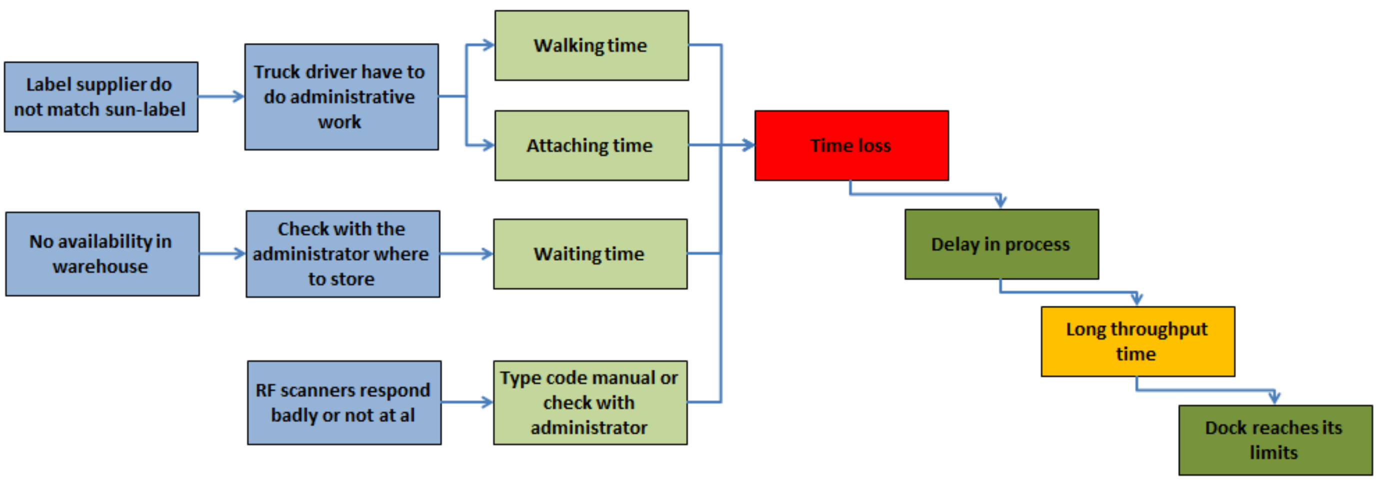
1	Arrival of supplier
2	Checking the quantity and quality of the goods
3	Dispatching of goods in ERP system and printing of the stickers
4	Attaching stickers to the pallets
5	Scanning components
6	Driving time towards storage location
7	Storing components in the correct bin and scan both pallet and bin location

Table 5.1 - Overview of the activities in the receiving and put-away process

Bottleneck

In this bottleneck the KPI is measured based on the productivity of the truck driver. Goal in this research is to reduce the non-value adding activities that cause long throughput time in the picking and line supply process.

Regarding observations and interviews with management and employees of Europlant a cause & effect diagram is made for exposing the bottleneck in this process. Picture 5.1 gives this diagram.



Picture 5.1 - Cause & Effect diagram bottleneck 1

The problems in the receiving and put-away process are viewed in the light green boxes. The truck driver receives the cargo at the dock from the supplier and checks for quality and quantity. Thereafter the truck driver has to dispatch the data into the ERP system and walk to the office. Stickers have to be printed and attached to pallets. The next problem faced during the observation period was that there was insufficient availability in the warehouse to store components. The truck drivers had to drive back to the office and ask the administrator where to store the components. The truck driver had to wait until the administrator decides where the components could be placed. The third problem faced in the process is with the RF scanners. It can occur that the system gives an error when the truck driver wants to scan the Sun labels. The truck driver has to type the code manually or ask the warehouse administrator for help. Already a kaizen (Lean tool, practice of continuous improvement) on the RF Scanners is going on at Europlant so this problem does not have the highest priority.

The problems result in a time loss and delay in the process. The problems cause long throughput times from the dock to warehouse. Due to the problems the truck driver cannot drive the pallets to a storage location and the dock area reaches its limits. If the dock area is full a new arrived truck can't be unloaded. When a new truck can't be unloaded it results in a delay in the whole receiving and put-away process. The delay has an impact on the throughput time of the receiving and put-away process.

Measuring the output
The tool Value Stream Map (VSM) is chosen to expose waste and give insight in the time per activity. Timing the activities of the processes gives insight in the total throughput time of the processes. A value stream involves mapping the flows within the operating system in order to identify the sources of loss (waste, variability and inflexibility) that block these flows and cause operational problems (Drew, McCallum, & Roggenhofer, 2004). Accordingly, Patel, Chauhan & Trivedi (2015) describe VSM as a process that likely expose a significant amount of non-value-adding activities which ultimately plays the role of loss are present in current processes. Activities can be classified in three types of values:

- Value adding activities (VA)
- Non-value adding activities (NVA)
- Necessary activities (NA)

The concept was introduced by the management Toyota in the 1950s and refers to the activities that the customer is willing to pay for. Customer is only willing to pay for the value adding activities and non-value-adding activities should be eliminated. The goal of VSM is to visualize the adding value activities, non-value adding activities and necessary activities. The sources of waste (non-value adding activities) can be detected by this tool. Waste is a process that doesn't result in reaching the goal or output.

Based on the theories of Toyota management, Womack & Jones (1996) popularized the concept and identified seven different types of waste:
- Over-production
- Defects
- Unnecessary inventory
- Inappropriate processing
- Excessive transportation
- Waiting
- Unnecessary motion

The receiving and put-away process is measured during previous research in 2010. The results from the previous measurement are rechecked as security that the results are still applicable in the current situation. Outcomes of this research are that during previous research no waiting time is measured, while at the current waiting time occurs because no storage space is available. In the previous measurements 36 minutes and 72 minutes is spend on additional work. Results from the measurements show that 50 percent of the additional work in the current situation is spend waiting for storage availability. Table 5.2 gives the overview of the activities of the truck drivers responsible for clearing the dock.

Day shift 07.00-15.00		**Evening shift 15.00-23.00**		
Activities	**Minutes**	**Activities**	**Minutes**	**Classification**
Transport	282	Transport	250	VA
Administration	72	Administration	72	NA
Handling	30	Handling	26	VA
Communication	30	Communication	30	VA
Additional work/waiting time	36	Additional work/waiting time	72	NVA
Total	**450**	**Total**	**450**	

Table 5.2 -Activities of truck drivers in receiving and put-away process

KPI bottleneck 1
The total average throughput time is chosen to be a suitable KPI for the receiving process in this research. The receiving process starts when a supplier places the load of the truck on the receiving dock. Per day on average 22 trucks unload goods at the dock. **The total throughput time of the receiving and put-away process is in the current situation 40.90 minutes per truck. The total time of the non-value adding activities in the current situation is 2.45 minutes. The total necessary activity in the current situation is 6.54 minutes per delivery.**

Improvement of the KPI speeds up the process and improves the pallet flow. Products can be stored faster by improving the pallet flow and the dock area occupation rate decreases.

5.1.2 Inefficiency in the storage process

This section of the study exposes three bottlenecks in storage process. The storage process is the most important process in the liquids warehouse, due to the number of bottleneck faced in this process. The first part of the section consists of the explanation about inefficient use of the ERP-system in the warehouse. Subsequent, in the second part of this section the second bottleneck; insufficient knowledge of the performance is described. Finally, further information about the bottleneck inefficient in storage strategy of components is provided.

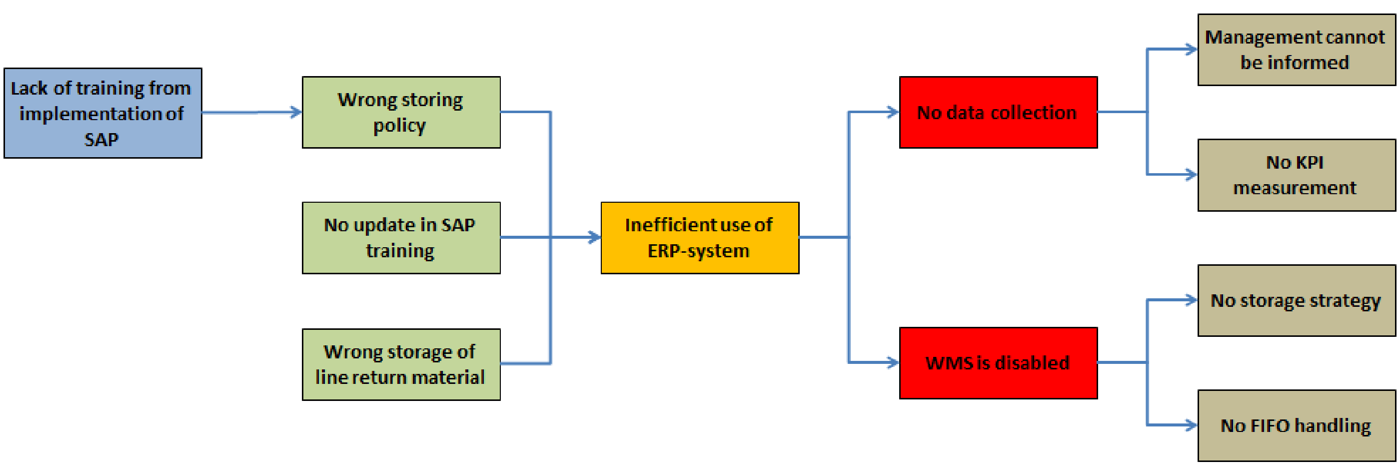
Bottleneck 2 - Inefficient use of ERP-system in warehouse

Management of Europlant in 2005 assumed that two days of training was sufficient education for warehouse administrators and truck driver to use SAP enterprise. Nevertheless, in subsection 4.2.2 is explained that due to this short period of training resulted in problems arose in the use of SAP. In later stadia little additional training was provided to upgrade the SAP knowledge level. Problem solving in SAP related questions has been done based upon own experiences or experience from colleagues working for SC Johnson. Resulting that the system that was original designed for all SC Johnson plants is different than the system that is used at Europlant.

These problems with SAP resulted that the basic settings of the component storage are not set correct. This incorrect storing of components settings led that WMS loses its functions and becomes disabled.

The second result due to the inefficient use of the system is that a performance cannot be measured, so management cannot be informed and no KPIs can be tracked. Warehouse utilization, storage space utilization and inventory turnover are examples that can imply the performance of a warehouse.

The problems and bottlenecks are summarized and pictured in a cause and effect diagram showed in picture 5.2.



Picture 5.2 - Cause and effect diagram bottleneck 2

Measuring the output

The output of the bottleneck is a percentage of correct used of the element storage type used in the ERP-system. The advice ensures management to get better insight about the performance of SAP in the liquids warehouse. SAP Enterprise professionals must be interviewed providing information about the correct setting of SAP and extra information about the possibilities of SAP WMS. Also trends and developments should be consulted in order to know what improvements are applicable at Europlant. As showed in table 5.3 in the current situation only one storage type is used correct compared to the storage types designed by SAP in 2005.

Storage type	Original designed storage types	Current usage of storage types	Correct use
017	Liq. Bulk components	Bulk components	✓
025	NFG Line Returns	Sleeves toilet duck/ Label storage	✗
031	RM process production loc	Free picking area and returnable goods	✗
041	Lic. Racks	Label storage	✗
043	Lic. Label Room	Pack code stickers	✗
044	Clocon Rack Cloth	Beechnut components	✗
045	Clocon Rack Pouches	L-42 beechnut cases	✗

Table 5.3 - Use of the storage types at Europlant

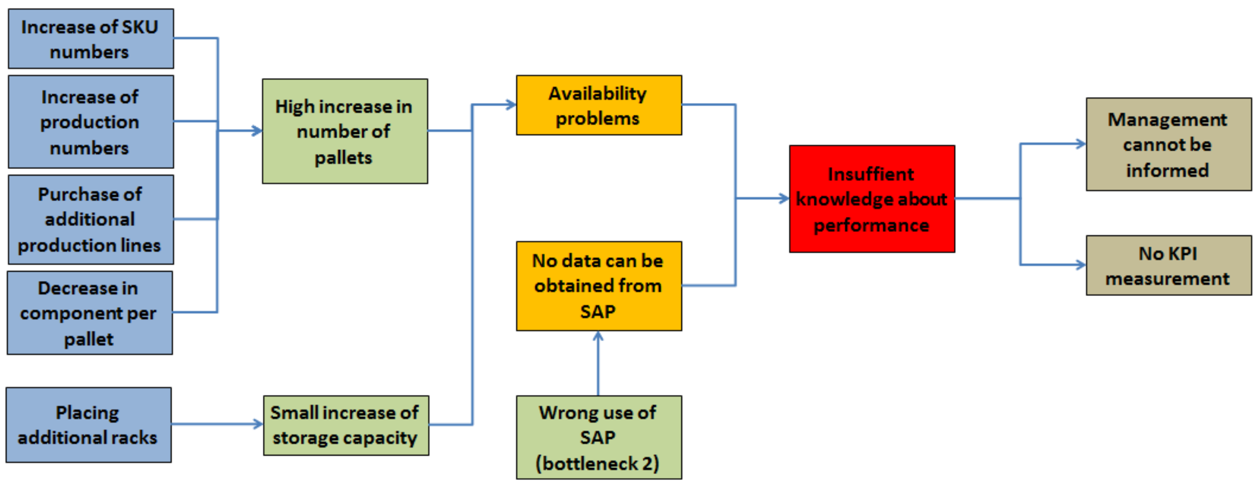
KPI bottleneck 2

In this research the goal is to use SAP correct in the warehouse and SAP WMS is able to support the storage standards. **In the current situation 14.3 percent of the storage types is used correctly.** This number is showed in table 5.3. The KPI in this research is the percentage of the number of storage types used correctly in the liquids warehouse. Improving the bottleneck must increase the performance of SAP in the warehouse, which result in better management involvement, a decrease in quality issues and implementation of FIFO. Also the improvements leads to better understanding and simplifying of the training methods.

Bottleneck 3 - Insufficient knowledge of the own current performance in the liquids warehouse

Increase of SKUs due to changes in labelling legislation, an increase of production due to higher demands and new product development, the purchase of additional production lines and a decrease of components per pallet caused an increase of warehouse utilization over time. These changes caused that availability in the liquids warehouse reduced in the last 10 year. Though, despite the fact that pressure grew on the utilization the warehouse has never been extended in space and since the introduction in 2005 of SAP the system has never been reviewed and little additional extra training is provided.

All these changes has result that warehouse employees started to complain that components could not be stored due to absence of availability. Interviews made clear that this issue occur frequent resulting that truck drivers have to wait until the warehouse administrator finds place and decides where to store the components. However, evidence of this matter could not be obtained from the system due to inefficient use of SAP. As described previous in bottleneck 2 warehouse personnel must be find space without use of the ERP-system. In 2015 the issue was at its peak, so management gave instruction to place extra selective pallet racking to add storage space. Yet availability pressure has not vanished and employees still have to be creative to store components.



Picture 5.3- Cause and effect diagram bottleneck 3

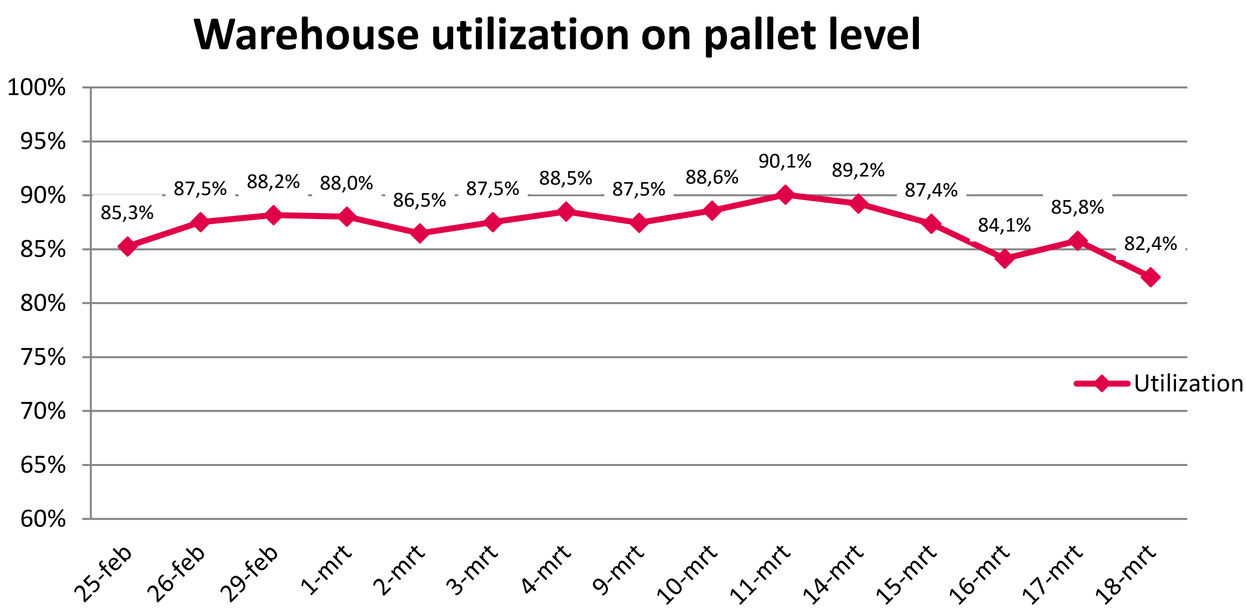
The main problem is that truck drivers and warehouse administrators experience that the warehouse reaches its limits in occupation and that components are stored too long before production without knowing what the risks are.

Measuring the output

The first KPI of the bottleneck is warehouse utilization on pallet level. The information is gathered from SAP and field research is done in the warehouse. Warehouse utilization on pallet level is measured by exporting the lists from SAP to Microsoft Excel. The bins that are active in two storage types have to be further researched. The storage types 017, 025 and 041 have issues with storage type 031. Line return materials are stored in the warehouse with storage type 031. The reason for this is because if the original storage type is used the components are placed incorrect on a new pick list. Filtering bins out that are active in both storage types gives the picture of warehouse utilization on bin level. A more specified explanation of this research is given in subsections 4.3.4 and 4.3.5.

To measure warehouse utilization on pallet level, field research in the warehouse is done to get an overview about the number of pallet locations of the block stacking lane areas. The pallet racking location all contain a pallet availability of one pallet. The total number of pallet locations situated in the liquids warehouse is 7985 pallets. Graph 5.1 portrays the recording period of 15 days. The warehouse utilization is measured in the period from 25 February until 17 March 2016 every morning.

In this research the kardex shuttle is left out of this KPI because it is a closed system and pallets cannot be stored. The kardex shuttle contains pack code sticker on rolls that are unpacked and stored after.



Graph 5.1 -Warehouse utilization on pallet level

Second KPI of this bottleneck is storage space utilization. As mention in subsection 4.3.1 the volume of the liquids warehouse is 48980.75 cubic meters. The maximum availability in the liquids warehouse is 7985 pallets. The pallets used in the production are mostly euro pallets. These pallets are 0.80 meters broad and 1.20 meters long. The average height of the pallets is 1.80 meters. The total volume in square meters of the stock is 13798.08 cubic meters. The storage space utilization used at Europlant's liquids warehouse is 13798.08/48980.75 = 28.17 percent.

The following step regarding this bottleneck is that literature must be searched providing information about the current warehouse performance compared to benchmark. Literature must be give indications about advantages and disadvantages about the current performance and further the opportunities and risks must be analysed.

KPIs bottleneck 3
The goal of this bottleneck is to measure and understand the current performance in the liquids warehouse. To measure the performance, warehouse utilization at pallet level has to be measured in the liquids warehouse. Thereafter, the measurement outcomes are compared in a literature review about warehouse utilization. Analysing the results provides information about the current performance. **The average warehouse utilization level in the liquids warehouse on pallet level is 87.1 percent. The storage space utilization is determined at 28.17 percent**

Bottleneck 4 - Inefficient storage strategy of components in the liquids warehouse

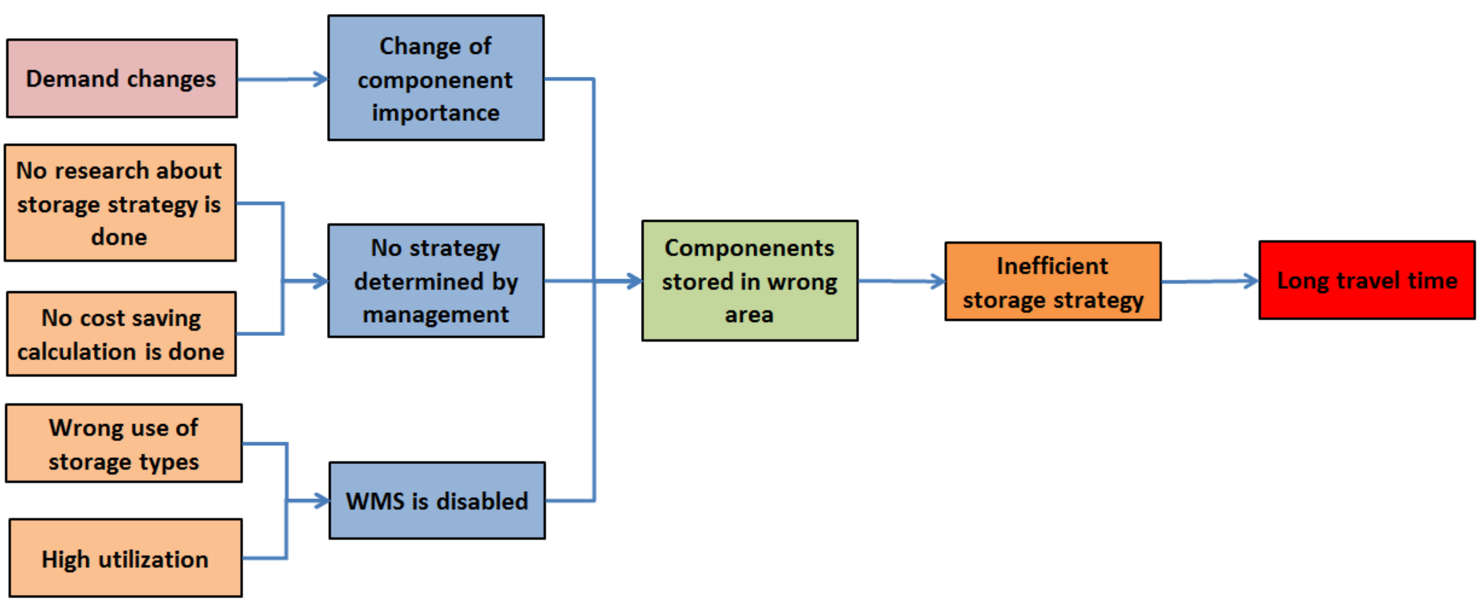
This part of the study consists of the hypothesis that the storage strategy of components in the liquids warehouse is inefficient. As described in subsection 4.2.2, Europlant's management has never implemented a storage strategy in the warehouse. Focus of management has always been on improving the production lines and the warehouse was kind of neglected.

Yet warehouse staff made some initiatives regarding strategy improvements. The first initiative was to store some components as close as possible to the corresponding production line. These components were stored with storage type 031 in a blocked area. Dependent on the stock level some block stacking bins were blocked. The components do not have to be scanned and FIFO is not executed. However, this is not storing policy is not always executable because of the high utilization in the warehouse. The second initiative was to store components that are returned from the production line on 031 storage location after a production order has fulfilled.

In every SC Johnson plant around the globe SAP Enterprise is used as ERP-system. In 2005 SC Johnson bought a customized edition from SAP that was also equipped with a warehouse management system. WMS is a tool integrated in SAP that can control the processing of the component movements and in manage inventory in the warehouse. However, due to the fact that SAP is not used efficient, the tool WMS is disabled.

The problems emphasize the bottleneck in the current situation. Analysis reveals that the process contains waste that must be eliminated. The problems of this bottleneck are also viewed in a cause and effect diagram in picture 5.4.

The purple box cannot be influenced. Demand changes by customers cannot be influenced by the warehouse. No research, cost saving calculations and wrong use of SAP Enterprise can be influenced. These three problems cause the bottleneck: Inefficient storage strategy. The bottleneck finally results in long travel time for reach trucks.



Picture 5.4 - Cause and effect diagram bottleneck 4

Measuring the performance

Travel time (transport) can be classified as waste in a process. Goal of this research is to reduce or eliminate the non-value adding activities. In this research the travel time per component is used as KPI. The travel time is based on the picking popularity of the components in the liquids warehouse.

To measure the travel time first an activity profiling has to be done. Bartholdi and Hackman (2011) argue that warehouse activity profiling is a measurement and statistical analysis of warehouse activity. The authors describe that is the first necessary step to almost any warehouse storage strategy project. When the importance customer orders are understood, the system can be driven. In the case of Europlant the production line are the warehouse customers.

A commonly used storage assignment policy for allocating inventory is cube-per-order index (COI); the position is based on the volumes of the components. Due to the fact that headquarters regulates volumes it is possible that volume is only for strategic reasons on stock. So in this study the storage assignment is based on the picking popularity of the components. From the S&OP of November 2015 and February 2016 data is obtained and analysed according the following formula:

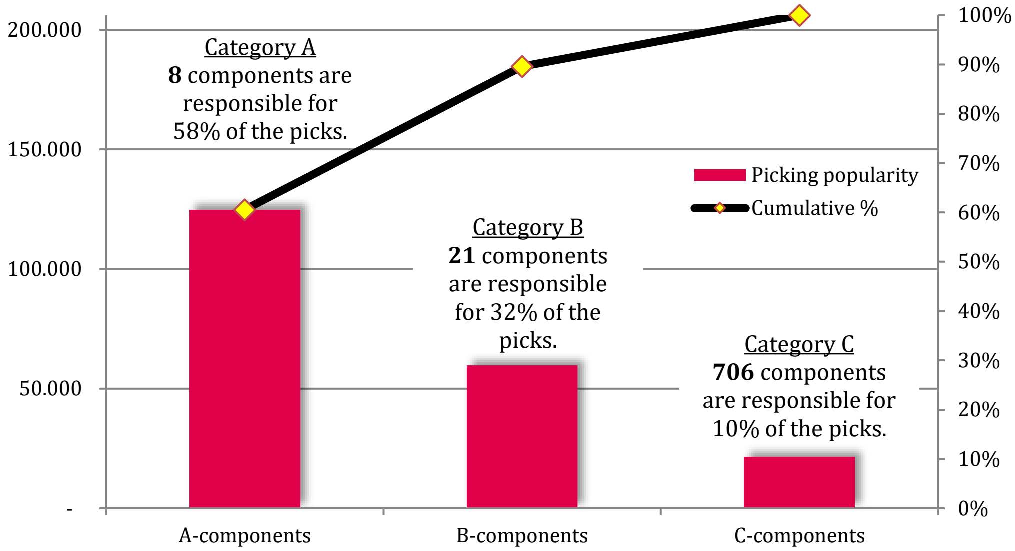
$$\textit{Picking popularity per component} = \frac{(\textit{Forecasted SKUs / Component needed per SKU})}{\textit{Number of components per pallet}}$$

Picture 5.5 gives an example of the Excel sheet belonging to the popularity of picking.

SKU	Forecast	Comp. Code	Component name	Type	Forecasted number 2016	Components per pallet	Popularity of picking
621442	204936	**742081**	LA PCST MM Fresh 750ml/2x6/MENA	Packcode 12-pack	*17.078*	*480*	**35,58**
	204936	**715363**	Bottle Duck White NO TWD 750ml	Bottle	*204.936*	*1.296*	**158,13**
	204936	**750339**	Cap 20mm PP CR Yellow	Cap	*204.936*	*84.000*	**2,44**
	204936	**750340**	PC Insert InjM LDPE Toilet Duck	Inserts	*204.936*	*120.000*	**1,71**
	204936	**741697**	CC RSC TDuck 750ml/2x6	Carton 12-pack	*17.078*	*480*	**35,58**
	204936	**834316**	LA Shslv MM SqzS HRSL VFrsh 750ml/12Mena	Sleeve	*204.936*	*160.000*	**1,28**
621492	237072	**715363**	Bottle Duck White NO TWD 750ml	Bottle	*237.072*	*1.296*	**182,93**
	237072	**742078**	LA PCST MM OcnForce 750ml/2x6/MENA	Packcode 12-pack	*19.756*	*3.500*	**5,64**
	237072	**750339**	Cap 20mm PP CR Yellow	Cap	*237.072*	*84.000*	**2,82**
	237072	**750340**	PC Insert InjM LDPE Toilet Duck	Inserts	*237.072*	*120.000*	**1,98**
	237072	**741697**	CC RSC TDuck 750ml/2x6	Carton 12-pack	*19.756*	*480*	**41,16**
	237072	**834315**	LA Shslv MM kSqzSHRSLVOcnFrc750ml/12Mena	Sleeve	*237.072*	*160.000*	**1,48**

Picture 5.5 - Example of the excel sheet regarding to the picking popularity

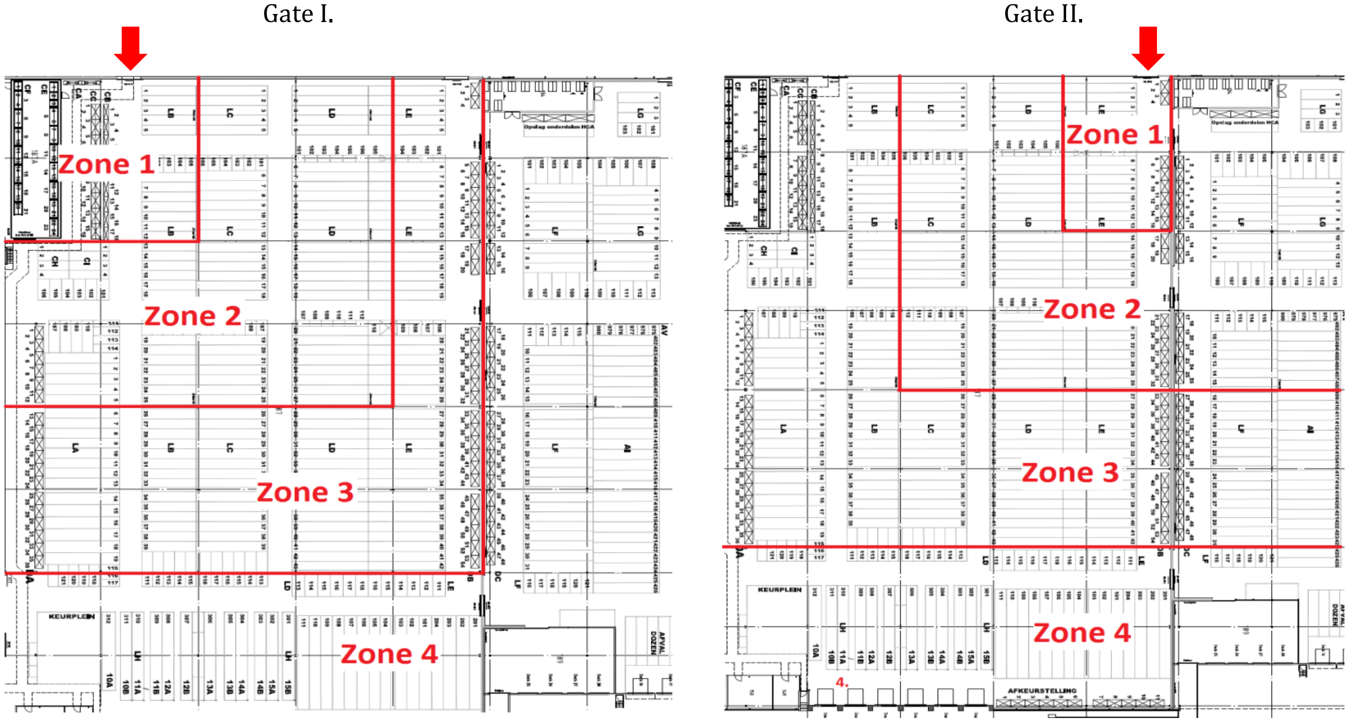
The next step is to combine all the components of the eight production lines related to the liquids warehouse together. The pack code stickers are not included in the ABC analyse because the rolls are always stored in the kardex shuttle, so no availability in the warehouse is used. Analysis show that totally 735 different components are stored in the liquids warehouse. A deeper investigation into the analyse show that only 8 components are responsible for 58 percent of all the picks done by the truck driver. That is only 1 percent of the components stored in the warehouse. This is the A category. The B category consists of 21 components for 32 percent of the picks. That is just 3 percent of the total components. The other 706 components directly related of production liquids products are responsible for 10 percent of the picks. That is 96 percent of the components. The Excel Pareto in graph 5.2 gives an overview of the ABC analyse.



Graph 5.2- 58-32-10 Pareto graph of the components stored in the liquids warehouse

The next step in analysing of the KPI is to measure the travel time in the current performance. No elaborate storage policy has been implemented in the warehouse. The travel time in the current situation is calculated based on the location zone where the components are stored. The zones are classified by the gate (indicate with red arrow) located the closest to the production line. Line 4, 8, 41 & 42 are supplied via gate I and 27, 29, 33 and 94 are supplied via gate II. Per zone the average time is determinate by measuring the average travel distance divided by the travel speed of a reach truck (2.77 m/s). An overview of the zones is given in picture 5.6. The starting point is the gate where the production line belongs to. The travel time between the gates and the production line are excluded in this research because it is equal in the old and new situation.

Gate I. Gate II.



Picture 5.6 - Zone distribution gate I & II

From SAP the locations are extracted where the components are stored. The locations are linked with the storage zones and multiplied with the picking popularity per component. The theoretical approximate of the driving times is checked by real-life measurement of the actual driving times. The driving times of a retour trip to the zones from the gates are showed in picture 5.4.

Gate 1		***Gate 2***	
Zone 1	10,4	Zone 1	10,4
Zone 2	38,9	Zone 2	35
Zone 3	54,6	Zone 3	51,8
Zone 4	68,7	Zone 4	63,5

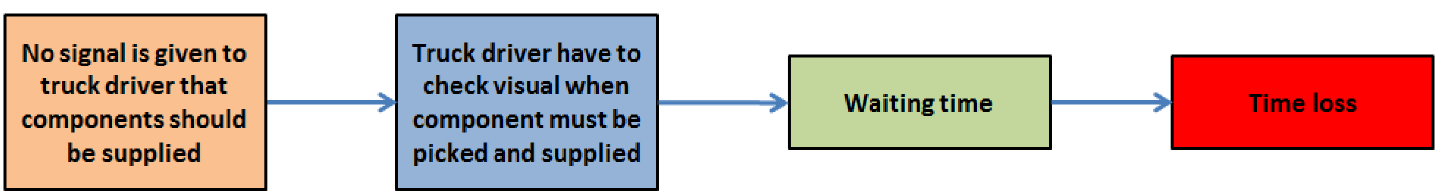
Table 5.4 - Time table of average travel time to zone

KPI bottleneck 4:
The total travel time is calculated by use of the average drive times in a zone. The current travel distance is calculated by multiplying the average travel time of a zone multiplied by the zone location of the components and the picking popularity. **The total travel time in the current situation based on fiscal 2015-2016 is 2429.19 hours.**

5.1.3 Inefficiency in the picking and line supply process

The inefficiency in the picking and line supply process is further analysed in this subsection. The picking and line supply in the current situation is described in section 4.4.

Bottleneck
In this bottleneck the KPI is measured based on the productivity of the truck driver. Goal in this research is to reduce the non-value adding activities that cause long throughput time in the picking and line supply process. Additional management wants to know if batching at the production line is necessary. Management position is that batching is needless and causes a higher risk factor for quality issues. A cause and effect diagram of this bottleneck is given in picture 5.7.



Picture 5.7- Cause and effect diagram bottleneck 5

Measuring the output
The measurement tool to investigate this bottleneck is the same as used with bottleneck 1. Value stream mapping is used to find where and when in the process the truck driver doesn't work efficient.

Previous research from 2010 is analysed and rechecked in a post-test. These post-test measurements are done to control if the results match the current situation in 2016. Table 4.5 gives an overview of the current activities of the truck drivers responsible for picking and supply of the production lines. Remarkable in this study is to notice that 36 percent or 161 minutes of the time the truck driver is waiting for the next task.

Day shift Truck driver					
Activities	**Time in seconds**	**Frequency**	**Total time in minutes**	**Percentage**	
Transport	110	55	101	22 percent	VA
Handling pick list	60	11	11	3 percent	VA
Handling bottles	50	87	73	15 percent	VA
Returning pallets	240	8	32	8 percent	VA
Line returned material	110	13	24	5 percent	VA
Emptying containers	240	4	16	4 percent	VA
Communication			32	7 percent	VA
Waiting time			161	36 percent	NVA
Total			**450**	**100**	

Table 5.5 - Activities of a truck driver in the picking and line supply process

KPI bottleneck 5
The total average throughput time is chosen to be a suitable KPI for the picking and line supply process in this research. The picking process starts when the truck driver receives the pick list till the moment that the truck driver places the last pallet on the pallet conveyer system. **The total work time of a truck driver is 450 minutes. The total time of the non-value adding activities is 161 minutes.** Considering this amount of waste in the process, this bottleneck is a serious problem. Improving this KPI is going to make the work of truck more efficient. Time that the truck driver stands still should be converted into efficient work time.

5.2 Summary bottlenecks

The assumptions for bottlenecks in the current situation in the liquids component warehouse are validated in this chapter. The bottlenecks are exposed regarding previous research, observations, interview and analysis of ERP data. The bottlenecks and their performance are summarized in this section.

Process 1 - Inefficiency in the receiving and put-away process

Bottleneck 1: Inefficiency causes long throughput time in the receiving and put-away process

KPI	**Time**
The average total throughput time per truck	*40.90 minutes*

Process 2 - Inefficiency in the storage process

Bottleneck 2: Inefficient use of ERP-system in warehouse

KPI	**Percentage**
Number of correct storage types	14.3 percent

Bottleneck 3: Insufficient knowledge of the own current performance in the liquids warehouse

KPI	**Percentage**
1. Warehouse utilization	87.1 percent
2. Storage space utilization	28.17 percent

Bottleneck 4: Inefficient storage strategy of components in the liquids warehouse

KPI	**Time**
Total travel time	2429.19 hours

Process 3 - Inefficiency in the picking and line supply process

Bottleneck 5: Inefficiency causes long throughput time in the picking and line supply process

KPI	**Percentage**
Non-value adding activities in picking and line supply process	36 percent

6. Literature review

> This chapter gives answer to the sub-question: *"What does literature say about improving the performance measured by these KPIs and in what way can the performance of the bottlenecks be improved?"* The first part of the sub-question is answered in section 6.1, description of the approach for solving the bottlenecks. Section 6.2 contains the execution of the plan of approach. Relevant information is searched for solving the bottlenecks and influencing the KPIs. Finally a summary is added in section 6.3 with the suitable alternatives for solving the bottlenecks.

6.1 Approach for solving the bottlenecks

This section contains information on how to find relevant literature or information to solve the bottlenecks. An approach is established for each bottleneck that is defined in chapter 5. The literature that is searched for provides alternatives for each bottleneck. All information is searched by use of the databases Google Scholar, Scopus and Web of Science. The databases that cover the most relevant papers in the research area are Operation Management and Logistics Management.

6.1.1 Receiving and put-away process

The same tool that is used for exposing the bottlenecks, VSM, can be used for mapping a future state. The root cause of this bottleneck is more a practical problem than a theoretical problem for which a possible solution can be found in the literature. No literature is searched for this bottleneck, but VSM and real life simulation is used for improving the KPI of this bottleneck in Chapter 7.

6.1.2 Inefficient use of ERP-system in component warehouse

There are three main problems that cause that the ERP-system is used wrong.
1. Wrong storing policy
2. No update in SAP training
3. Wrong storage of line returned material

Approach:
No literature is searched regarding the problem how SAP works correct in the warehouse area. The goal in the research cannot be found in academic literature. Section 4.3 gives a comprehensive description of the bottleneck. Due the high technological difficulty of the problem next step in this research is to interview SAP specialists and SAP super user at SC Johnson.

6.1.3 Insufficient knowledge of the own current performance in the liquids warehouse

There are three problems that have an influence in the exposure of the current performance in the liquids warehouse.

1. Availability problems
2. Problems in obtaining data from SAP

The solution for these problems must give an overview of the overview of the current performance in the liquids warehouse.

Approach:
First information must be gathered how performance should be measured in current situation. Goal is to find models and formulas for calculating the performance in the liquids warehouse. The next step is to find literature that explains how the bottleneck can be solved. This performance is going to be compared with available information according to the bottleneck.

6.1.4 Inefficient storage strategy of components in the liquids warehouse

The problems with the storage strategy are caused by several problems:

1. No strategy is implemented by management
2. No knowledge about component popularity
3. SAP is not working efficient

Solving these problems must result in a decrease of the average order pick time and the total travel distance.

Approach:
Literature must be found in which ways components could be scaled if terms of importance. The results on the importance of components are compared with literature about storage strategies. The strategy that is most applicable for Europlant liquids warehouse must be found. Furthermore research must be done regarding SAP in contribution with the new strategy.

6.1.5 Inefficiency in the picking and line supply process

The problems that are faced regarding picking and line supply process.

1. Waiting times
2. Batching

In the current situation 36 percent of the working time of a truck driver is spent on looking and waiting if components are needed at the production. This stand-by activity should be converted to efficient activities. Literature has to be searched for this bottleneck. Hence, this bottleneck is also a practical problem than a theoretical problem, improvements must be made in order to reduce the waiting time and enhance the flow of components to the production line.

Approach:
Theory must be consulted in order what improvement can be made to the efficiency in the processes. Goal is to implement line supply alternatives.

6.2 Literature review

The search strategy is mentioned earlier in the project approach section 3.3. Relevant literature is searched in the databases: Scholar, Scopus and Web of Science. These databases cover the relevant papers in the area of Operation Management and Logistics Management. Bottom up search is used for finding relevant literature. Papers are also found by use of backward searching; papers are looked up that are referenced by papers that are found by use of the databases. Finally information is gathered from several books in the area of warehouse management. The literature found per bottleneck is described in the following subsections.

6.2.1 Insufficient knowledge of the own current performance in the liquids warehouse

Keywords in finding current performance indicators in relevant literature are: warehouse utilization, utilization risks, overflow, FMCG benchmark and warehouse occupancy risks.

Storage and order picking are complex often labour intensive processes that determine warehouse performance to a large part (Faber, de Koster & Smidts, 2013). Karácek (2013) furthermore argues that it is highly important to monitor these processes in order to measure and maintain performance. The author describes the storage process as one of the most important parts of the management system because management wants to know which goods are available and where. However, in operational literature is stated that performance measurement is important but extensive systematic research into warehouse performance and warehouse utilization seems to be lacking.

What influences warehouse performance
The core concept that captures the effects of the organization's environment on its performance is uncertainty (Thompson, 1967). Operational theories describe two major dimensions of uncertainty: complexity and dynamism (Hatch, 1997; Premkumar and Zailani, 2005). Complexity refers to the number and diversity of the elements in an environment (Hatch, 1997). A warehouse system can be characterized by the components that have to be stored and picked, the processes to store and pick these components, and the orders that request the delivery of these products. Complexity increases as the number and diversity of components, order lines, and processes increase (Faber et al., 2013). In the case of Europlant all complexity features have increased over the last period of 10 years, so uncertainty in complexity has increased. This is confirmed by employees arguing that warehouse occupancy has increased in the last 10 years.

In general, if the number of SKUs increases, more storage space is needed and more products have to be registered and managed in the warehouse information system. Some warehouses have a greater number and/or variety of processes and some of these activities are labour intensive and have substantial impact on order throughput time. The number of order lines is a good indicator for the total amount of work in order picking and thereby for the total amount of work to be done in the warehouse. Task complexity affects warehouse management through the comprehensibility of the work to be done (Faber et al, 2013).

The second dimension of uncertainty is dynamism. Dynamism is characterized by the rate of change and technology innovation in the industry as well as the uncertainty or unpredictability of the actions of competitors and customers (Thompson, 1967). Faber et al. (2013) describe factors relevant to the warehouse's goal setting as; consumers, competitors, suppliers, government, technology, economy, and labour. These settings have a direct influence on Europlant warehouse performance.

Applicability at Europlant
In this study both complexity and dynamism uncertainty influence the performance of the liquids warehouse. Faber et al. (2013) describe that if the uncertainty in a warehouse grows the planning, rules complexity, control refinement and information system specificity have to be controlled. So in order to keep the uncertainty controlled, it is important that Europlant's management should be informed about current performance. However, in the current situation at Europlant's warehouse no information can be gathered and no information can be provided to management.

In this study information about utilization has been gathered via a complicated method using SAP and Microsoft Excel. The mean warehouse utilization rate in the liquids warehouse during a measurement period of 15 days is established on 87.1 percent. Frazelle (2002) suggests that as occupancy rates exceed 86 percent utilization, productivity and safety decline exponentially with each percentage point increase in occupancy. The author goes on to say that if a warehouse managed in real time might be able to operate at 90 percent occupancy, although this is completely dependent on the accuracy of the system and the experience of the warehouse team (Frazelle, 2002). Other authors write that the occupancy rate in the warehouse should not be higher than 80 percent, because of the risk of overflow (Deng, Yuan & Yan, 2015). During the measurement period, the utilization level at the aerosol warehouse was much lower. Enough storage space is available and processes could continue without waiting time for truck drivers. In the aerosols warehouse is the average warehouse utilization 78 percent. However, one month after measuring the utilization level at the aerosol warehouse, the level had increased to 85.3 percent. Because of this level no space can be added to the liquids warehouse, because the aerosol warehouse also needs the capacity.

The occupancy rate suggested by Frazelle (2002) is too high for Europlant. In chapter 5 is argued that the number of pallet locations in the liquids warehouse is 7985. At an 86 percent utilization rate the availability on pallet level is only 1117 pallets. With an average supply of 726 pallets per day there is only 1.5 day of free space before overflowing. Risks of overflow are too high at 86 percent utilization. The utilization standard which is used in this study is 80 percent. Docks can be still unloaded 2 days after an issue occurs. The vendor schedulers can react to the issues by cancelling or delay the ordered components at the supplier.

6.2.2 Inefficient storage strategy of components in the liquids warehouse

Keywords to find information relevant to storage strategies in the warehouse were among others; storage strategy, ABC storage, random storage, zone storage, order picking, warehouse management, warehouse design and warehouse logistics. Goal of this subsection is to review relevant literature about storage strategies in the liquids warehouse.

Storage strategy
Storage strategies are often examined in literature about operational management and logistics management. In this literature study the following search strategy is applied: articles are scanned by titles and summary. In this subject several articles are read following this subject.

De Koster et al. (2007) provided the article that delivers the most useful overview of the available storage strategies. In their paper the five most frequently used storage strategies are further described: Random storage, closest open location storage, dedicated storage, full turnover storage and class based storage. These storage strategies can all be adapted in the component warehouses at Europlant. The storage strategy that is most applicable at the liquids warehouse can also be copied and implemented to the aerosols warehouse in the future. In this subsection all storage strategies are described briefly. Literature from other articles relevant in this study is added per subject.

Random storage
In random storage assignment, products are allocated arbitrarily to one of the available storage bins. The random storage strategy is the easiest policy to implement but can only be applied to a computerized warehouse (Le Duc and De Koster, 2005). Advantage of this strategy is the high utilization rate of the warehouse. However the strategy is not ideal, due to the possibility of large travel times from having to traverse the entire warehouse (Petersen, 1999). It is suitable for warehouses which have a space limitation, as they are highly space efficient. However, this comes at the expense that travel distance increase (Choe and Sharp, 1991). Random storage is the most common storage policy used in warehouses today (Petersen, 1999). Randomized storage policies can be calculated by calculating the average travel time per location regarding the uniform probability (Petersen, 1997).

Closest open location storage
This storage strategy is often applied in non-computerized warehouses. Pickers may follow a similar assignment pattern in choosing the location for storage. The first free location is allocated for storage. This leads to a high utilization of the front of the warehouse and low utilization at the back (De Koster et al., 2007). According to Hausman, Schwarz and Graves (1976), when items are moved only by full pallets, random and closest open location storage achieve similar performance levels. The largest disadvantage is that the storage policy is driven by the employees and not by system. When an employee is not accurate or forgets where the SKU was stored problems can occur (Hausman, Schwarz and Graves, 1976).

Dedicated storage
The third strategy is dedicated storage. Hereby each product has a designated storage location, leading to inefficient space utilization. However, pickers can memorize the locations of each product, which decreases the overall searching time. A disadvantage of dedicated storage is that a location is always reserved and blocked, even when components are out of stock. Moreover for each component in dedicated storage a maximum inventory must be blocked. Compared to the random storage the space utilization is much lower. The advantage of dedicated storage is that the order pickers get familiar with the location of the SKUs.

Full turnover storage:
Components are assigned to location regarding their turnover. Products with a high turnover rate are stored close to the production and slow movers are stored in the back of the warehouse. Full turnover storage suffers from a significant drawback. When product demand and variety fluctuate, the method does not perform well, requiring frequent reshuffling. Caron, Marchet and Perego (1998) argue that this method is a less attractive storage assignment due to the information intensity compared to the random storage. A benefit of volume based policies is that picker's travel time is diminished (Petersen, 2002). Petersen (2002) thinks that volume-based storage is superior to random storage.

The full turnover storage strategy has a big overlap with the COI rule Cube per order index (de Koster et al, 2007). While the full turnover storage strategy only focuses on the turnover rate does the COI rule combines the demand rate with the required space. The COI of an item is defined as the ratio of the item's total required space to the number of trips required to satisfy its demand per period. Items with the lowest COI are placed closest to the depot (Heskett, 1964; Kallina and Lynn, 1976). The ratio is defined of the item's space to the number of trips required to satisfy its demand per period. Disadvantage of this strategy is the change of ratio.

Class-based storage:
One of the most popular storage policies employed by managers is class-based storage, which combines several of the methods mentioned above. Products are grouped into classes in such a way that the fast moving class contains a certain percentage of the products contributing a significant percentage to the turnover. Pareto's analysis describes 15 percent of the products which contribute 85 percent of the turnover. Each class is then assigned to a dedicated area of the warehouse. The storage within these classes is random (de Koster

et al 2007). The advantage of the class based storage is the less time to administer the policy regarding dedicated storage. Second advantage is the gain of travel time regarding the randomized storage strategy. The disadvantage is the reserving of extra locations in a zone, however this is less than with the dedicated storage policy.

From literature can be obtained that there are diverse ideas about the class division in a class based storage strategy. De Koster et al. (2007) describes the 15-85 rule, 15 percent of the SKUs contributes to 85 percent of the picks. The classes are mostly classified into three classed, but more can be implemented if this affects the travel time positively. An important argument the authors make is that in the warehousing literature, no firm rule exists to defining the class distribution. The class distribution compromises the number of classes, percentage of items per class, and percentage of the total pick volume per class.

Dekker et al. (2004) advice to perform experiments with the percentage of picks allocated to the classes. In the same article Dekker et al (2004) uses 70 percent of the picks or at most 15 percent of the SKUs to allocate in Class A. The next 20 percent of the pick popularity (to 90 percent) or at most 50 percent of the SKUs are assigned to Class B. The rest of the SKUs must be assigned to Class C.

Other commonly used Classed based strategies are, 20 percent of the SKUs that correspond with 80 percent of the picks in Class A, the next 15 percent of the picks (30 percent of the SKUs) in Class B and the remaining 5 percent in Class C. Or 66,6 percent of the picks (10 percent of the items) in Class A, 23,3 percent of the pick in Class B and the rest in Class C. The storage space needed by each class is determined by calculating how many locations are occupied by the products assigned to each class. Each zone must contain safety stock locations to cover peaks.

Method	**Advantage**	**Disadvantage**	**Applicable at Europlant**
Random storage	- High warehouse utilization rate - Not information intensive - No update needed	- Possibility of long travel time - System driven	Yes
Closest open location storage	- Order picker can choose location	- Employee driven - Human mistakes	No
Dedicated storage	- Familiar with locations - Positioning of products	- Location reservation even for SKUs that are out of stock - Administer intensive	No
Full turnover storage	- High rated turnover close to production - High sale rate = easy accessible	- Data intensive approach - Demand rate changes - Products assortment changes - Update intensive policy - Loss of flexibility	Yes
Class based storage	- Combination of random and dedicated - Flexibility - less time to administer regarding dedicated	- update of policy (new ranking) - more space needed than randomized storage	Yes

Table 6.1 - Applicability of the storage strategies at Europlant

Applicability of the storage strategy at the liquids warehouse
In this subsection several alternatives are considered for the storage strategy in the liquids warehouse. The storage strategy in the warehouse is discussed in the next subsection. Table 6.1 gives an overview of the discussed storage strategies and their advantages and disadvantages. The first discussed storage strategy, random storage is suitable for implementing at Europlant. The advantages and disadvantages of this storage strategy are showed using calculations in the next chapter. The closest open storage is not a suitable storage strategy for Europlant. The picker chooses the closest location for storage. The chance of making mistakes is too high regarding the high utilization rate and because the different truck drivers work in different shifts. Dedicated storage strategy is also not suitable for Europlant. Due to the high utilization and the large number of different components too little space is available in the liquids warehouse. Furthermore the full turnover strategy can be applied at Europlant. However, this policy is a high information intensive approach and each change in demand or assortment requires a reshuffling of stock. Components that are only seasonal produced can have the highest turnover. These components can be stored close to the production line but aren't picked during half of the year. The full turnover strategy is not further discussed as an alternative for Europlant. The last storage strategy, the class based storage, can be applied as a storage strategy for Europlant. Diverse policies and rules must be applied to the case for comparison.

6.2.3 Inefficient picking and line supply process

Petersen (1999) argued that the performance and efficiency of the order picking operation depend mainly on the following factors:

1. The demand pattern.
2. The layout of the warehouse.
3. The storage strategy.
4. Order distribution.
5. The routing and sorting method.

In the previous subsections storage strategy and warehouse utilization are described. Also the factors layout of the warehouse, storage strategy and the routing method are already described. This subsection includes the literature about the factors that not have been investigated in this study. In the sequel of this subsection the demand pattern and the order distribution are described elaborate.

In literature is order picking described as "the process of retrieving products from storage (or buffer areas) in response to a specific customer request" (de Koster et al, 2007). Order picking is the most labour intensive operation in warehouses with manual systems, and a very capital-intensive operation in warehouses with automated systems (Tompkins, White, Bozer & Tanchoco, 2010). For these reasons, warehouse experts determine that the order picking is the process with the highest need for productivity improvements (de Koster et al, 2007).

Table 6.2 gives the overview of the activities of the truck driver in the process with the associated operation factor.

Activities of truck driver during 1 shift			
Activities	**Percentage of time**		Order picking operation factor
Transport	22 percent	VA	Layout, storage & routing
Handling pick list	3 percent	VA	Order distribution
Handling bottles	15 percent	VA	-
Returning empty pallets	8 percent	VA	Storage strategy
Line returned material	5 percent	VA	Storage strategy
Emptying containers	4 percent	VA	Layout
Communication	7 percent	VA	Order distribution
Waiting time	36 percent	NVA	Demand pattern
Total	**100**		

Table 6.2 - Activities of truck driver and operation factor

Demand
Europlant is a production environment where the production line is the customer (receiver) of the components. The amount of components needed fluctuates per production line and production order.

The demand of components starts when truck driver receives the pick list. The truck driver picks the components before the change-over of the production line is finished. The line operator may insert the components of the new production order only if the production line is totally cleared and the component of the finished order are removed.

A truck driver can check the demand of the separate components on the pick list based on the size of the production order. Based on the demand of the production order the truck driver can determine the time between the picks. For example, Pack code are attached on a roll of 90,000 stickers, if a production order of 60,000 products is released one trip to the warehouse suffice for the whole production order. Other components with less numbers of components per pallet have to be picked more often.

The number of production lines the truck driver have to supply differs due to differences in work ability and the experience per truck driver. The truck driver has to check visually if components have to be provided to the production line. No signal is given to the truck driver if the production has issues and the demand stops or if the pallet conveyor is empty. Truck drivers must be stand-by and wait if the production line demands additional components. This waiting time is a non-value adding activity in the supply process.

As earlier mentioned Toyota started as one of the first global manufacturers investigating efficiency improvements. The basis of the Toyota efficiency improvement was an absolute elimination of waste. One of the pillars that this is based on is just-in-time production. In just-in-time production, a later process goes to an earlier process in the operation flow and withdraws only the number of parts needed, when they are needed. This process is called *pull* (Ohno, 1987). Womack and Jones (2003) describe pull in simple terms as that the upstream consumer should not produce or deliver a good unless an customer downstream ask for it.

Ohno also argues that the Toyota Production System forecasts demand based only required numbers. Required numbers are actual demand. They cannot be increased or decreased arbitrarily (Ohno, 1987). The goal of this part of the study is to change from visual demand checking into a pull strategy.

Order distribution

In literature order distribution is often described as the determination which order should be allocated to which supplier (Zhang, Deng, Chan & Zhang, 2013). The benefit of order distribution is that risks are spread in a supply chain. In Europlant's warehouse the term order distribution is used as the distribution of the production orders between the truck drivers. Production lines with high productivity speed and high demand are combined with slow production lines. Generally two truck drivers are responsible for the picking and supply of the production line. The activity handling pick list is an order distribution factor, because time of this factor is influenced by the number of production lines which the truck is responsible for.

Another problem in the current situation at Europlant is called batching. Batching in a special buffer zone is allowed as advantage during the peak moments (i.e. lunch break, coffee break, use of toilet). Interviews with truck drivers diverted that batching is essential because production lines do not have enough capacity at the peak moments. However, others argue that the batched pallets are not used the peak moment and that the pallets are used at end of the shift. Furthermore when a production orders stops the batched component has to be returned to the warehouse. This is an unnecessary inventory waste because time is lost.

The picking and line supply process is made up of two components: waste and work. Waste included needless repetitive movement (i.e. waiting for parts). The term work includes both value adding work, which is processing, and non-value adding work, such as walking to pick up parts. Non-value adding work can also be classified as waste, but it is necessary for the current way business is done. So in order to enlarge the flow of components and the efficiency in the processes value stream mapping is used to eliminate the waste.

In this study the following types of waste are identified:

- Waiting, due to checking when component have to be supplied
- Unnecessary inventory, due to batching

6.3 Summary literature study

6.3.1 Insufficient knowledge of the own current performance in the liquids warehouse

Literature state that performance measurement is highly important, but benchmark comparison seems to be lacking. Operational theories describes that the core concept of performance is uncertainty which can be further distributed into complexity and dynamism. Complexity refers to the number and diversity of the elements in an environment and dynamism is characterized by the rate of change and technology innovation in the industry as well as the uncertainty or unpredictability of the actions of competitors and customers.
In this study both complexity and dynamism uncertainty influence the performance of the warehouse. The KPI of this bottleneck is exposed in warehouse utilization. The level at the liquids warehouse is on average 87.2 percent. From theory are different utilization level suggested. In this study a utilization standard which is maintained is 80 percent. Components still can be stored two days after an issue with production occurs. The vendor schedulers can react to the issues by cancelling or delaying the ordered components.

6.3.2 Storage strategy

Several storage strategies are discussed in the literature section: random, closest open location, dedicated, full turn over and class based storage. Closest open location, dedicated and full turnover storage are not applicable for the case Europlant's liquids warehouse. Further calculations of the storage strategies must reveal if random or class based storage is the best alternative. Interesting finding in literature is that no firm rule exists to defining the class distribution. So, several distributions must be performed in finding the best strategy. Experiments regarding the dimensions of the zone and which SKUs to place in which zone must indicate savings for this alternative.

6.3.3 Inefficient picking and line supply process

Warehouse experts determine that order picking is the process with the highest need for productivity improvements in a manufacturing organisation. All manufacturing is made up of two components: waste and work. Improvements regarding the supply process are desirable at Europlant, because 36 percent of the time a truck driver is composed of waste. The truck driver has to check visual if components must be supplied in the production area. Theory state that every non-value adding activity should be converted to a pull strategy. The demand should be changed in the process. Furthermore truck drivers place components at the production line which can be seen as unnecessary inventory. Eliminating of waste and change the demand must improve the KPI.

7. Alternatives

This chapter gives answer to sub question 5: *"What alternatives are available for the bottlenecks?"* The relevant literature found in chapter 6 is applied in the case of Europlant. The constraints of the practical situation are taken into account. The alternatives are tested to what extent they improve the KPIs.

The alternative solutions for the five bottlenecks are each discussed. The first section applies VSM to improve the total throughput time of the receiving and put away process. The second section contains of alternatives for improvements of SAP. Section 8.3 describes the alternatives concerning warehouse utilization. The fourth section compares the storage strategies available in the warehouse. The last section of this chapter gives further information about the efficiency in the picking and line supply process.

7.1 Improving the total throughput time in receiving and put away process

This section contains the alternatives for the receiving process. Chapter 5 concluded that the receiving process is a bottleneck due to the long throughput time. This long throughput time is caused by the administrative tasks and the storage availability in the warehouse. The incoming pallets cannot be stored in the bins because SAP has no available storage space or the free space is blocked by the free picking area with storage type 031.

The incoming goods process is mapped with use of value stream mapping. Each activity is timed and categorized as value adding, non-value adding or necessary activity. The goal is to eliminate or reduce the non-value adding activities. The total throughput time is going to decline when waste is eliminated or reduced.

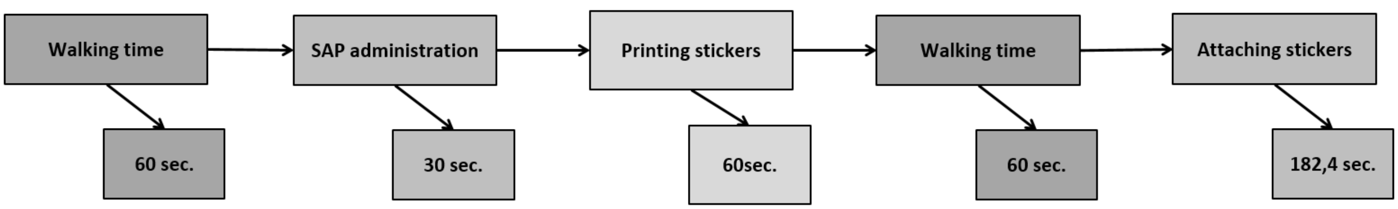
Day shift 07.00-15.00		Evening shift 15.00-23.00		
Activities	**Minutes**	**Activities**	**Minutes**	**Classification**
Transport	282	Transport	250	VA
Administration	72	Administration	72	NA
Handling	30	Handling	26	VA
Communication	30	Communication	30	VA
Additional work/waiting time	36	Additional work/waiting time	72	NVA
Total	**450**	**Total**	**450**	

Table 7.1 - Table with the activities in the receiving and put-away process

Per delivery a truck driver has on average 40.90 minutes time to store the pallets before a new truck arrives at the dock. From that period the truck driver is 6.54 minutes busy with administrational tasks, a necessary activity. Furthermore on average 2.45 minute per truck load the truck driver losses with waiting on availability to store the incoming pallets. Waiting time is a non-value adding activity that should be eliminated.

Elimination of non-value adding activity
First task in improving the efficiency in the receiving and put-away process is eliminating the non-value adding activities in the process. The bottleneck in chapter 5 described that waiting occurred when the truck driver isn't able to store pallets in the warehouse due to problems with availability. The root cause of this waste lies in the storage process. Improving of the storage opportunities eliminates the waiting activity. Key in solving this bottleneck lies in the following sections. If availability to store components is guaranteed the non-value adding activity in the current situation is automatically eliminated. So, throughput increases with 6 percent if the waiting times are eliminated.

Elimination of necessary activity
The second opportunity in improving the efficiency in the receiving and put-away process is eliminating the necessary activities. Necessary activities are in the current situation required but can be different designed that the activity becomes a non-value adding activity. In the case of the administration this example is applicable. A truck driver is 6.54 minutes doing the administrational task. Picture 7.1 shows the VSM of the administration activities.



Picture 7.1 - VSM of the administrational tasks

Goal of this research is to improve the efficiency in the warehouse. If waste can be eliminated efficiency and performance improve. In the following part of this section the alternative for the receiving and put-away are further described.

Alternative 1: Electronic Data Interchange
Electronic Data Interchange (EDI) is an electronic communication method that provides standards for exchanging data via any electronic means. If two companies are connected with each other to the same standard, documents can electronic exchanged. The connected companies don't have to be in the same country to be connected. Research from the AberdeenGroup showed that in the industrial sector 37 percent of the companies use EDI (AberdeenGroup, 2008). The companies use EDI exchange for the purchase orders, invoices and shipping notices. At Europlant EDI is used to exchange data with Crown Mijdrecht. The signal is send from Europlant through a satellite via SC Johnson headquarter to the plant of Crown and vice versa.

The advantages of EDI communication for Europlant are:

Speed
Information moving between computers moves more rapidly. There is little or no human intervention in the process. Integrating data flows directly into the SAP system, so it speeds up the processing of orders, picking, packing, shipping and invoicing.

Accuracy
Information that passes directly between computers without having to be re-entered eliminates the chance of data entry errors. There is almost no chance that the receiving computer inverts digits or adds extra digits.

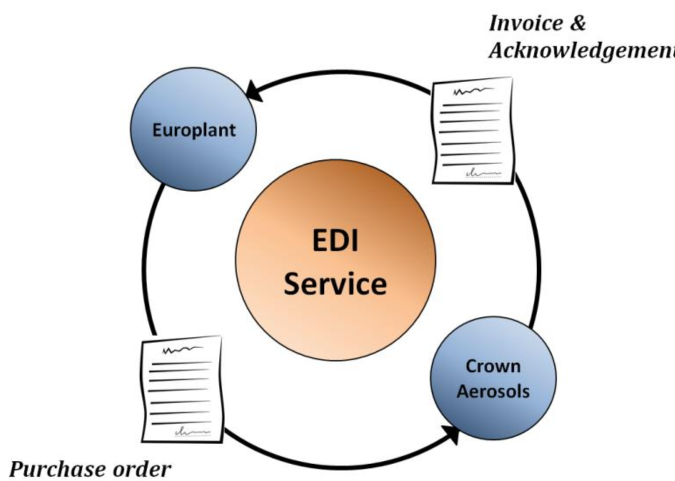
Economy
The cost of sending an electronic document is not a great deal more than regular postage. The reductions in cost afforded by eliminating the rekeying of data, human handling, routing, and delivery makes it for Europlant a viable alternative.

However, EDI involves also some disadvantages:

Expense
If a business has no application systems at all, implementing is complex and expensive. So while there were substantial savings to be gained from the use of EDI. The cost of redesigning and deploying software applications to integrate EDI into an existing portfolio of business applications is too high. However, because the software applications are already working in SAP due to the corporation with Crown Mijdrecht the dis advantage is negligible.

Network Complexity
The need for extensive telecommunications capability posed a second major barrier to widespread EDI implementation. Beyond the computer itself, a basic requirement of EDI is a means to transmit and receive information to and from a wide variety of customers or suppliers. This required a heavy investment in computer networks. Unlike the mail, to send electronic documents there must be a specific point-to-point electronic path for the document to take. So companies were either required to develop extensive and expensive networks, or rely on intermittent point-to-point modem communication.

EDI is already used regarding aerosols cans delivered by Crown Aerosols Nederland. Picture 7.2 shows how EDI is used regarding the purchase activities of crown components. Crown is located on the property of Europlant and the plants are interlinked by a train.
If the vendor scheduler plans a purchase order, the data regarding this order is automatically to Crown and already all the data is included. Subsequently, Crown print and attach the Sun labels on the pallets. The only activity the truck driver is responsible after implementing EDI is scanning and put-away of the components. SAP designated automatically a bin location.



Picture 7.2 - EDI connection with crown

Improving the KPI
The supplier where EDI must be deployed is Alpla Mijdrecht. Alpla is responsible for 64 percent of all the deliveries at the liquids dock. The other suppliers are responsible for the other 36 percent of the deliveries. In subsection 5.1.1 is described that per truck 6.54 minutes is spend on administrational tasks. **So, if the alternative is implemented only for Alpla efficiency increase with 10.24 percent. If the necessary activity is eliminated for all the suppliers the total throughput time decreases with 16 percent. If the waiting times are eliminated and storage availability can be guaranteed throughput increases with 6 percent.**

7.2 Improvements in the use of SAP Enterprise in warehouse

This section discusses the improvements that can be made according to the use of SAP in the liquids warehouse. Let us first recall the issues with sap in the current situation.

SAP was implemented at Europlant in 2005, just little training was applied and the use of the system has never been reviewed. Issues with scanning material, work pressure and line returned material cause that the use of the storage types has changed over time. The main problems faced in the current situation are that the characteristics of the storage types are not right and the storage types have to be active in two types due to the line returned material.

Storage type	Original designed storage types	Current usage of storage types	Correct use
017	Liq. Bulk components	Bulk components	✓
025	NFG Line Returns	Sleeves toilet duck/ Label storage	✗
031	RM process production loc.	Free picking area and returnable goods	✗
041	Lic. Racks	Label storage	✗
043	Lic. Label Room	Pack code stickers	✗
044	Clocon Rack Cloth	Beechnut components	✗
045	Clocon Rack Pouches	L-42 beechnut cases	✗

Table 7.2 - Original design & current usage of the storage types

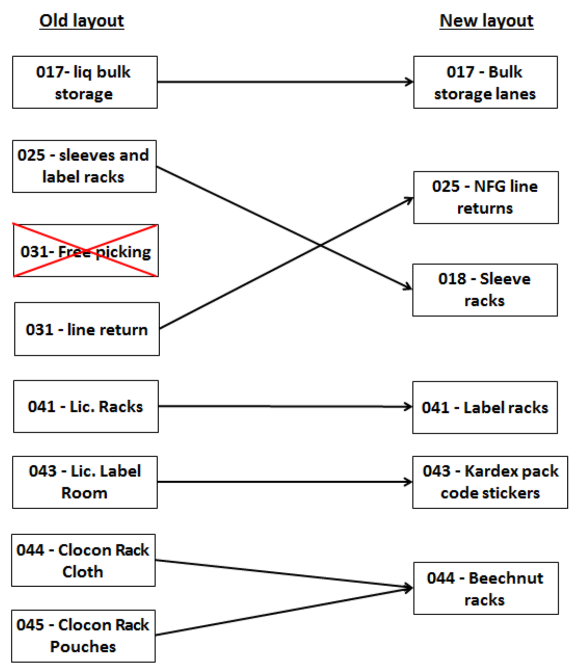
Adjustments steps
Goal of the alternatives is right description the storage type and correct institution of the settings of the storage types. If these setting of the storage types are correct, management can be informed about the current activities and performance in the warehouse. Furthermore WMS is activated and a functioning storage strategy can be implemented.

First step is to give the alternatives for the largest bottleneck in the current storage type situation. Storage type 031 is currently used as free pick area, where components can be picked random and scanning is unnecessary, and the storage type for line returned material. Solution to this matter is to eliminate the free picking areas. The components that are stored at 031 must be stored at their original storage types. The line returned material also stored current situation with 031 is going to be stored with 025.

The alternative for line returned material consisting of less than a full pallet is picked first from 025 storage type (NFG Line Return). The recommendation is to have single deep racks, meaning they only hold one pallet containing one component. This means they physically exist and are only used for this activity. For full pallets the alternative is to store them in the main warehouse with other full pallets of the same component. The storage type should be the same as the other full pallets. For this alternative adjustments have to be made regarding the amount of pallet locations in the warehouse.

Second step in changing the layout is the change of the names of the storage types. New truck drivers can easily understand where to store and pick components. Result in a higher productivity and decreasing numbers of wrong components at the production line. Furthermore it is easier to understand the storage type in SAP. If a storage type face problems in storage availability, actions can be taken fast to maintain performance.

The layout changes of the storage types are showed in picture 7.2. The old layout is displayed in the first row; the second row displays the new situation.



Picture 7.3 - Layout changes

SAP changes

Customization of the storage types has to be done by SAP super user at SC Johnson headquarters in America. No employees at Europlant currently have the authorization to change or create storage types. Europlant have to set a list of adjustments, which are adapted by the super user in SAP Master Data with the transaction code - define Storage Types. The list must be send to the SC Johnson SAP department located in America. Adjustments to the system are made by specialists.

The most important change in the new layout is storage type 031. The free picking areas are eliminated. The components that are stored with this storage type are redistributed in the correct storage type. Bulk is stored with 017, labels are stored with storage type 041 and Beechnut components are stored with 044 storage type. Furthermore, elimination of the free picking area implies that a truck driver in the new situation always has to scan the components that are picked. So, the actions of the truck driver is always controlled if the correct components are picked. Elimination also means that FIFO handling of the components is going to return. Due to the scanning requirement the truck driver always picks the component that is delivered first.

Component with storage type 025 are going to be separated. Firstly labels are stored with the rest of the labels in storage type 041. The sleeves are stored in a new storage type, because 025 must be released due to the line return material. The reason to design a new storage type instead of 031 is because the truck driven can be confused with 031. Mistakes can be made because truck driver can think that component doesn't have to be scanned. So stock differences and picking control becomes a risk.

The beechnut components are going to be stored in the new layout in one storage type 044. In the current situation these components are stored with 044 and 045. The name has to be changed so for warehouse personnel it is clear to what components is referred to.

Advantages

- Control in the picking process
- Less risk for mixed components
- Less risk for wrong components at the production line
- FIFO handling can be maintained
- KPIs can be measured
- Management can be informed about performance

Improving the KPI

Analysing the KPI regarding inefficient use of SAP shows that 14.3 percent correct use of the storage types. If the changes are applied **the KPI of correct storage types is going to improve to 100 percent.**

7.3 Alternatives regarding warehouse utilization

This section discusses the risks that are obtained in the current situation. Let us first recall the restrictions of the current utilization at the liquids warehouse.

The warehouse can facilitate 7985 pallets at maximum. Pallets can be stored in lanes or racks. All rack location can facilitate one pallet, while the lanes can facilitate between 2 and 34 pallets depending on the material that is stored and the depth of a lanes. The current utilization is measured over a period of 15 days between 25 February and 18 March. The maximum utilization level is measured on 11 March with 90.4 percent of the pallet locations occupied. The minimum utilization level was measured on 18 March with a warehouse utilization level of 82.4 percent. The average pallet availability in the measurement period was 1030 pallets. The average utilization level during in the period was 87.10 percent.

From literature in the previous chapter was concluded that the warehouse utilization level should not be higher than 80 percent. If the warehouse faces problems according to the availability it directly cost extra money. Stock has to be stored elsewhere. In the case of Alpla Mijdrecht every 500 pallets stored in their warehouse an amount of 5000 euro is charged each month.

In the case of Europlant relocation or facility expansions aren't feasible options because of investments problems. Because of these restrictions, the next three paths may be followed: Leveraging outside storage, internal warehouse redesign and improving inventory management.

Leveraging Outside
Leveraging outside can be done by using third party warehousing to store excess inventory or by store product on trailers for short periods. This path is extremely expensive due to the rent, labour expenses of the trailer loading and unloading, and security risks. Due to high expenses and the high risks related to leveraging outside, this path is not applicable at the warehouse at Europlant.

Internal warehouse design
Internal warehouse design cannot only be derived from theory; logical thinking and common sense should be used. The primary objectives of warehouse redesign are to:

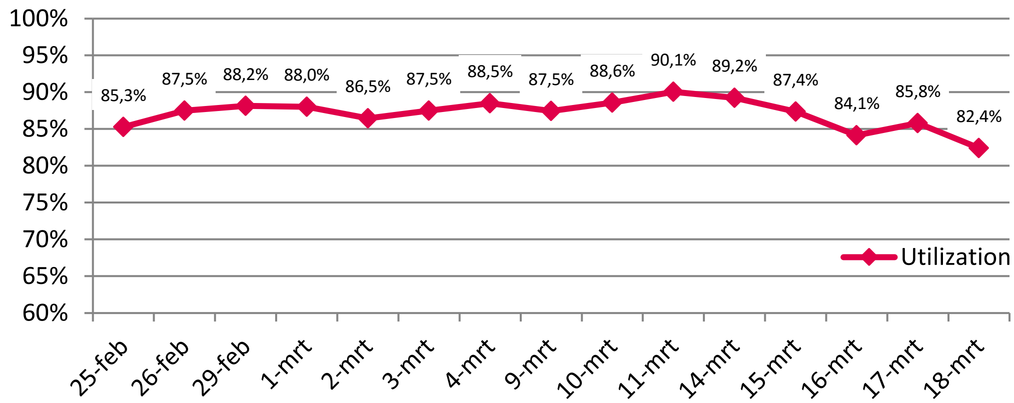
- Use space efficiently
- Allow for the most efficient material handling
- Provide the most economical storage in relation to costs of equipment, use of space, damage to material, handling labour and operational safety
- Provide maximum flexibility in order to meet changing storage and handling requirements

Improved Inventory Management
In order to properly manage inventory, information on demand at all levels of the supply chain must be maintained in real-time. This includes information at point-of-sale down to material deliveries at suppliers. This requires a real-time warehouse management system (WMS) to maintain inventory and transaction data. A program of cycle counting should also be implemented to track inventory and to ensure obsolete product is not occupying valuable space within the warehouse.

The Improved Inventory Management path is the most strategic and futuristic path. This path is not applicable at Europlant because purchasing is centralized from Switzerland. SC Johnson EMEA headquarters in Zurich controls the purchasing contracts and decides on strategic stock. Although, improved inventory management can help Europlant in the future to better understand performance and utilization in the warehouse.

In this research the best alternative to maximize warehouse availability is to change the internal warehouse design. All physical changes in the liquids warehouse incur costs; yet these investments are for a long period of time and improve performance significantly.

Deng, Yuan & Yan (2015) assume that the warehouse utilization should not exceed 80 percent. Recall to the warehouse utilization numbers show that during the measurement period of 15 days this number exceeded every day.



Graph 7.1 - Warehouse utilization

As mentioned before it is hard to decrease the inventory levels due to centralized purchasing from SC Johnson Switzerland. Better alternative for this KPI is to increase the number pallet location in the liquids warehouse. In the current situation the average occupancy is 6955 pallet locations at 87.10 percent. Goal is to reach a level of 80 percent. At 80 percent utilization level the number of pallet locations in the warehouse should be:

(6955 pallet locations/80 percent) x 100 percent = 8693 pallet locations

8693 – 7985 = 708 pallet locations must be added.

In order to achieve this level additional pallet locations have to be added to the liquids warehouse without the opportunity of adding space. In the current situation mostly block stacking is used as storing method.

The advantages of floor stacking

- Low setup costs
- High flexibility

The disadvantages of block stacking

- Low density storage (Requires a large storage facility to store only a small amount of stock)
- Storage height depends on several variable factors (safety, load strength, load stability)
- Only one SKU can be effectively stored in one block stacking bin, empty pallet spaces are created that cannot be utilized effectively until an entire lane is emptied
- You have to move the top pallet to get to the pallet underneath (LIFO)

This is also the case in the warehouse at Europlant. The maximum stack height is two because of the safety regulations and stock has to be stored in pyramid shape. The height of the warehouse is not used effectively and the warehouse offers too little short block stacking bins to store components that are low in stock.

Alternative 1: Selective Pallet Racking

Selective pallet racking is the most common type of pallet storage used today. Selective rack uses uprights and a pair of cross beams to create a shelf for storing a pallet. Depending on the height of the pallet and ceiling, selective rack systems typically have multiple levels per bay. A bay is typically only one pallet deep, although double deep pallet racking systems are also a possibility.

Advantages

- Low investment compared to more dense storage solutions
- Accessibility to all pallets
- FIFO or LIFO can be implemented

Disadvantages

- Low storage density due to aisles between rows of rack

Alternative 2: Pallet Flow Rack System

This type of racking uses uprights and cross beams to support a gravity roller conveyor within the rack. The rollers are pitched slightly, so pallets flow naturally toward the front of the system. After the truck driver picks the first pallet the next pallet in line moves to the following position. This type of system is best suited for storing a large quantity of pallets of the same product. Pallet flow rack systems support FIFO handling.

Advantages

- High storage density
- Can be stored 20+ pallets deep
- Propulsion by gravity
- No need to drive inside the racking system
- FIFO handling

Disadvantages

- Poor accessibility to all pallets
- High investment due to the expensive rollers
- Expensive in maintenance

Alternative 3: Pallet Shuttle System

This system is comparable with the pallet flow rack system. In this system a shuttle driven by an electric motor runs on rails inside the storage channels. The system is horizontal constructed and the propulsion of pallets is not made through gravity, but by an electronic shuttle. Pallet Shuttle System also supports FIFO handling.

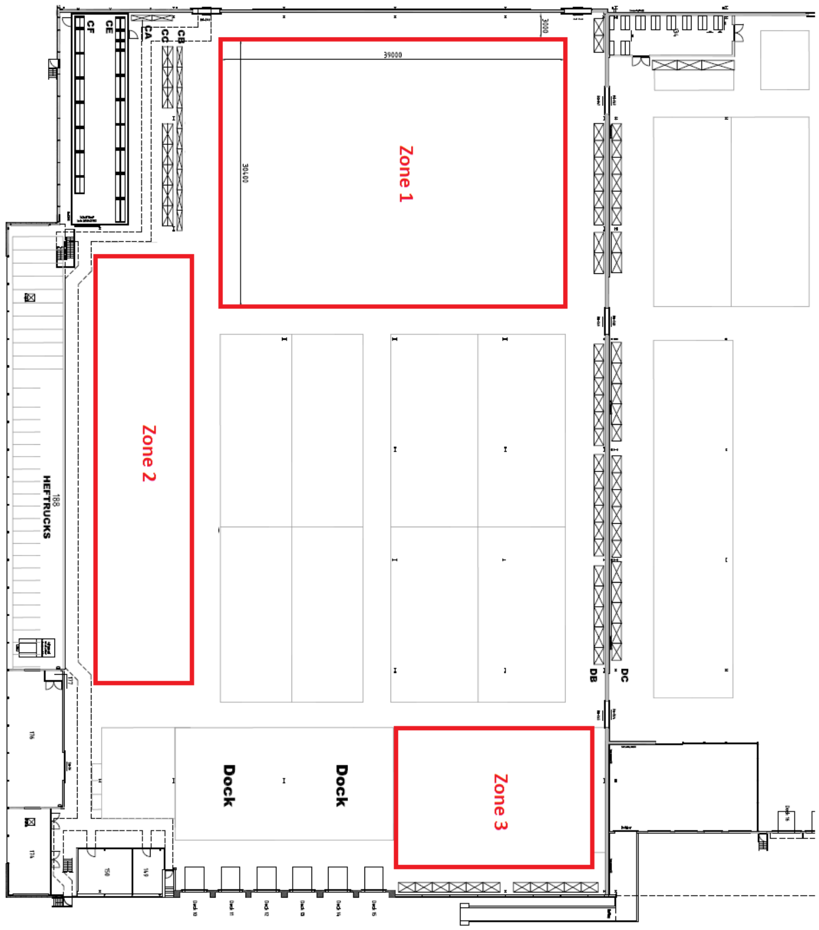
Advantages

- High storage density
- Can be stored 20+ pallets deep
- Propulsion by shuttle
- Cheap in maintenance
- No need to drive inside the racking system
- FIFO handling

Disadvantages

- Poor accessibility to all pallets
- High investment due to shuttles

In order to improve the number of pallet locations in the warehouse, areas have to be designated that are most suitable for an updated. Picture 7.2 gives the overview of the warehouse map. The layout consists of several zones that are suitable for adjustments.



Picture 7.4 - Overview zone classification

Zone 1

This zone must be adjusted because in the current situation lots of storage space is inefficient spent on driving aisles. Also this area is located closest to the production lines and therefore particularly suitable to store the most important components. First importance is that in the new layout an aisle has to be created with latitude of 3 meters. This aisle is created from the wall in the direction of the production lines to the zone.

Considering that the existing gates remain in the new layout, zone 1 has maximum dimensions of 30 by 39.4 meters. Suitable alternatives for this zone are a pallet flow rack system or a pallet shuttle system. Both systems fit in zone 1, but still there are differences in the use of the systems. Table 7.3 gives the specifications of the system and thereafter the alternative that fits best is going to be implemented.

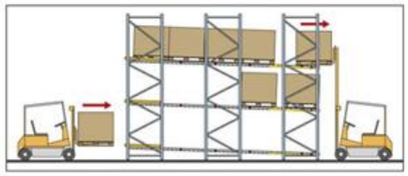
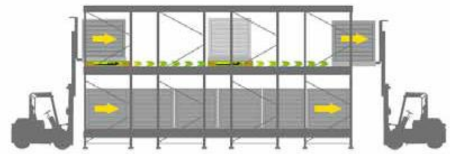
System	Pallet flow rack system	Pallet shuttle system
		
Propulsion	Gravity rolls	Electronic shuttle
Propulsion (picture)		
Maximum levels	2	2
Maximum bins	76	50
Pallets per bin	24	36
Total pallet capacity	1824	1800
Pallet handling	Pallets along the length	Pallets along the width
Pallet handling corresponding with pallet conveyor system	✗	✓
Pallet picking	2 pallets, only if reach truck can tilt forks	2 pallets
Throughput	Continuous throughput	Throughput only if shuttle is available
FIFO	✓	✓
Inbound and outbound separated	✓	✓
Investment costs	± €330.000	± €160.000
Maintenance costs	High	Moderate

Table 7.3 - Specification of alternatives zone 1

The most suitable alternative for zone 1 in the new layout is the pallet shuttle system. The pallet capacity and the continuous throughput are in favour of the pallet flow rack system. Yet, implementing a pallet shuttle system in zone 1 is better because advantage of the system is that the investment costs and the maintenance cost are much lower. Furthermore pallets are also stored along the width so the truck driver doesn't have to turn the pallet before supplying onto the pallet conveyer.

Zone 2
Zone 2 in the new layout is suitable area to store pallets with a selective pallet racking system. The zone is currently used as a block stacking bin area with capacity of 699 pallets in 43 bins. In the new layout the number of pallets locations increase with 517 pallets to a capacity 1216 pallets. The complete capacity of zone 2 is used for selective pallet racking to increase overall capacity in the warehouse. Picture 7.2 gives an example of selective pallet racking.

Picture 7.5 - Example of selective pallet racking
Adapted from jracking, retrieved April 26, 2016, from http://www.jracking.com. Copyright 2015.

Zone 3
In zone 3 some slight changes are planned. First the bins LH 201 until 204 and LH 101, 102 and 103 are added as storage space. The recycled material that have to be shipped back to the supplier is stored at the quality square. All the block stacking bins regarding LH are shortened by 1 meter over the entire length. This creates storage availability to place one extra pallet racking over the entire length with a height of 4 pallets, due to the extra pallet racking system and add of the block stacking bins 253 extra storage bins are created.

Short block stacking bins
The additional pallet racking systems in zone 1, 2 and 3 are sufficient to store the small SKUs. Therefore, the alternative for short block stacking bins is to replace them into long block stacking bins.

Improving the KPI
Recall shows us that the KPI of warehouse utilization is 87.1 percent during the measurement period of 15 days. The number of pallet locations available in the warehouse is 7985. The norm of 80 percent utilization can be achieved if 708 additional pallet locations are created**. If the alternatives are implemented the number of pallet locations increase to 8712. If the stock levels stay the same warehouse utilization in the new situation is going to be 79.8 percent. Additional improvement is that FIFO handling is secured.**
In the next chapter in this research an elaborately description how the alternatives for this bottleneck are implemented and the financial forecast is presented.

7.4 Storage strategy in the liquids warehouse

This section discusses several alternatives for storing strategies in the liquids warehouse. Recommendations for a new storage strategy are done regarding the new capacity from bottleneck 3 in the liquids warehouse.

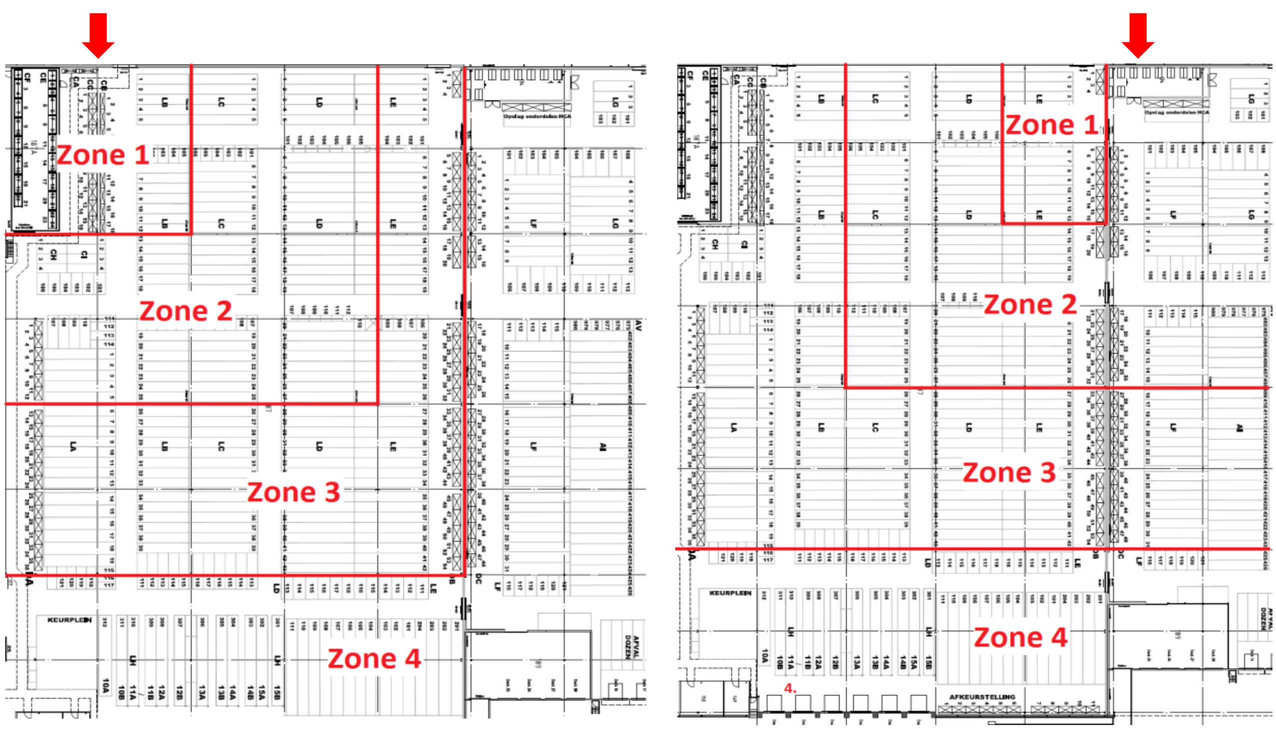
Two different storage strategies are applicable, random storage and class based storage. In this section five different strategies are compared. 1. Current policy, 2. Random storage, 3. Class based storage 66.6-10 rule, 4. Class based storage 58-32-10 and 5. Class based storage strategy 50-30-20.

In this study a comprehensive research is done regarding the best applicable storage strategy. From literature can be derived that the lowest distribution manufacturers normally use is the 66-32-10 rule. Hence, at the liquids warehouse the zone suitable to store class A components has a limit in storing pallets. So, in this study own invented class based distribution are introduced. In sequel of this section the class based distribution of the rules 58-32-10 and 50-30-20 are measured based on the classification of the component, the production line the component is needed for and the nearest gate belonging to the gate.

1. Current policy

Currently no theoretical storage strategy has been implemented in the warehouse. Warehouse employees have tried to store the component with high demand close to the production area but due to the utilization levels this often cannot be realized. The calculation of the current travel times is based on the zones wherein the components are stored. Per zone the average time is determinate by measuring the average travel distance divided by the travel speed of a reach truck (2.77 m/s). The zones are classified by the gate located the closest to the production line. Line 4, 8, 41 & 42 are supplied via gate 1 and line 27, 29, 33 and 94 are supplied via gate 2. An overview of the zones is given in picture 7.4. The average driving time of a retour trip to the zones is given in table 7.5.

Gate 1. **Gate 2.**



Picture 7.6 - Zone classification per gate

Gate 1		*Gate 2*	
Zone 1	10,4	Zone 1	10,4
Zone 2	38,9	Zone 2	35
Zone 3	54,6	Zone 3	51,8
Zone 4	68,7	Zone 4	63,5

Table 7.4 - Driving time from the gate to zone

Storage location are extracted from SAP and linked with the storage zones. The outcomes are multiplying by the number of picks of the component. The total drive time picking components based on the fiscal year 2015-2016 is showed in table 7.

Strategy	**Travel time based on fiscal 2015-2016 in hours**	**Percentage difference**
Current storage policy	*2429.19*	100 percent

Table 7.5 - Total driving time current policy

The travel time is rechecked with the measurement of productivity of a truck driver. Per shift 2 truck drivers are responsible for picking and supplying of the production line. During the year there are 50 weeks of production, 40 hours a week. The calculation shows that every day 1.22 FTE could do the job. However, this calculation is based on travel times and a truck driver spends 22 percent of the time driving on the truck. So, every day 6 truck drivers are needed in the picking and line supply process. This number corresponds with the current situation.

2. Random storage

Recall that every incoming pallet is assigned to a location in the warehouse that is selected randomly from all eligible empty locations with equal probability (Petersen, 1997). The ERP system randomly selects the first free storage opportunity and assigns the incoming pallet to that location. No division is made between popularity of the component. The average travel time is measured from the centre of the warehouse. The average driving time of 52.65 seconds is taken for calculating the total travel time for random storage. According to the fiscal year 2015-2016 in total 206.138 pallets are picked.

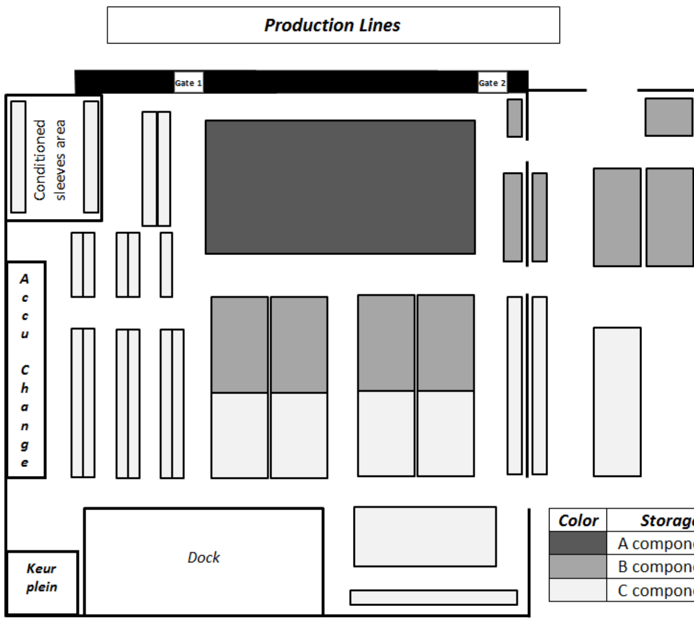
Strategy	**Travel time based on fiscal 2015-2016 in hours**	**Percentage difference**
Current storage policy	*2429.19*	*100 percent*
Random storage strategy	***3014.77***	***124 percent***

Table 7.6 - Total driving time random storage strategy

When random storage is compared to the current storage policy no improvement can be achieved. The driving time increases with 24 percent if the random storage strategy is applied in the warehouse.

Class based storage strategies

In the following part of this section the class based storage strategy is further investigated. In section 6.1.4 is described that many class based distributions are applicable in a warehouse. At Europlant should be considered that only a small number of component belonging to the A class have a high popularity of picking. The zone distribution is established regarding the picking popularity of the components in the warehouse calculated with the corresponding average travel time for the corresponding zone. In the measurement to the suitability of the components in the zones is taken into account that the A components should not trespass 1800 pallets. An overview of the warehouse regarding the ABC distribution is given in picture 7.7.



Color	Storage	Average Time
	A components	8.19
	B components	45.46
	C components	60

Picture 7.7 - Zone distribution

The travel time of both the class based storage strategy derived from literature as the own invented class based storage strategies is measured by real time measurements. From gate I and II an average time is determined as showed in picture 7.7. In excel an overview is composite with the component designation to the specific zone. This overview is based on the S&OP from November 2015 and February 2016 with the fiscal forecast of 2015-2016. Based on the overview the travel time and the picking popularity are multiplied.

3. Class based storage strategy 66-32-10 rule

The first ABC analyse that is investigated in this research is selected from academic literature and explained as the class based 66-32-10 rule. On average 10 percent of the items are responsible for 66.6 percent of the picks. The next 20 percent items are responsible for 23.3 percent. The remaining 70 percent of the items are responsible for 10.1 percent of the picks (De Koster et al., 2007). At the liquids warehouse this means that just 1.6 percent of the products are responsible for 66.6 percent of the picks. The next 3.6 percent for 23.0 percent of the picks and finally 94.7 percent of the products are responsible for the last 10.1 percent of the picks.

Strategy	Travel time based on fiscal 2015-2016 in hours	Percentage difference
Current policy	*2429.19*	*100 percent*
Random storage strategy	*3014.77*	*124 percent*
ABC 66.1-23.3-10.1	***1317.76***	***54.25 percent***

Table 7.7 Total driving time ABC 66.1-23.3-10.1

When the class based storage strategy is applied regarding the ABC 66-32-10 rule an improvement of 45.75 percent can be achieved. The average number of pallets that have be stored in the A zone in this situation is 2003 pallets. This number exceeds the maximum number of pallets that can be stored in the A zone. However, despite the efficiency improvement the 66-10 rule can't be implemented due to capacity exceeding.

4. First own class based storage strategy

The first own invented ABC strategy is the 58-32-10. Measurement in the excel file showed that 58 percent of the picks is the first percentage to fit in zone A based on the average stock levels of the last years. 1.1 percent of the items are responsible for 58 percent of the picks. The next 2.4 percent of the items is responsible for 32 percent of the picks and the remaining 96.5 percent of the items is responsible for 10 percent of the picks. In this study the maximum number of pallets that can be stored in the A zone is 1800 pallets. From the stock levels compared with the picking popularity if 58 percent can be obtained that the average stock of this 1.1 percent is 1675 pallets. The stock level can increase in this situation with 7 percent before the zone reaches the maximum occupancy.

Strategy	Travel time based on fiscal 2015-2016 in hours	Percentage difference
Current policy	*2429.19*	*100 percent*
Random storage strategy	*3014.77*	*124 percent*
ABC 66.1-23.3-10.1	*1317.76*	*54.25 percent*
ABC 58-32-10	***1524.49***	***62.76 percent***

Table 7.8- Total driving time ABC 58-32-10

The first own rule in this study gives an improvement of 37.24 percent compared to the current policy.

5. Second own class based storage strategy

The second own invented ABC strategy is distributed into 50-30-20. This strategy is investigated in this study to considerate the extra rest capacity for A components. In this situation 0.8 percent of the items are responsible for 50 percent of the picks. The next 1.6 percent of the items is responsible for 30 percent of the picks and the remaining 97.6 percent of the items is responsible for 20 percent of the picks. From the stock levels compared with the picking popularity if 50 percent can be obtained that the average stock of this 0.8 percent is 1400 pallets. The stock level can increase in this situation with 22.23 percent before the zone reaches the maximum occupancy.

Strategy	Travel time based on fiscal 2015-2016 in hours	Percentage difference
Current storage strategy	*2429.19*	*100 percent*
Random storage strategy	*3014.77*	*124 percent*
ABC 66.1-23.30-10.1	*1317.76*	*54.25 percent*
ABC 58-32-10	*1524.49*	*62.76 percent*
ABC 50-30-20	***1767.56***	***72.76 percent***

Table 7.9 - Total driving time ABC 50-30-20

The second own rule in this study gives an improvement of 27.24 percent in comparison with the current policy. However, this results of this strategy gives a decrease of improvement of 10 percent compared to the first own ABC analyse.

Improving the KPI
The starting point for this research is the current situation. The new strategies are compared regarding the total travel time in fiscal year 2015-2016.

Strategy	Travel time based on fiscal 2015-2016 in hours	Percentage difference
Current policy	*2429.19*	*100 percent*
Random storage strategy	*3014.77*	*124 percent*
ABC 66.1-23.30-10.1	*1317.76*	*54.25 percent*
ABC 58-32-10	***1524.49***	***62.76 percent***
ABC 50-30-20	*1767.56*	*72.76 percent*

Table 7.10 - KPI storage strategy

Let us recall the bottleneck and KPI defined in chapter 5 of this study. The bottleneck is that no storage strategy has obtained by management. The current policy in the liquids warehouse has an average total travel time of 2429.19 hours. Goal was to find relevant literature to improve the total travel time. **If the ABC 58-32-10 rule is implemented an improvement of 37.24 percent can be achieved in the total travel time in comparison with the current policy. Resulting that per year a time reduction of 904.70 hours can be achieved.**

7.5 Improvement of the flow in the picking and line supply process

This last section of the alternatives chapter discusses several alternatives for the picking and line supply process.

Let us first recall that the bottleneck in this process is that a truck driver is in 'stand-by modus' 36 percent of the workday. Converted to minutes per day this means that the driver waits 162 minutes every shift. Womack and Jones (1996) appointed a waiting activity as a non-value adding activity. In this research non-value activities have to be eliminated or reduced. So, the non-value activity time must be converted into value adding activities.

Literature in subsection 6.2.4 made clear that the cause of the waiting time is demand pattern. The demand fluctuates per production line and per component. The truck driver has to wait and check every time if components have to be added in order to continue production. The alternatives regarding this bottleneck must eliminate waste. Thus, waiting time must be converted into productive time. Lean manufacturing is a tool that uses minimum amount of recourses in the various activities of the enterprise. It involves identifying and eliminating non-value-adding activities in design, production, supply chain management and dealing with customers (Blackstone, 2008). The theory also describes that one lean tool used at a production plant is a pull system. This system is a strategy used to reduce waste in the production process. In this system, components used in the manufacturing process are only replaced once they have been consumed. The alternatives in this section must eliminate the stand-by time in the process and convert it into efficient time.

In the first part of the section alternatives for the stand-by time are described. The alternatives are altered from a total manual system to an automatically system. Per alternative a description is presented and also the advantages and disadvantages of the alternatives are described. In the sequel of this section an alternative for scanning in the warehouse is presented.

Alternative 1: Kanban Pull cards

The first alternative to improve the efficiency in the process can be achieved by kanban pull cards. The kanban pull cards method is a manual method that regulates the flow of components towards the production line. On a large central board (sometimes mentioned as checkpoint Charlie) between the production lines and the warehouse, a board displays the stock that is available per machine per production line. The available stock is designated by cards in a lean flash FIFO system. Implementation is immediate and very easy, starting from cards on whereon a label is attached. The label contains all the information about the pallet stored at/in the production line.

Picture 7.8 – Lean flash FIFO Adapted from SESA Systems, Retrieved April 28, 2016, from http://www.sesa-systems.com/newsletter/gestion_des_flux.php. Copyright 2015.

Every time the truck driver supplies a full pallet of components to the production a card has to be added into the system. The line operator and/or casual are responsible for removing the card out from the lean flash FIFO system when the pallet is removed. No diversity is made about the numbers of pallets that can be stored in the buffer zone. The rule has to be made applied if one pallet is empty one card have to removed. Otherwise production differs from supply and failures are made.

In this system the truck has always a clear notion of the status of the component at the production lines, when component are expected and what amount of components must be add. The advantages and disadvantages of the manual system are the following:

Advantages of kanban Pull cards

- Clear overview production status
- Saving of driving time
- improved time management for truck drivers
- Less chance of production stop due to lacking components
- Low investment

Disadvantages of kanban pull cards

- Change of safety issues because operator have to walk to system
- Time consuming for line operators
- Production of cards is time consuming
- Risk of missing cards

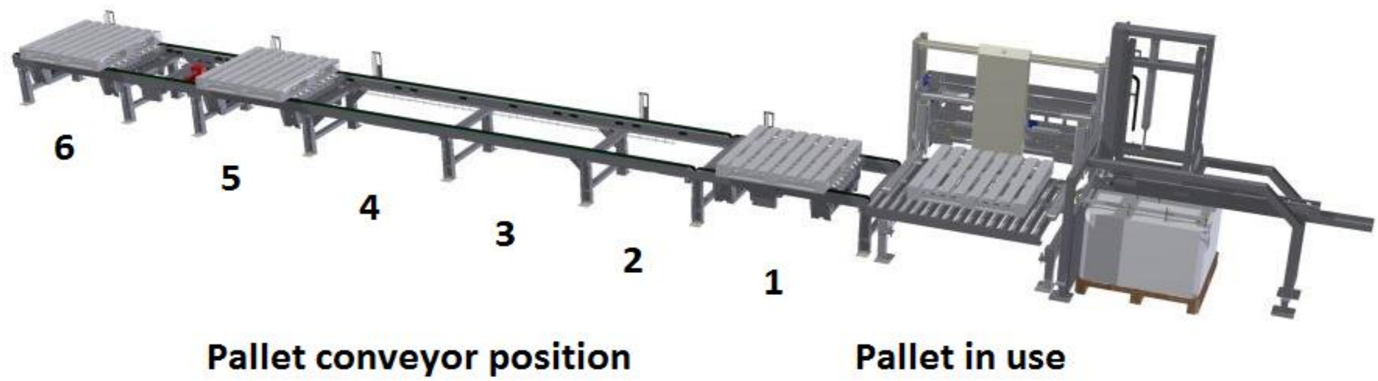
Alternative 2: Stack lights

The second alternative regarding the improvement of the picking and line supply bottleneck is production flow through automatic stack lights. The component flow in the current situation consist of that a truck driver has to check at the production line if components must be supplied. In the previous alternative the flow of components are maintained through a lean flash FIFO system where operators and truck drivers manual have to add or withdraw cards. In this alternative a more automated system is going to be introduced.

Process

Component are supplied to the production line and can thereafter processed by two different processing methods. The first method is the easiest process, whereby the line operator or casual processes components manual into the machine. The operator or casual is responsible for removing an empty pallet and supplying a full pallet from the buffer zone. The truck driver then supplies a full pallet to a buffer zone.

The second process is a more technical complicated process. In this process the truck driver places full pallets on a pallet conveyor. The throughput of the pallets is automatically coordinated via sensors on the conveyor. An overview of this process is given in picture 7.9 and thereafter explained.



Picture 7.9 - Overview of a pallet conveyor system

The process is as follows: When production starts the truck driver supplies seven full pallets on the pallet conveyor. A full automatic robot withdraws components from the pallet, located on the pallet in use position. If the pallet on the pallet in use position is empty a depalletizer robot removes the pallet from that location. Thereafter, when the sensor of position pallet in use does not pick up a signal, position 1 puts the pallet through. This process continues until position 5 is vacant and position 6 puts the pallet through. The truck driver in the current situation has to check visual if pallets can be supplied.

Picture 7.10 - Stack lights
Adapted from automationdirect, retrieved May 1, 2016, from http://www.automationdirect.com/adc/Overview/Catalog/Stacklights. Copyright 2016.

Stack light

In this alternative stack light have to be added to show the throughput of the pallets. An example of stack light is added in picture 7.10. In the manual process a stack light gives a sign when components are needed. This yes or no question can be full filled with a 2 colour stack light. If the process is more sophisticated additional colours have to be added in order to inform the truck driver correct. In this situation the recommendation is that if pallet level is equal to position 6 or 5 the stack light turns green. If the last pallet reaches level 4 or 3 the colour turns orange. The colour turns red if the level of pallets reaches level 2 or 1, the truck driver must supply additional pallets to the production line. If the truck driver miss the red sign the production stops.

Location of stack lights
The stack lights can be attached directly on the production line. The advantage is that the line operator or casual also can check if there is demand for components. And a disadvantage is that the truck driver still has to drive along the production lines to see if there is demand. Another location possibility where the stack light can be placed is at the central point between the production area and the warehouse. Above gate I and gate II a sign board can be placed where the stack lights can be attached together so the truck driver can see straightforward which components should be picked.

Advantages of stack lights
- Quick overview of component demand
- improved time management for truck drivers
- Less chance of production stop due to lacking components
- Low maintenance
- Safe in use

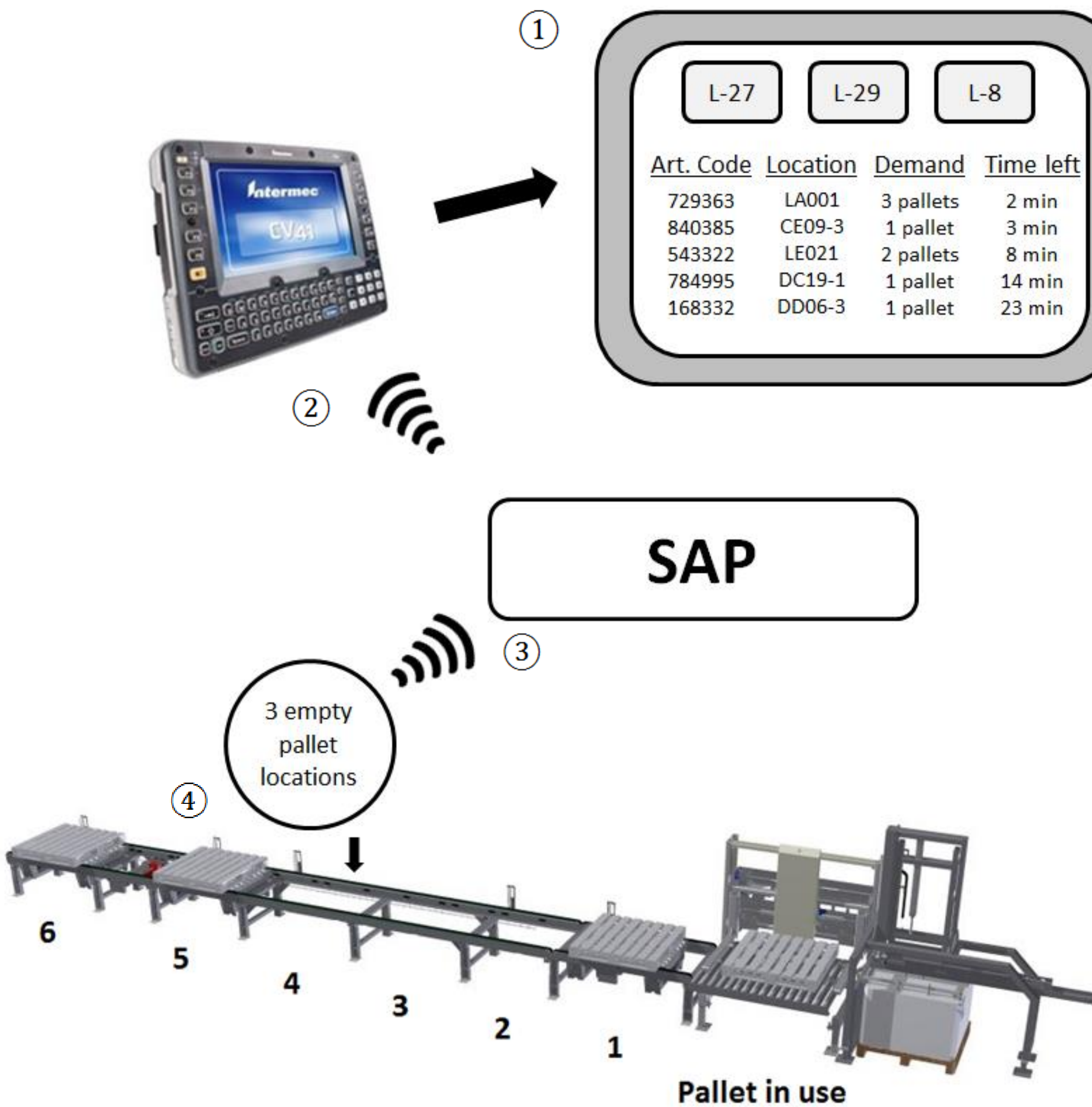
Disadvantages of stack lights
- High numbers of stack light can be confusing
- No signal if truck driver isn't driving along stack lights
- Moderate investment
- When production order changes no signal is given

Alternative 3: Kanban pull automatic
The last alternative regarding the improvement of the fifth bottleneck is kanban pull automatic. Kanban pull automatic is the most progressive solution for the improvement of the picking and line supply process. This alternative is comparable with the stack lights only the signal is not visible through a light, but is directly transmitted to the truck driver's terminal. However, this kanban pull system isn't introduced yet in production manufacturing. Hence, the alternative is introduced in this section and further research is necessary about this topic.

The component flow in the desired situation must contain out of a continuous flow of components to the production area. In a perfect world no production line should face downtime and truck drivers should always be driving and moving components. Recall show us that 36 percent of the time the truck driver is waiting before he can supply components towards production. In kanban pull automatic system the truck driver is always able to see which component should be picked first in order to continue production.

Picture 7.11 gives an overview of the alternative kanban pull automatic process. Designated with number 1 is the first step in the method whereby the reach truck driver selects the responsible production lines that have to be supplied. SAP automatically links the production orders to the selected lines and uploads them to the terminal.

When the line operators start up the production line, the truck driver supplies all the machines in the production area. After completing the supply, the task of the truck driver is to keep production provisioned. In the automatic kanban pull method the pallet conveyor detects automatically the demand (number 4) and sends first a signal to SAP (number 3). SAP converts this demand into MWS data. Thereafter SAP sends a signal to the terminal (number 2). The component that is needed first is showed on top of the demand list. The demand list contains the following information: Component code, storage location, demand and the time that is left before productions stops. The demand list reassigns because when a production line face downtime or a production order finishes. Furthermore, the demand list shows the exact pick location of the components. The location of the components must be scanned so FIFO is guaranteed. If the production order is finished line return material is added to the list on the terminal. The major benefit of the method is that production always maintain constant and the flow of component is continuous.



Picture 7.11 - Overview of kanban pull method

Advantages of kanban pull automatic

- Continuous flow
- No downtime because of lacking components
- FIFO is guaranteed
- Safe in use
- SAP is up-to-date and active
- WMS advantages (routing, demand planning)

Disadvantages of kanban pull automatic

- High investments costs
- Total customized system
- Technological complicated

Most suitable alternative

The recommendation for Europlant to improve performance on short term is the alternative stack light. Although investment the stack lights are higher compared to the cards system, the system is less time consuming than the cards system. Another benefit is that stack light is a fixed system while the cards can be fall of the pallets. Both alternatives improve performance but stack light is more suitable alternative for Europlant.

When management wants to improve the picking and line supply performance on the long term, kanban pull automatic is a better solution. Implementation however shall be a challenge because the system must be customized to Europlant's production standards. Also the investment costs are higher compared to the other alternatives because new complicated technological software has to be developed for Europlant. The advantages of this solution compared to the other alternatives are that FIFO implementation is guaranteed, component flow is continuous and no downtime is faced due to lacking components. Major advantages are that Europlant features already a comprehensive SAP edition and WMS is active and up-to-date after solving the other bottlenecks.

Improving the KPI

No direct improvement is made because extra research is needed regarding the kanban pull automatic alternative. Management should consider the alternatives on short times because the KPI stays at 36 percent non-value adding activities if nothing is done.

Extra alternative 4: Voice picking

Recall that an alternative for scanning is not the highest priority because a kaizen on the RF Scanners is carried out. In the investigation phase of this study several companies were visited where voice picking was used on daily basis. During these visits information has been gathered about voice picking. So, in this alternative voice picking is further explained and also information is provided if voice picking is going to improve Europlant's liquids warehouse performance.

Picture 7.9 - Voice picking device
Adapted from Inther, Retrieved May 3, 2016, from http://www.inther.nl/order-picking/voice-picking/ Copyright 2016.

Voice picking is a warehouse picking system that applies to the use of the voice direction and speech recognition devices. It has been introduced in the late 1990s, and the popularity of the software still increases since. Warehouse employees wear a headset connected to a small computer which tells the warehouse employee the location and the number of components that have to be picked by using verbal prompts. Employees confirm their tasks by speaking simple commands and reading confirmation codes printed on locations or products throughout the warehouse. If the software recognizes the employee's responses and confirms the following task is communicated.

There are several advantages of voice picking compared to the RF scanning Europlant uses in the current situation. Hence, voice picking also has some disadvantages. In the next part of this section the specifications of voice picking and RF scanning are further described and thereafter a recommendation regarding voice picking for Europlant is presented.

System	Voice picking	RF scanning
		
Communication	By voice	By barcode
Tool		
SAP connection	✓	✓
Extra connection needed	✓	✗
Throughput	Continuous	Non-continuous
Failure sensitive	Low	Moderate
FIFO	✓	✓
Connectivity	Cord or cordless	Cordless
Battery life	Cord: Infinite Cordless: 72 hours	Cordless: ±50 hours
Education	English language	None
Major benefit	Hands-free/eyes-free use	Scanning from truck
For use with	Small batches	Large batches
Investment costs	± €80.000	€0
Maintenance costs	High	Moderate

Table 7.11 – Specifications of voice picking and RF scanning

The alternative of voice picking adds no extra value to Europlant. The reason of this is that truck drivers at Europlant mostly pick components in bulk. The major benefit of voice picking; picking hands-free and eyes-free gives no value. The components that are picked by hand is often done once per production order. Furthermore the investment of ± € 80,000 is not going to be earned back.

8. Implementation plan

> This chapter gives answer to the last question of this research: *How to implement the solutions at SC Johnsen Europlant B.V. in order to improve performance?* A stepwise implementation plan is made how to implement the new alternatives.

8.1 Implementations receiving and put-away process

There are no direct implementations in the receiving and put-away process. In this research two key improvements opportunities regarding performance were discovered. The elimination of non-value adding activity waiting time can be solved if the alternatives are implemented in the next section of this research. If availability to store components is guaranteed the non-value adding activity in the current situation is automatically eliminated. Implementations regarding the elimination of the necessary activity in this process require additional research. The EDI connection with the suppliers must be further researched. In this research EDI connection with Alpla Mijdrecht has the highest priority because of the high frequency of deliveries.

8.2 Implementations regarding SAP

This section contains an overview of the activities that must be done for implementing the solutions given in chapter 7. The implementation of the recommendations has a big impact on the current process. The new layout of storage types give also changes in material handling by truck drivers. This section describes a stepwise approach for implementing these solutions.

Step 1:
Create a clear schedule of the storage bins in the desired situation. The schedule must contain of data about storage strategy, storage type per bin, storage availability per bin and activity status.

Step 2:
After creation the complete list of changes must be send to SC Johnson headquarters in Racine. SAP super users must adjust all the settings that are figured out from Europlant. During the adjustment process Europlant management has to keep close contact to the SAP super users.

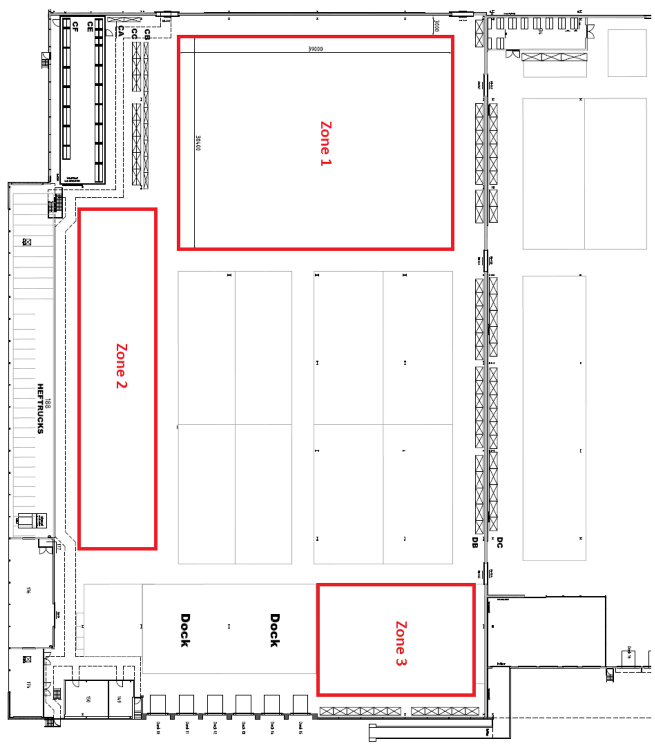
Step 3:
A training plan and material has to be developed for the warehouse employees. The material should contain of detailed work instructions and more in-depth instructions should contain out of one points lessons.

Step 4:
After training material is developed it is recommendable to examine personnel according to the new standard work method of SAP.

Step 5:
Every two years the new standard work method of should be reviewed and also the training material has to be discussed and adjusted when outdated.

8.3 Implementations in warehouse utilization

In order to improve performance, but also take storage space into account and control the investment costs, zones have identified that are most appropriate for adjustments. Three zones have been selected that are most suitable in order to improve availability. In this section of the research an implementation plan is presented regarding the utilization level. In the implementation plan the best fitting alternative is elaborated per zone, also the financial assessment of the best alternative is worked out. The zones are designated with red in picture 8.1.

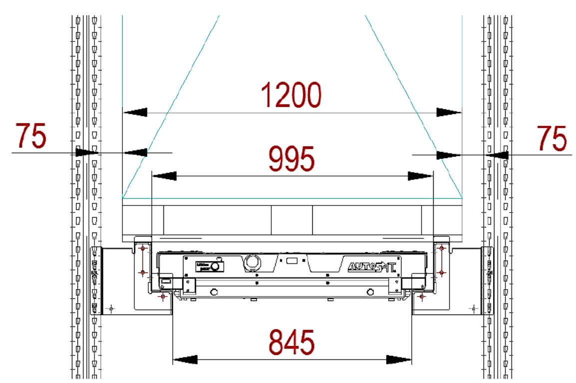


Picture 8.1 - Zone classification

Zone 1:

The best alternative for zone 1 is the pallet shuttle system. The system consist of a horizontal pallet racks including two electric shuttles. The zone covers an area of 39 meters width and 30.4 meters length. It is located close to the production area and is special designed that the doors are not blocked. The input side of the system is on dock side of the zone and the production area is the output side. Throughput to the system is executed by the electric shuttle. The system has availability for 1800 pallets divided into 50 bins.

The bins are divided into two layers and spread over the total width of zone 1. Picture 8.2 shows a schematic representation and the measurement of a storage bin.



Picture 8.2 - Technical drawing and measurements of a storage bin

Financial forecast
During this study different suppliers have been contacted for information and quotations of a pallet shuttle system. In this study the quotation of Constructor Dexion Holland B.V. (Dexion) has been taken into account. Dexion provided the quotation with most information and was also best priced. Dexion was responsible for placement of the current pallet racking systems in the warehouse. Table 8.1 provides information about the investments costs of the pallet shuttle system. This forecast excludes tax and is based on consultations with the Managing Director of Dexion. Also fire protection and sprinkler installation are not included in this research.

Description	***Unit price***	***Quantity***	***Total price***
Shuttle service pallet racking	€ 65.00	1800	€ 117,000.00
Shuttle	€ 20,000.00	2	€ 40,000.00
Remote control	€ 0.00	2	€ 0.00
Battery load station	€ 0.00	2	€ 0.00
Installation	€ 0.00	1	€ 0.00
Total			€ 157,000.00

Table 8.1 - Financial forecast alternative zone 1

Zone 2:
As mentioned in section 7.3, zone 2 is adjusted from block stacking bins to a pallet racking system. If the alternative is implemented additional storage availability of 517 pallets is created. The total storage location amounts 1216 pallets. Table 8.2 gives the overview of the financial forecast of the pallet racking system in zone 2.

Zone 3:
Zone 3 is also equipped with a pallet racking system. One meter is removed from the original block stacking bins and on that area a racking system is placed by Dexion. Due to the changes in zone 3 additional storage availability of 44 pallets is created. Table 8.2 gives the overview of the financial forecast of zone 3.

Description	***Unit price***	***Quantity***	***Total price***
Pallet racking zone 2	€ 22.00	1216	€ 26,752.00
Pallet racking zone 3	€ 22.00	44	€ 968.00
Installation	€ 0.00	1	€ 0.00
Total			€ 27,720.00

Table 8.2 - Financial forecast alternatives zone 2 and 3

8.4 Implementations storage strategy

Best alternative regarding the storage strategy for management of Europlant is to work out an implementation plan of the 58-32-10 distribution.

The following new strategy is proposed:

Zone A: 58 percent of the picks
- Pallet shuttle system: bulk components
- Pallet racking: line return material

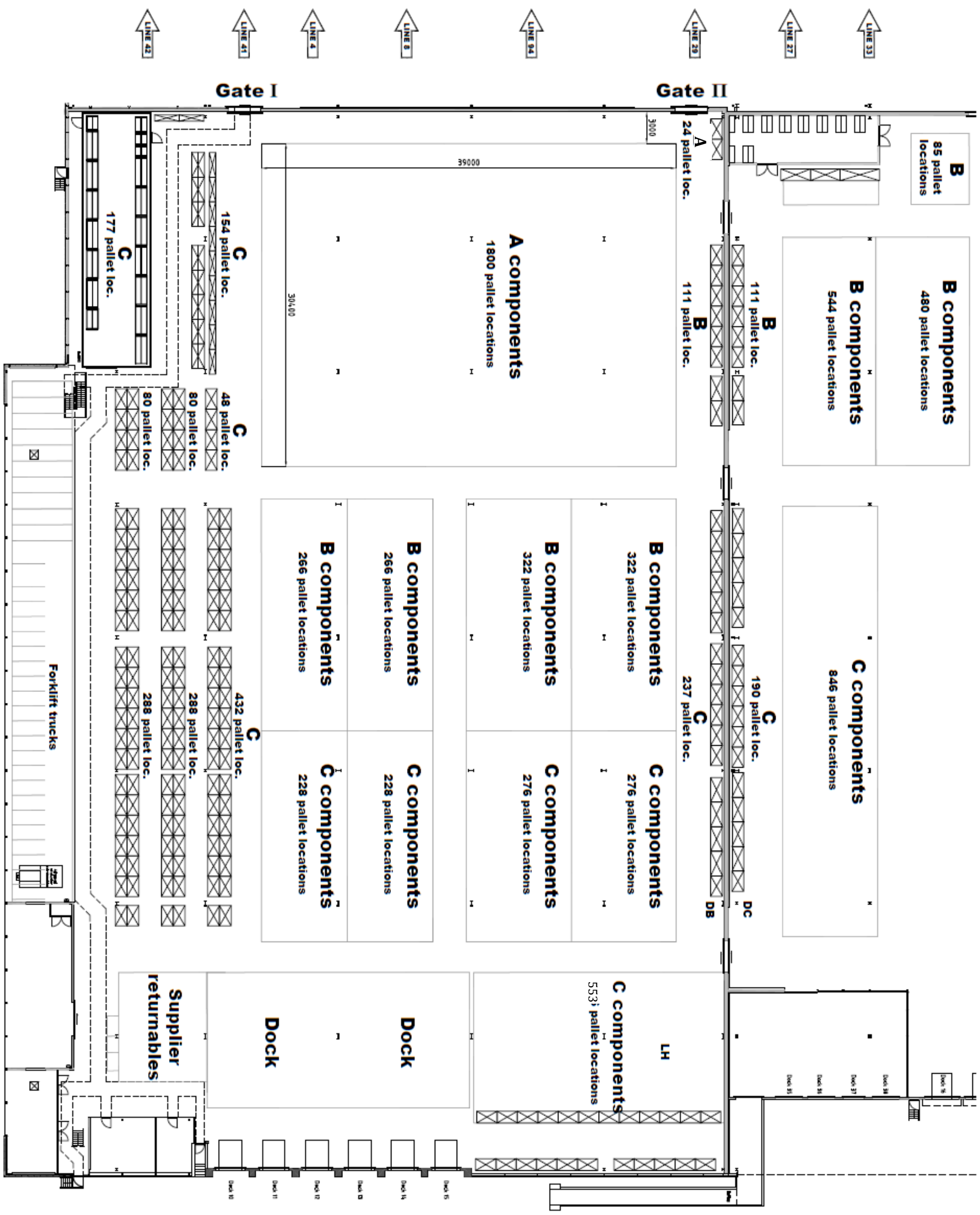
Zone B: 58 percent to 90 percent of the picks

- Block stacking: Bulk components
- Pallet racking: Pallet number per components < 2, line return material

Zone C: 10 percent of the pick

- Block stacking: Bulk components
- Pallet racking: Pallet number per components < 2, line return material

Picture 8.3 represents the new layout of the liquids warehouse.



Picture 8.3 - New layout of the liquids warehouse

The next step of the implementation is to categorize the components in the predetermined zones. For each zone a list is made with the SKUs that are assigned to this zone. The list is based on the components needed per SKU. The components are ordered based on the picking popularity of the components. After the picking popularity was determined the components have been assigned to a new zone.

		Pallet shuttle system	Block stacking bins	Pallet racking system	**Total availability**	**Average stock 2015 - 2016**	Rest capacity
A	**8 components**	1800	-	24	**1824**	**1675**	7 percent
B	**21 components**	-	2285	222	**2507**	**2067**	17.55 percent
C	**706 components**	-	2319	2062	**4381**	**2646**	39.6 percent

➢ *The figures indicate the number of pallets.*

Table 8.3- Number of pallet location in new situation

Stepwise approach for the implementation:

Step 1:
First the alternatives have to be finished from the previous bottleneck in the three physical zones.

Step 2:
Adjust the physical zone in SAP regarding the new layout from picture 8.3.

Step 3:
Assign component codes to the correct production line. Components are stored based on the gate closest to the production line. Truck drivers are on the right side of warehouse and efficiency is improved.

Step 4:
Adjust the new category per component code in SAP. SAP locates the components automatically in the right component zone when components are scanned at the dock.

Step 5:
The capacity per zone must be monitored by the ERP system. SAP automatically counts the occupations rate per zones. Monitoring KPIs give good overview of warehouse performance.

Updating the policy
This new policy must be updated once a year. New data per component must be gathered from the S&OP based on the forecast per fiscal year. This new list of data per SKU must be ranked regarding the new popularity. If seasonal product and customer demands fluctuations influence the picking popularity, components should be reallocated and switched manual between the zones. In that case the settings in SAP must be adjusted.

8.5 Implementations picking and line supply process

There are no direct implementations recommended regarding the picking and line supply process. First of all implementation of voice picking gives no extra value to Europlant. Because truck drivers mostly pick components in bulk, so the major benefit of voice picking the hands-free and eyes-free use adds no value. The investment of ± € 80,000 is not going to be earned back.

Research revealed that implementation of the stack lights to a central point is going to increase performance of the line supply and also the investment costs are moderate. Nevertheless implementations of stack lights is going to be time consuming and in a world that is technologically rapid developing, stack lights are quickly outdated. Subsequently, it is advisable not to implement any alternative in the picking and line supply, but additional research to the kanban pull automatic system must performed as mentioned as alternative in section 7.5.

9. Conclusion and recommendations

> The last chapter of this report describes the conclusions and recommendations of this study. The objective of this research is improving the performance in the inbound logistical processes. This research gives insight in the current bottlenecks and performance and come up with alternatives. The objective is formulated as: gain insight if there are problems in the inbound logistical process, how to solve these problems and subsequently how it improves the performance of Europlant. Research exposed five bottlenecks in the current situation at Europlant. These bottlenecks are observed and their performance is measured and calculated. Also previous research have been analysed and rechecked. Each bottleneck is expressed in KPIs which are indicating the performances of the processes. Per bottleneck a literature study is done to find alternatives for the bottlenecks. The solutions are applied to the case of SC Johnson Europlant. This chapter describes if the objective is reached.

9.1 Receiving and put-away process

9.1.1 Conclusion receiving and put-away process

The activities of the receiving process were observed, timed and schematically viewed. The total throughput time in the current situation was 40.90 minutes before a truck loading has been fully processed. The activities were measured from the arrival of a truck until all incoming pallets are stored in the storage location. Results show that waste in the process can be identified as waiting and unnecessary motion. The waiting times has caused by problems regarding storage availability. Unnecessary motion are necessary activities causing time loss due to the administrational tasks.

9.1.2 Recommendation receiving and put-away process

The total throughput time can be eliminated due to the solutions given by this research. The solutions are presented in bottleneck 3 and will only be successful if storage availability can be guaranteed. The total throughput time depends on whether SAP can designate a storage location. It is important for the management of SC Johnson Europlant to increase the pallet locations and secure storage availability. This recommendation increases the throughput time with 2.45 minutes. The second recommendation in this first process are alternatives regarding the administrational task of the truck drivers. EDI speeds up the process and decrease the total throughput time of a pallet at the dock. Most important is to implement EDI and connect Alpla Mijdrecht. It is important to connect Alpla Mijdrecht first because the supplier delivers almost 64 percent of the truck loads per day. After Alpla Mijdrecht it is advisable to EDI connect the rest of the suppliers because the alternative results in improvement of 6.54 minutes per truck.

9.2 SAP problems

9.2.1 Conclusion regarding SAP

The second bottleneck was exposed regarding observations and analyses of the ERP system data.
Incorrect decision making in the usage of the ERP-system led that in the current situation components can be picked without scanning resulting in quality and financial losses. This also led that no data can be analysed so no KPIs can be measured and management cannot be informed. Research exposed that only one storage type is described correct and has the right settings. Goal in this research was to find information what the correct usage of SAP is and how the incorrect storage type should be adjusted. Interviews with SAP project managers and SAP super users based at SC Johnson headquarters gave the information that the storage types in SAP must be adjusted before data can be collected about performance.

9.2.2 Recommendation regarding SAP

The recommendation can be given that Europlant must customize the storage types in the liquids warehouse. The storage types must changed so data can be measured and analysed. Furthermore quality of the finished products will improve because truck drivers make less mistakes and the possibility of mixed components shall decrease. Because Europlant's personnel have no authorization to change or create storage types, the list of adjustments has to be set. The list must be send to Racine and must be adjusted by a SAP specialist based at SC Johnson headquarters in America. It is advisable for the management of SC Johnson Europlant to put effort in improving the use of SAP in the warehouse. SAP is an extensive ERP system with a lot of possibilities. It is important to improve the skills and abilities of the employees regarding SAP.

9.3 Warehouse utilization

9.3.1 Conclusion about warehouse utilization

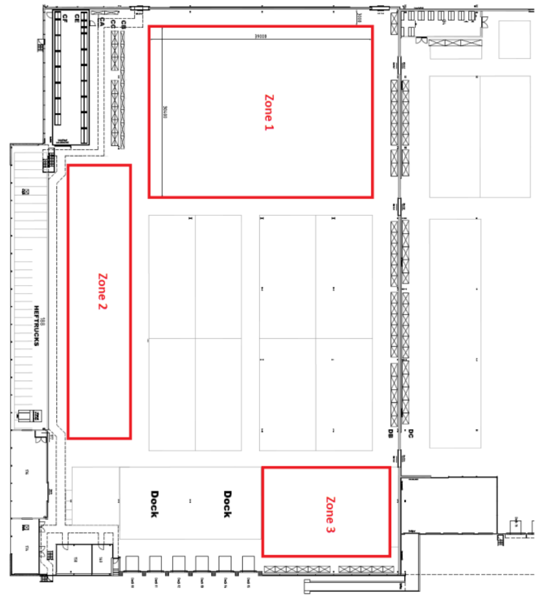
The third bottleneck was exposed by interviews with warehouse personnel, observations in the warehouse, analysis of the ground plan and data from the ERP system. In the current situation no KPIs are measured and also no data is available. In the previous bottleneck the cause of the data availability problems has already be explained. If the recommendation in the previous bottleneck is applied, data can be gathered from SAP.

In this bottleneck warehouse utilization is gathered through a time consuming examination by exporting SAP data to Microsoft Excel. Bins that are double active are filtered out based an occupancy level. A KPI is defined for this bottleneck. A literature study is done to research the maximum utilization rate for the warehouse. Literature showed that the utilization should not exceed a rate of 80 percent, preventing overflow risks. The result of the measurement is that the utilization in the current situation is on average 87.1 percent at an availability level of 7985 pallets.

No outside leveraging is feasible due to high costs and also inventory management is of no value due to centralized purchasing from Switzerland. Best option in this research is to enhance the number of pallet locations in the warehouse. The conclusion in this research is that if the warehouse should utilize at 80 percent the number of pallets locations must increase to a level of 8693 pallets.

9.3.2 Recommendation about warehouse utilization

The recommendation can be given to enhance the pallet locations with at least 708 extra pallet locations. The areas that are most appropriate to adjust are showed in picture 9.1. Zone 1 is an area of 39 meters width and 30.4 meters of length. The recommendation for this zone is a pallet shuttle system that can contain 1800 pallets. Compared to the current situation additional availability of 192 pallet locations are created. In the current situation Zone 2 has availability to store 699 pallets. Recommendation for this zone is to change from block stacking bins to selective pallet racking. In zone 2 five short pallet racking constructions (4 levels high) should be placed. Furthermore four long pallet racking constructions must be added of four levels high and two long pallet racking constructions of six levels high must be add. The six levels are special designed for storing labels and line return materials. The total storage availability in zone 2 increases to 1216 pallets.



Picture 9.1 - Zone classification

Zone 3 in the current situation has storage availability of 300 pallets. Recommendations are that the block stacking bins must be restricted with 1 meter so an extra pallet racking construction can be placed. Recycled materials that currently stored in this zone must be stored at the disappearing quality square, so these bins can be used as storage locations. The new layout of zone 3 has an availability of 553 pallets. The last recommendation regarding better warehouse layout is to replace short block stacking bins into long block stacking bins. The additional pallet racking systems are sufficient to store the components with small stock. The improvements in the zones combines gives a total pallet storage availability of 8712 pallets. In total 727 extra pallet locations are created that will lead to an estimated saving of € 7270 each month.

9.4 Storage strategy in the warehouse

9.4.1 Conclusion storage strategy

Observation and analysis of the strategy, ground plan and data from the ERP system exposed that the absence of a storage strategy is a bottleneck in the warehouse. The main problem is that no thoughtful storage strategy has been implemented. Warehouse staff made some initiatives regarding storage improvements. They try to store components as close as possible to the corresponding production line in free picking areas and store line return material with the bulk components. However, these initiatives resulted in long travel times for the truck drivers. Based on the S&OP’s of fiscal 2015-2016 the travel time has been calculated indicating the current performance: 2429.19 hours. A literature study is done to find a storage strategy alternative. Class based storage strategy is concluded to be the best solution for Europlant. The practical issue that the A component should not infringe 1800 pallets is solved first. The 58-32-10 rule improves the total travel time with 37.24 percent in comparison with the current situation. A new layout with the new zone division is made and an implementation plan is established for Europlant. An Excel sheet is made with a division of the components per zone.

9.4.2 Recommendation storage strategy

This research consist of an excel file that designates automatically designates the right class to the component. Management can determine how often the storage strategy in the liquids warehouse should be updated. The popularity must be attained from S&OP regarding the planning for the fiscal year. The components can be categorized regarding the new popularity and the average stock of the components. The management of Europlant received an Excel sheet with the calculations and procedure of the classification in this report. It is also advisable to review the occupation rate per zone with the planning department weekly.

9.5 Picking and line supply process

9.5.1 Conclusion picking and line supply process

The activities of the receiving process were observed, timed and schematically viewed. The total throughput time in the current situation is measured. The picking and supply towards the production line has been based on the activities of a truck driver during a shift. The measurement exposed waste mostly caused by waiting before additional component are needed at a production line. The waiting times were caused by the fact that the truck driver has to check visual if component have to be add in the production process. Measurements exposed that 161 minutes of a total workday of 450 minutes was wasted on the stand-by activity. In percentage it amounts 36 percent of the total workday.

9.5.2 Recommendation picking and line supply process

Three alternatives are founded that improves the picking and line supply process: kanban pull cards, stack lights and kanban pull automatic. In a fast changing world were technological innovation is every day's business, kanban pull automatic will improve the picking and line supply most. On short terms implementation of stack lights is cheaper and easier to implement. In this research we recommend kanban pull automatic because in a world that is technologically rapid developing, stack lights are quickly outdated. For Europlant it is advisable to investigate this alternative because the performance improvement will be significant.

9.6 Recommendations regarding further research

It is advisable for Europlant to further research the automatic kanban pull system. The system can be the solution to the elimination of all the waiting time in the picking and supply process and also reduces the paper information exchange. Furthermore it is also important that the Kaizen about improving the RF scanners must be finished because voice picking is not a good alternative.

A deeper investigation must be performed regarding the implementation of EDI at Europlant. The EDI software is already in-house at Europlant, so the next step is to investigate if the rest of the supply chain can be connected. First step in this research should be at Alpla Mijdrecht because the supplier is responsible for almost 64 percent of the deliveries.

Further research should be done for the same bottlenecks in the aerosols warehouse. In the beginning of this research utilization levels were low and employees from the aerosols warehouse complained less compared to the liquids warehouse. However, in the course of the study the aerosols side of the warehouse also faced problems regarding the storage availability. Therefore, improvements regarding performance and efficiency are also desirable at the aerosols warehouse.

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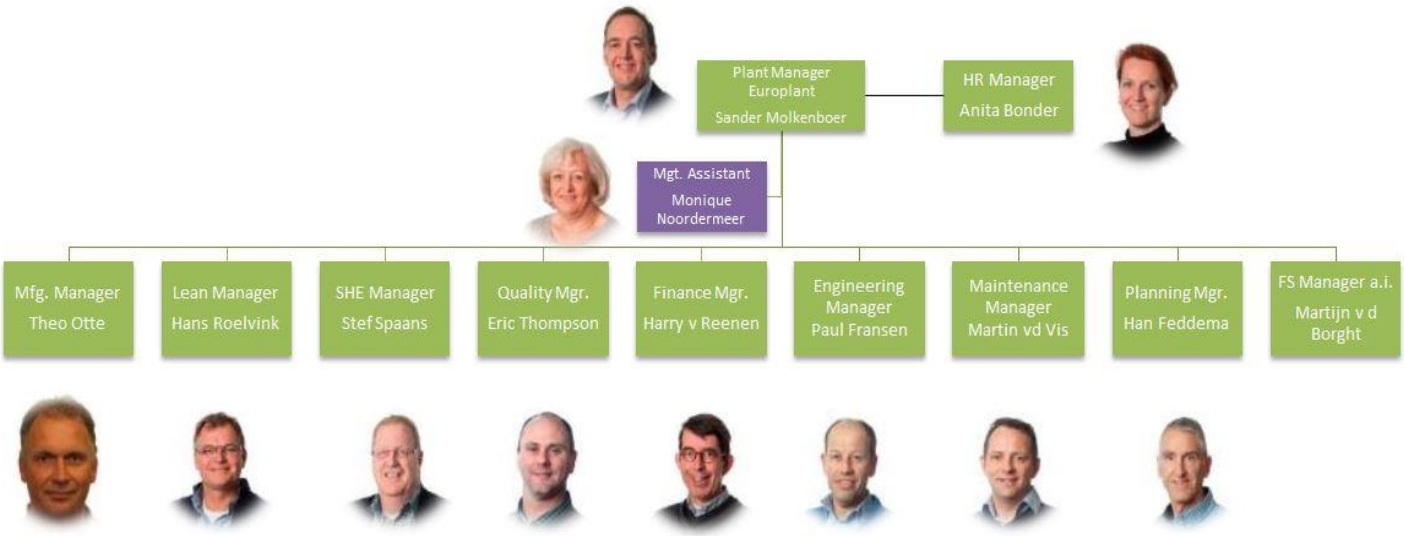
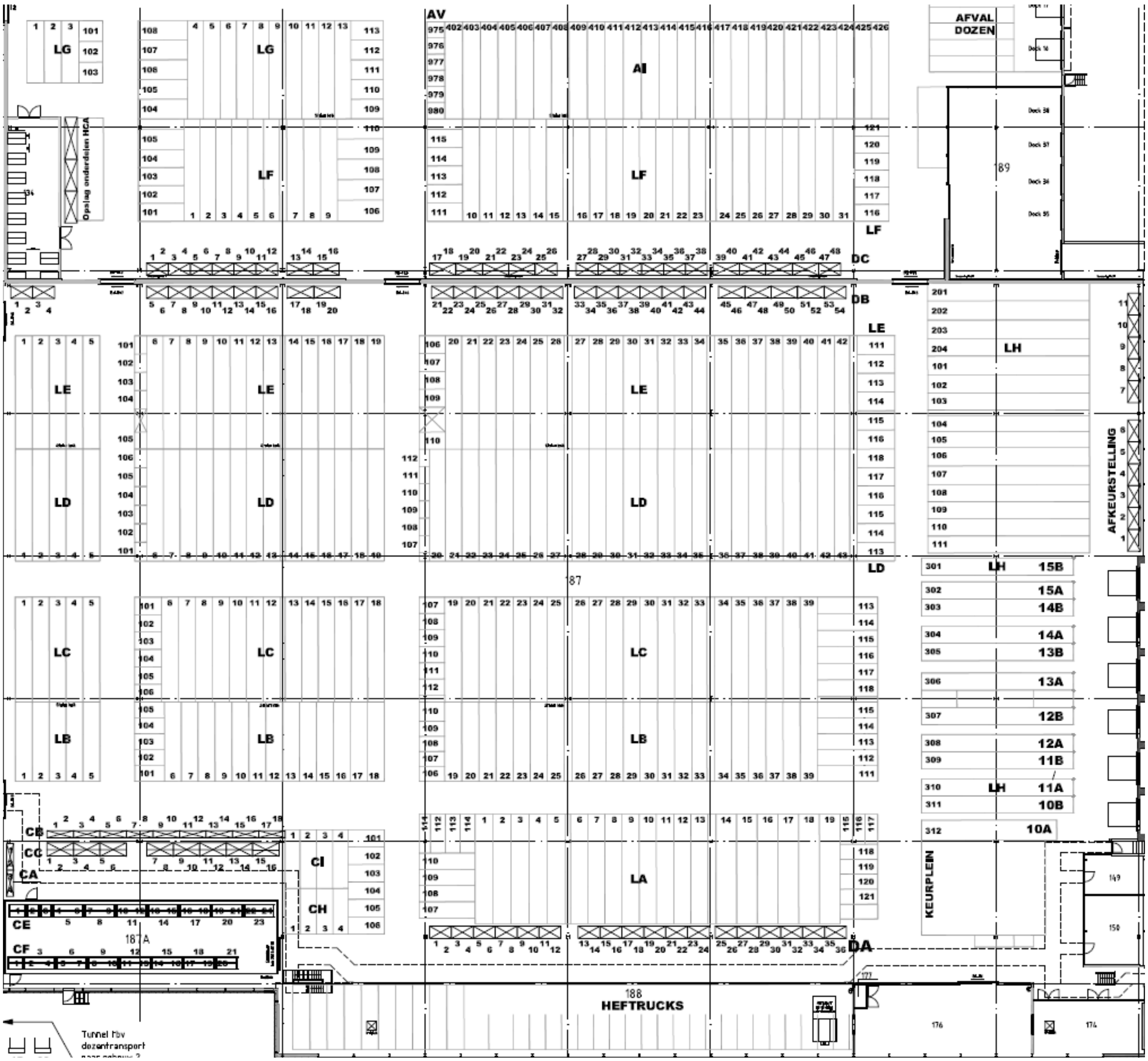
Appendix I - Organizational chart SC Johnson Europlant



Appendix II - Product overview

Appendix III – Warehouse tools

Appendix IV – Liquids warehouse ground plan



Appendix V – Example of pick list liquids

Warehouse No. 620 Mijdrecht MFG Plant

TO Number	TR No.	Item	Materia	Typ	Source Bin	Srce tgt qty	Typ	Dest. Bin
0013363382	5576091	0002	884563	031	HS222-1	1.896,000	122	0002158948
* 0013363382			884563			1.896,000		
0013363382	5576091	0001	920005	031	AB076	22.794,000	122	0002158948
* 0013363382			920005			22.794,000		
0013363383	5576091	0001	884562	026	GH025-3	350,000	122	0002158948
* 0013363383			884562			350,000		
0013363434	5576091	0001	884562	026	GM100-3	1.559,000	122	0002158948
* 0013363434			884562			1.559,000		
0013363435 0013363435	5576091 5576091	0001 0002	884464 884464	031 031	HP102-3 HP102-3	10.284,000 12.623,000	122 122	0002158948 0002158948
* 0013363435			884464			22.907,000		
0013363436	5576091	0001	884463	024	HR169-3	22.794,000	122	0002158948
* 0013363436			884463			22.794,000		
0013363437	5576091	0001	870064	031	PROC-U503	25,515	122	0002158948
* 0013363437			870064			25,515		
0013363438	5576091	0001	772349	031	AX752	22.680,000	122	0002158948
* 0013363438			772349			22.680,000		
0013363934		0001	884562	001	0029309780	5.441,000	122	0002158948
* 0013363934			884562			5.441,000		
0013363937		0001	884463	001	0029441952	9.956,000	122	0002158948
* 0013363937			884463			9.956,000		
**						110.377,000 25,515		

Appendix VI – Bin specification

Block stacking Lanes - Long	Number of bins	Block stacking Lanes - Short	Number of bins
LA	19	**LA**	21
LB	39	**LB**	15
LC	39	**LC**	18
LD	43	**LD**	18
LF	42	**LE**	11
LF	31	**LF**	21
LG	13	**LG**	13
LH	8	**LH**	0
CH	0	**CH**	3
CI	0	**CI**	4
Pallet Racking	**Number of bins**	**Kardex shuttle**	**Number of bins**
DA	285	**KL**	377
DB	372		
DC	300		
DD	36		
CB	90		
CC	64		
CE	93		
CF	84		
HS	36		